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Effects of feeding processed kidney bean meal (*Phaseolus vulgaris*) by replacing soybean meal on egg fertility and qualities of chicks of white leghorn hens

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ABSTRACT

A study was conducted to evaluate the effects of feeding processed kidney bean meal (PKBM) by replacing soybean meal (SBM) on fertility, hatchability, embryonic mortality and chick quality of white leghorn (WL) hens. A total of 225 white leghorn hens (195 layers and 30 cocks) with uniform body weight (BW) and age were randomly distributed into 15 pens and assigned to five treatments (i.e., T_1, T_2, T_3, T_4, and T_5). A total of 360 eggs collected from all the treatment birds were used for the analysis. The feeds of the treatments were SBM substituted by PKBM at 0, 25, 50, 75 and 100% levels for T_1, T_2, T_3, T_4, and T_5, respectively. Replacement of SBM with PKBM in the diet did not affect the fertility, hatchability, embryonic mortality, chick length, chick weight, and chick quality by visual score. As no difference is observed, 100% replacement of SBM by PKBM (dosed at 100 g/kg concentrate diet) is possible.

Keywords

Embryonic Mortality, Fertility, Hatchability, Kidney bean, Soybean Meal

ARTICLE HISTORY

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INTRODUCTION

Chick quality is affected by pre-incubation storage conditions, time in the Hatcher, and size of egg. Tona et al. (2004) found that increased incubation storage produced poor quality chick. Larger eggs tend to have significantly poor quality chicks as compared to other egg size (Tona et al., 2004).

The fertility of an egg is affected by several factors originating from the hen such as her ability to mate successfully, to store sperm, to ovulate an egg cell, and to produce a suitable environment for the formation and development of the embryo. The fertility also depends on the cock's ability to mate successfully, quantity and quality of semen deposited (Brillard, 2003). When fertility is low, it can affect other categories because of the lack of uniformity of embryo temperature inside the egg set (not as much heat provided by the developing embryos).

Hatchability is a process that has several critical points that can be monitored and controlled to produce consistently healthy and mature hatchlings. These includes assessing hatching egg, fertility, egg storage and care, evaluation of hatch residue, poultry processing, sanitation, and poultry health and viability (Hulet, 2007).

The cost of poultry feed is very high and it accounts for 60-70% of the layer production cost (Wilson and Beyer, 2000). In recent years, the price of conventional or basic feed ingredients has tremendously increased. This has made poultry and live-stock production very

expensive. In Ethiopia where soybean and its meal are in short supply and very expensive, the use of soybean meal as protein source of poultry ration is limited. Thus, an alternative protein source should be assessed and used. Therefore, the present research was initiated to evaluate the effect of feeding processed kidney bean meal (*Phaseolus vulgaris*) by replacing soybean meal on egg fertility and qualities of chicks of white leghorn hens.

MATERIALS AND METHODS

Management of Experimental Chickens: The experimental house had 15 experimental pens partitioned with a wire mesh, each having a 2.5×2 m dimension. It was cleaned and disinfected (with a cavlon *i.e.*, 10 mL in 1 L H_2O) very well before the commencement of the experiment. Similarly watering and feeding troughs and laying nests were thoroughly cleaned, disinfected and sprayed against external parasites, and the floor of each pen was covered with teff straw of 10 cm depth.

The birds required for the experiment were obtained from Haramaya University Poultry Farm. Total 225 birds used for the experiment were uniform in size, age and free from any defects. The birds were vaccinated against Newcastle disease, salmonellosis and coccidiosis at the farm, and were adapted to the experimental diets and experimental procedures for 7 days before the actual data collection was started. The birds were also given aminovate vitamin (*i.e.*, 10 g in 20 L water) and piperazine citrate (*i.e.*, 900 mL in 20 L water) for ascaris deworming. Feed was measured and provided to the birds in group twice a day at 800 and 1700 h *ad-libitum*. The feeding and watering troughs were cleaned every morning before feeding. Feed was offered in hanging tubular feeders, which was suspended approximately at a height that birds can reach. Water was available all the time, and the experiment lasted for 90 days.

Ingredients and Experimental Rations: The feed ingredients used in formulation of the different experimental rations of the study were processed kidney bean, maize grain, wheat short, soybean meal, noug seed cake, vitamin premix, limestone and salt as indicated in **Table 1**. The kidney bean, maize grain and noug seed cake were coarsely ground before formulating the treatment rations. The five layer rations were formulated on an iso-caloric and iso-nitrogenous basis in such a way to consist about 2800-2900 KCal/ME per kg DM and 16-17% CP to meet the requirements of layers. The treatments consisted of 0% (T_1), 25% (T_2), 50% (T_3), 75% (T_4) and 100% (T_5) processed kidney bean as a substitute for soybean meal as protein source.

The kidney bean seed was cleaned from dust and dirt materials soaked in water at a proportion of 5 L H_2O to 1 kg bean for 5 h, rinsed and poured into boiled water (100^0C) at the same proportion and heated for 1 h. The cooked kidney bean was rinsed and sun dried by spreading the grain on a canvas until it was sufficiently dried to ground (Emiola et al., 2007).

Experimental Design and Treatments: The experiment was conducted in a completely randomized design with 5 dietary treatments each with three replications. Each replicate contained 15 birds (13 pullets and 2 cockerels). A total of 195 white leghorn pullets and 30 cockerels both were 7 months of old (at their early production stage) were collected from Haramaya University Poultry Farm.

Measurements and Observation

Fertility and hatchability of eggs: Total 45 eggs with medium size and normal shape per treatment, 15 per replication, were taken and used for fertility and hatchability analysis. The eggs used for incubation were collected at the middle of the experimental period and stored for not more than 5 days at a temperature of 10^oC to 12^oC until incubated. Incubation was done using electrically heated incubator. The temperature and relative humidity of the setter unit was adjusted at 37.7^0C and 85-90%, respectively, and the eggs were kept in the tray with small end down and turned automatically by slanting the tray at 45-degree then turning the eggs 45-degree in two direction by operating turner of the incubator at an interval of 2 h, whereas the hatchery unit was set at 37.6^0 C, and 90% of relative humidity.

Fertility was determined by candling the incubated eggs on the Day 7 of incubation. Candling was done at dark room with egg Candler powered by electricity. Eggs found to be infertile, which are characterized by clear appearance of the egg white and yolk that have a structure encircle with blood ring, absence of blood vessels, adhering to the shell membrane and eggs with early dead embryos that did not have clear demarcation (between embryo and air cell) were considered as having dead embryo and removed from the incubator. The eggs found to be fertile, i.e. eggs having small dark spot, numerous blood vessels arising from those dark spot of yolk at Day 7 of candling,

clearly visible thick and dark and well fill structure was further kept in the incubator for hatching. The average percentage fertility on the 7th day of incubation was determined according to the following formula, as mentioned by Bonnier and Kasper (1990).

$$\% \text{ Fertility} = \frac{\text{Number of Fertile Eggs}}{\text{Total Eggs Set}} \times 100$$

At the 22nd and 23rd days of incubation, hatched chicks were observed and counted to determine hatchability in relation to percentage of all eggs set or as percentage of fertile eggs (Rashed, 2004; Fayeye et al., 2005).

$$\%\text{Hatchability on fertile eggs base} = \frac{\text{Number of Chicks Hatched}}{\text{Total Fertile Eggs}} \times 100$$

$$\%\text{Hatchability on total eggs base} = \frac{\text{Number of Chicks Hatched}}{\text{Total Eggs Set}} \times 100$$

Embryonic mortality: Embryonic mortality was determined by breaking of eggs that seemed to be mortal on the days of candling eggs at 7th, 14th and 18th days of incubation and the last three days of hatching to determine early, mid, late and piped embryonic mortalities, respectively (Bonnier and Kasper, 1990). The eggs that did not hatch were opened for visual observation, and classified according to time of embryonic mortality. According to Butcher (2009), the stage of death can be classified as early, mid, late and piped. The criteria used for these classifications were as follows: **Early:** show signs of early embryonic development, which is characterized by eye development, but a lack of limb buds. Early embryonic mortality represents embryos that die during the first 7 days of incubation. This is usually a result of failure of embryos to resume development after having been stored and placed in the setter. **Mid:** displaying mid embryonic development signs, which is characterized by developed limbs. The mid-dead embryonic mortality period represents the eggs that die between 8-14 days. Nutritional deficiency is the main cause for such death. **Late:** showing late embryonic development signs, this is characterized by presence of feathers. The late embryonic mortality represents the eggs that die during the last week of incubation periods, which is mainly caused by abnormal position, complication in physiological changes, such as respiration and lethal gens. **Pip:** exhibiting signs of breakage by internal forces regardless of whether the chick was alive or dead. Pip embryonic mortality represents the eggs that die during the last day of incubation.

The embryonic mortality was computed by dividing the number of died embryo to the number of fertile eggs set and multiplied by 100 (Rashed, 2004). The formulas are given below:

$$\% \text{ of Early Mortality} = \frac{\text{Total Number of Early Dead Embryo}}{\text{Total Number of Fertile Eggs}} \times 100$$

$$\% \text{ of Mid Mortality} = \frac{\text{Total Number of Mid Dead Embryo}}{\text{Total Number of Fertile Eggs}} \times 100$$

$$\% \text{ of Late Mortality} = \frac{\text{Total Number of Late Dead Embryo}}{\text{Total Number of Fertile Eggs}} \times 100$$

$$\% \text{ of Pip Mortality} = \frac{\text{Total Number of Pip Dead Embryo}}{\text{Total Number of Fertile Eggs}} \times 100$$

Chick Quality Measurement: The quality of the day-old chick has an important effect on the growth performance of the chicken (Wolanski et al., 2007). Visual score, chick length and day-old chick weight are commonly used for measuring chick quality (Tona et al., 2005). Visual scoring employed grading of chicks by visual examination based on the quality standards outlined for this method. However, chick quality has proven to be a difficult and subjective matter to define. It is very much a subjective matter, depending on the judgment of each individual person (Willemsen et al., 2008).

Visual scoring: When chicks are removed from the hatcher, the chick should be clean (free from adhering dried yolk, shell and membrane), absence of deformities (straight feet and legs with no lesions or swellings), and ready to engage the world. Visual scoring of chicks is used to obtain a general overview of chick quality by above listed characteristics. According to Meijerhof (2005), although visual scoring is a fast method and is used in a lot of hatcheries, chick quality is only estimated and not recorded by a number. Comparisons between days, flocks or hatcheries are difficult, and visual scoring is influenced by personal opinions and the system remains subjective and poorly repeatable.

Chick length: Chick length is determined by stretching the chick along a ruler and measuring length from beak to the end of the middle toe (Molenaar, 2005). Measuring chick length is a fast method to evaluate chick quality. At hatching period, the uniformity of chick length (CL) was more important compared to body weight since it was affected by yolk body mass. As reported by Wolanski et al. (2007), CL might be much more important for acquiring the greatest uniformity and predicting growth performance. The

CL might be an indicator for chick quality and potential growth because longer chick would have better uniformity and might have better development organs.

There is positive relationship between body weight and chick length suggesting that the use of chick length measurement of day-old chick can be used to make prediction on the chick quality (Petek et al., 2010). Therefore, at hatch, measuring body length might be a useful tool to estimate growth potential rather than using hatch body weight (Joseph et al., 2006). Molenaar (2005) also reported that chick length is found to be positively related with subsequent performance.

Chick weight: The body weight is the most widely used parameter for assessing day-old-chick quality. However, the differences observed in hatch weight may have been mainly influenced by initial egg weight (Tona et al., 2004). Although this is an easy and highly objective measurement, the value is relative. A heavy chick indicates a good development, but this is not true when this bird has a large residual yolk which does not express the development of the bird. Evaluating chick quality by measuring body weight is therefore, difficult and can be misleading (Molenaar, 2009).

The visual assessment was made by the researcher and two other experienced technicians, and the quality of the chicks was determined based on agreed decision by the three observers. The mean percentage of quality chicks was calculated by expressing the number of quality chicks as percentage of the total number of chicks hatched.

% Quality Chicks of Visual Score

$$= \frac{\text{Total Number of Quality Chicks}}{\text{Total Number of Hatched Chicks}} X100$$

Day old chick weight was taken for 5 chicks randomly selected from each replicate and their average was taken. Chick length was determined by measuring the length of stretched chick from the tip of the beak to the tip of the middle toe in centimeters (cm) using a ruler and recorded for the same chick from which weight measurement was taken.

Statistical Analysis and Models: The data collected during the study period were subjected to statistical analysis using SAS computer software version 9.1.3. (SAS, 2008). During data analysis, chick weight and length were analyzed following one way analysis of variance procedure. When the analysis of variance indicated the existence of significant difference between treatment means, list significant difference (LSD) method was used to locate the treatment means that were significantly different from the other (Gomez and Gomez, 1984).
The model used for statistical analysis was:

$$\mathbf{Y_{ij} = \mu + T_i + e_{ij}}$$

Where: Y_{ij}=Individual observation, T_i=Treatment effect, μ=Overall mean, e_{ij}= Error term

General logistic regression analysis was employed for analysis of data recorded on fertility (fertile/infertile), hatchability (hatched/un-hatched), embryonic mortality (alive/dead), and visual scoring (normal/poor). The general logistic regression model used is given below:

Model: $\ln \left\{ \frac{\pi}{1-\pi} \right\} = \beta_0 + \beta_1 * (\mathbf{x})$

Test H0: No treatment effect (*i.e.*, $\beta 1=0$) vs. HA: Significant treatment effect ($\beta 1 \neq 0$).

Where, π=probability, β=slope, x=treatment

RESULTS AND DISCUSSION

Mean values of fertility and hatchability for the treatments are presented in **Table 3.** The logistic regression results for fertility and hatchability of eggs showed no significant difference. Similar concentration of nutrients used in all treatments might have been the reason for comparable fertility and hatchability among treatments observed in this study. Protein content of feed is known to affect fertility of egg, and its hatchability. Gabreil et al. (2006) reported, level of dietary protein significantly affected egg fertility and hatchability. As documented by Hocking et al. (2002), poor hatching results occurred when nutritionally deficient feeds were used for layers. Odunsi et al. (2002) also stated that inadequacy of nutrients in the breeder diets resulted in poor hatchability of fertile eggs. Thus, the results indicated that replacing processed kidney bean meal for soybean meal up to 100% (dosed at 100 g/kg concentrate diet) did not alter nutrients that enhanced fertility and hatchability of eggs.

The mean embryonic mortality values for the treatments are presented in **Table 3.** The logistic regression result of early, mid, late and pip mortality provided a wald value of 2.16, 1.06, 2.28 and 0.29 with *pr>chisq.* value of 0.70, 0.90, 0.68 and 0.99, respectively, which shows no significant difference in mortality at all

Table 1. Proportion of ingredients (percentage of total ration) used in formulating the experimental rations.

Ingredients (%)	Treatment diets				
	T_1	T_2	T_3	T_4	T_5
Maize grain	38	38	38	38	38
Wheat short	18	18	18	18	18
Soybean meal	10	7.5	5	2.5	0
Kidney bean	0	2.5	5	7.5	10
Noug seed cake	25	25	25	25	25
Limestone	7.8	7.8	7.8	7.8	7.8
Vitamin premix	0.7	0.7	0.7	0.7	0.7
Salt	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100

PKBM = processed kidney bean meal; T_1= ration containing 0% PKBM; 100% SBM (control); T_2= ration containing 25% of SBM substituted by PKBM; T_3= ration containing 50% of SBM substituted by PKBM; T_4= ration containing 75% of SBM substituted by PKBM; T_5= ration containing 100% SBM substituted by PKBM.

Table 2. Chemical composition of treatment diets containing different proportions of kidney bean as a replacement for soybean meal.

Chemical composition	Treatments				
	T_1	T_2	T_3	T_4	T_5
DM (%)	92.24	92.10	91.96	91.82	91.68
CP (%DM)	17.20	16.91	16.62	16.33	16.03
EE (%DM)	5.97	5.87	5.77	5.68	5.58
Ash (%DM)	5.69	5.75	5.81	5.88	5.94
CF (%DM)	7.38	7.34	7.31	7.28	7.25
Ca (%DM)	3.30	3.29	3.29	3.28	3.28
P (%DM)	0.32	0.32	0.31	0.31	0.31
ME (Kcal/kg)	2868.53	2868.27	2868.01	2867.75	2867.49

DM = Dry matter; CP = Crude protein; EE = Ether extract; CF = Crude fiber; Ca = Calcium; P = Phosphorus; ME = Metabolizable energy; Kcal = kilo calorie; kg = kilo gram; Kb = kidney bean; SBM = Soybean meal; T_1= ration containing 0% PKBM; 100% SBM (control); T_2= ration containing 25% of SBM substituted by PKBM; T_3= ration containing 50% of SBM substituted by PKBM; T_4= ration containing 75% of SBM substituted by PKBM; T_5= ration containing 100% SBM substituted by PKBM.

Table 3. Fertility and hatchability of eggs of White Leghorn chicken fed diets containing different proportions of processed kidney bean meal as a replacement for soybean meal.

Parameters	Treatments					*pr*>F	SEM
	T_1	T_2	T_3	T_4	T_5		
Fertility (%)	95.56	91.11	95.55	91.11	91.11	0.78	3.22
H/on fertile egg basis (%)	86.67	87.73	93.18	90.29	92.78	0.86	4.50
H/on total egg basis (%)	86.67	80.00	88.89	80.00	84.44	0.66	4.38
Early E.M (%)	5.13	7.32	4.76	7.32	7.93	0.94	2.88
Mid E.M (%)	2.56	4.94	2.38	4.76	2.22	0.93	2.62
Late E.M (%)	4.44	4.94	2.22	4.94	2.22	0.91	2.51
Pip mortality (%)	2.56	2.38	2.22	2.38	2.78	0.99	2.14

PKB= processed kidney bean; SBM= soybean meal; T_1= ration containing 0% PKBM; 100% SBM (control); T_2= ration containing 25% of SBM substituted by PKBM; T_3= ration containing 50% of SBM substituted by PKBM; T_4= ration containing 75% of SBM substituted by PKBM; T_5= ration containing 100% SBM substituted by PKBM.

Table 4. Effects of different proportion of processed kidney bean meal as a replacement of soybean meal in White Leghorn layers ration on chick quality measurements.

Parameters	Treatments					*pr*>F	SEM
	T_1	T_2	T_3	T_4	T_5		
Chick weight (g)	34.20	33.33	33.00	32.87	32.90	0.63	0.59
Chick length (cm)	16.21	16.57	16.39	15.67	16.32	0.31	0.25
Chick visual score (%)	97.78	97.44	97.62	97.22	97.62	0.99	2.14

cm = centimeter, g = gram; % = percent; PKBM = processed kidney bean meal; SBM= soybean meal; T_1= ration containing 0% PKBM; 100% SBM (control); T_2= ration containing 25% of SBM substituted by PKBM; T_3= ration containing 50% of SBM substituted by PKBM; T_4= ration containing 75% of SBM substituted by PKBM; T_5= ration containing 100% SBM substituted by PKBM.

stages of development among the treatments. Hocking et al. (2002) reported that the embryonic mortality of eggs of the breeder hens' fed with low protein was higher than that of hens fed on high protein diets. Similar mortality rates in the current study would probably thus be associated with similar concentration of nutrients such as CP.

The visual scores of chicken is presented in **Table 4**. Wald chi-square statistics indicated that visual scoring of chicken was not significant (*pr*>*chisq* 0.641 α=0.05). The only minor problems observed were deformed legs and toes which were not firm and straight in some of the chicks across the treatment indicating that the problem is not related to feeding treatment. Such cases were also reported in previous studies and attributed to condition encountered in the incubator or the strains used (Raghavan, 1999).

The weight and length of chick is presented in **Table 4.** There was no significant difference (p>0.05) among treatments in chick weight and chick length. Chicks with better yolk utilization will develop more body mass during the incubation period, and therefore grew longer (Meijerhof, 2006). Meijerhof (2005) reported that chick length to be a more practical way to measure chick development, and chick length and has been reported to have a positive correlation with performance. Therefore, increasing the proportion of PKBM as a replacement for soybean meal in chicks ration do not have a significant effect on chick length and chick quality, indicating similar effect of the two dietary ingredients on the performance of layers. Petek et al., (2009) classified length intervals into short, middle and long for day old chicks. According to the author, broiler chick with a length of <18, 18-18.3 and >18.3 cm and layer chick with a length of <17.8, 17.8-18.2 and >18.2 cm respectively are grouped as short, medium and long chicks, respectively. According to this classification, length of chicks in all treatments falls within short category.

CONCLUSION

Substitution of PKBM for SBM had no significant (p>0.05) effect among treatments on fertility, hatchability, embryonic mortality, chick weight, chick length, and chick visual score. Thus, PKBM can be fully substituted with SBM in layers ration when price of SBM is very high, and scarcity of SBM is occured. Since the highest soybean in the ration to only 100g/kg in the present study, substitution at higher level per kg should be evaluated in order to know the maximum level of kidney bean in layers ration.

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