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Full Length Research Paper

Effect of replacing soybean meal (*Glycine max*) with kidney bean (*Phaseolus vulgaris*) on egg quality parameter of white Leghorn layers

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An experiment was undertaken in Haramaya University to find out the effect of replacing Soybean meal (SBM) by processed kidney bean (PKB) on egg quality parameters. To carry out the experiment, 180 white leghorn hens of similar initial body weight of 1121.17 g ± 24.92 and 6.5 months of age and 30 cocks were randomly distributed into five treatments using complete randomized design (CRD). Each treatment consisting 12 layers and 2 cocks was replicated three times. PKB replaced SBM at a rate of 0 (control), 25, 50, 75 and 100% for T1, T2, T3, T4 and T5, respectively. The optimum amount of biological and economic level of SBM (26%) recommended in layers' ration in the Haramaya University poultry farm was used as a basis of replacement. Three eggs per replicate or 9 eggs per treatment were collected every two weeks to assess egg shell weight, shell thickness, albumen weight and height, Haugh unit and egg yolk weight and color. All qualitative egg quality parameters were analyzed by general logistic regression model while all quantitative egg quality parameters were analyzed by general linear model. The results showed no significant eggshell weight, albumin height, albumin weight, yolk height, yolk weight, and yolk diameter and yolk index among treatments. Yolk color of the layers fed T5 was significantly yellow compared to groups offered T1 and T2. It is concluded that PKB can replace SBM up to 75% (195 g/kg) without adverse effect on egg quality.

Key words: Egg weight, egg yolk, Haugh unit, shell thickness, yolk color

INTRODUCTION

The demand for animal protein for human nutrition in the developing world is high due to the increase in population and the wide speared malnutrition (OECD-FAO, 2010). Animal production, particularly poultry play a major role in bridging the protein gap and food deficiency in developing countries where average daily consumption is

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far below recommended standards (Onyimonyi et al. 2009; OECD-FAO, 2010).

However, the productivity of animals in the developing regions is low. Hence, there is poor animal protein intake (Alli-Balogun et al. 2003). The contribution of intensive commercial poultry industry to the supply of poultry meat and eggs in most developing countries in general and in Ethiopia in particular, has been very low. The overall per capita consumption of egg and meat in Ethiopia is about 0.12 and 0.14 kg, respectively (USAID, 2010) and their contributions do not exceed 2 to 3% of the total animal protein consumption in the country (Alemu et al., 2009).

The profit from poultry production can be attained by minimizing feed cost which accounts for more than half of the total cost of production (Girma et al., 2012). Within the poultry industry, 75 to 80% of the total cost of production is attributed to feed costs. Of this, nearly 30% is due to supplying protein in the ration (Coon, 2002). Protein sources are especially limiting factors in poultry feed production in the tropics (Atawodi et al., 2008). Diseases, poor feeding, management practices, limited quantity and quality of standard feed are the major constraints limiting poultry production in Ethiopia (Taddelle et al., 2000). However, soybean production in the country is low and the price of the grain as well as the cake is extremely high.

It is suggested that evaluation and nutritional characterization of alternative protein ingredients that are locally available and relatively affordable to improve commercial poultry production and increase its efficiency is an urgent requirement (Kamalzadeh et al., 2008; Nalle et al., 2010; Ani and Okeke, 2011). Kidney bean is one of the neglected tropical legumes that can be used to fortify cereal-based diets. Elsewhere, it is a potential component of diets of pigs and poultry, because of its high protein content, energy and amino acids content that is similar to that of soybean except for a content level of methionine (Laurena et al., 1991; Okaka et al., 1992). However, this legume contain various biologically active compounds usually referred as anti-nutritional factors (ANFs) that may lead to reduced nutritive value compared to the predicted when consumed by animals and humans. Even though ANFs limit the use of raw kidney bean, various processing techniques reduce the effects. Several studies have indicated that heat processing (cooking and dry heating) increases the digestible nutrients available to young animals, especially chicken resulting in improved growth (Emiola and Ologhobo 2006). Despite the importance of PKB; in Ethiopia there is limited research so far undertaken on the effect replacement of SBM with kidney bean meal in white leghorn layer diets. To date, there is only one work that suggests 100% replacement of kidney bean for soybean (Sisay et al., 2015a). But this work was based on 10% (100 g/kg) of soybean, which is lower than the percentage of SBM in layers' diet to meet the requirement for high production. Therefore, this experiment was carried out to assess the effect of replacment of SBM with PKB on egg quality.

MATERIALS AND METHODS

Ingredients and experimental rations

The experiment was carried out at Haramaya University Poultry Farm, Ethiopia that located at 42° 3' E longitude, 9° 26'N latitude and situated at an altitude of 1980 m above sea level. The area receives mean annual rainfall of 780 mm and average minimum and maximum temperatures 8 and 24°C respectively (Samuel, 2008). Corn grain (CG), wheat short (WS), soybean meal (SBM), noug seed cake (NSC), processed kidney bean (PKB), vitamin premix, limestone, and salt were used to formulate experimental diets.

To treat anti- nutritional factors, the kidney beans were cleaned, soaked in water for five hours, boiled for 1 hour at 100°C and dried under the sun until it is quite enough for grinding (Emiola et al.,2007; Sisay et al., 2015b). Firewood used as a source of heat energy. The temperature during boiling was roughly maintained at 100°C by adding or removing the wood into and out of fire by using thermometer to keep temperature roughly at 100°C. Corn grain, SBM, NSC, and PKB were ground to pass through a 2mm sieve before formulating the treatment rations at Haramaya University feed milling unit. Representative samples of CG, SBM, NSC and PKB were taken for chemical analysis before formulating the actual dietary treatments. The nutrient contents of each feed ingredient [dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), metabolizable energy (ME) and ash] were determined following the procedure of the AOAC (1990) were used to formulate the rations (Table 1). The experiment had five diets in which PKB replaced SBM at a rate of 0, 25, 50, 75 and 100% for T1, T2, T3, T4 and T5, respectively. The formulated diets contained 2800 to 2900 Kcal metabolizable energy (ME) per Kg of dry matter (DM) and 16 to 16.5% crude protein (CP) as recommended for layers (Leeson and Summers, 2001).

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Management of experimental animals

The experimental house was partitioned into 15 pens with wire-mesh and covered with grass litter material of 10 cm depth. Before the commencement of the actual experiment, the experimental pens, watering equipments, feeding troughs and laying nests were disinfected, sprayed against external parasites and thoroughly cleaned. The birds were vaccinated against common poultry diseases. Initially 180 white leghorn layers and 30 cocks of mature white leghorn breeds of similar age (6.5 months) and weight (1121.17 g ± 24.92), obtained from the University's poultry farm, were randomly assigned to the five dietary treatments as indicated in Table 1. Twelve layers and 2 cocks per treatment were assigned to five treatments. In a completely randomized design (CRD), each treatment was replicated three times.

Data collection and measurement

Egg quality parameters

Egg quality parameters were measured for each replicate. Three eggs per replicate were randomly sampled every two weeks for quality analysis. The total eggs used for quality analysis were 225 eggs (45 eggs per treatment). The sampled eggs were weighed and broken on flat mirror to examine shell thickness, shell weight,

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

Feed (%)	Treatments				
	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 cakeLs = lime ston; VPM = vitamin premix; 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.

yolk diameter, yolk index, yolk color, yolk weight, yolk height, albumen weight and albumen height.

Egg shell, shell weight and shell thickness

The sampled eggs were broken and the shell was separated. The weight of the shell was measured by using sensitive balance. The shell was further broken into parts, the shell membrane manually removed, and the thickness at the pointed, blunt ends and middle of the egg were measured using a micrometer gauge. The mean value of the three measurements was taken as shell thickness of the eggs.

Albumin

Haugh unit (HU) is a measure of albumen quality (Keener et al.,2006). The albumen of the broken eggs was carefully separated from the yolk. Tripod micrometer was used to measure the albumen height. Albumen weight was measured by using sensitive balance. The HU was calculated by employing the following formula (Raji et al.,2009).

$HU=100 \log (H + 7.5 - 1.7W^{0.37})$

Where, HU = Haugh unit, H = height of albumen and W = egg weight (grams) (Raji et al.,2009).

Yolk

After the separation of the yolk and albumen, yolk diameter and height were measured by tripod micrometer. Yolk weight was measured by using a sensitive balance. Yolk index was calculated as the ratio of yolk height to yolk diameter and the result was expressed as a percentage. After removing yolk membrane and taking yolk height, yolk weight, yolk diameter all yolk part was mixed. Then the yolk sample was placed on a piece of white paper and yolk color determined on Roche fan measurement strips as a color reference. The instrument has 1 to 15 strips representing pale to orange-yellow color (Vuillemiler, 1976).

Statistical analysis

Data on yolk color was analyzed by logistic regression; and all other parameters were statistically analyzed using the general linear model procedure of SAS 2008 version 9. 1. Differences between treatment means were separated using least significance difference (LSD). The general logistic regression model used was given as:

$$lan \left\{ \frac{\Pi}{1ne} \right\} = \beta0 + \beta1 * (x)$$

Test H_0, No treatment effect (that is, $\beta1 = 0$) vs. H_A, significant treatment effect ($\beta1 \neq 0$); β = slope, X = treatment.

RESULTS AND DISCUSSION

Nutrient composition of ingredients and the treatment

The results of the chemical analysis of ingredients used and nutritional composition of the diet for each treatment are given in Tables 2 and 3, respectively. The DM contents of PKB obtained in this study was slightly lower than reported by Marzo et al. (2002) (93.2%) and Audu and Aremu (2011) (96.8) but similar with Sisay et al. (2015a) (88.00) while CP contents were slightly higher than reported by Marzo et al. (2002), Audu and Aremu (2011), Emiola (2011), Sisay et al., (2015b) and Emiola and Ologhobo (2006) which were 20.9, 23.6, 24.7, 25.8 and 26.8%, respectively. The EE content of kidney bean was the same as that reported by Emiola (2011) while Sisay et al. (2015a) reported higher (4.69) content and the CP was higher than reported by Marzo et al. (2002). The CF content of kidney bean used in this study was comparable to that reported by Arija et al. (2006), Emiola (2011), Sai-Ut et al. (2009), Audu and Aremu, (2011) who reported 5.1, 5.0, 6.0, and 4.7%, respectively. The result of chemical composition of kidney been used in the

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

Feed type	Nutrient composition (% for DM and % DM for others)					
	DM	CP	EE	CF	Ash	ME kcal/kg
CG	89.5	8.7	4.3	8.0	6.21	3230.5
WS	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 3. Nutritional composition of treatment diets containing different levels of processed kidney bean as a replacement for soybean meal.

Treatments	Nutrient composition (% for DM and % DM for others)							
	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.

present experiment showed comparable ME contents to that of 3342.2 and 3365 kcal/kg, reported by Ofongo and Ologhobo (2007) and Arija et al. (2006) respectively.

Quality of eggs

Shell weight and shell thickness

The shell thickness and shell weight means are presented in Table 4. Eggshell weight of hens fed PKB as a replacement for SBM was not significantly (P>0.05) different. However, the shell thickness of the layers fed control diet (no PKB) was significantly (P<0.05) lower compared to diet in which PKB fully replaced SBM which contrasts Sisay et al., (2015b) report that there is no (p>0.05) difference among treatments in egg shell thickness. This could be an attribute of egg sizes, since calcium content is not much different in magnitude between the treatments. In this case, the available calcium should be spread across the surface of the egg, thus the egg with large size tend to have a thinner eggshell. In agreement with the present finding, Butcher and Miles (2003) and Rajkumar et al. (2009) reported that smaller eggs have stronger shells than larger ones, since the limited amount of calcium needs to be deposited over all part of the shell evenly. In contrast to this finding, Gernat (2001), Iyayi and Taiwo (2003), Kwari et al. (2011) and Gheisari et al. (2011) replaced shrimp meal, mucuna seed meal and sorrel seed meal for soybean meal at different level as protein sources and found no significant effect on shell thickness.

Albumin weight, height and haugh unit

As shown in Table 4, there was no significant difference (P>0.05) in albumen weight and height, but Haugh unit (HU) of layer fed control diet was significantly (P<0.01) lower than hens fed diet containing PKB as a substitute for SBM. The difference in HU might be related to the decrease in the magnitude of the value of albumin height and increase in egg weight of the hens in the control group. Albumin height and egg weight have a direct and indirect contribution for the HU values, respectively in which the increase in albumin height increase the he HU and the increase in egg weight decrease HU. This is in line with the result demonstrated by Suk and Park (2001) that albumen weight is positively associated with egg weight and that of Mousavi et al. (2013) who reported independence of HU and albumen height from dietary CP level. Wu et al. (2007) Related HU to nutrients and stated that the HU of hens fed higher nutrient density was significantly lower than that of hens fed lower nutrient densities, probably because of the higher egg weight of hens fed the high nutrient density. Though HU is

Table 4. Egg quality parameters of white leghorn layer fed diet containing different levels of processed kidney bean as replacement for soybean meal.

Parameter	Treatments						
	T1	T2	T3	T4	T5	SEM	SL
Sample egg weight(g)	50.26	50.20	52.33	49.50	48.33	1.41	NS
Shell thickness (µm)	0.31[b]	0.32[ab]	0.34[ab]	0.35[ab]	0.36[a]	0.008	*
Shell weight (g)	5.93	5.50	5.67	5.60	5.53	0.20	NS
Albumen weight (g)	28.80	28.40	28.57	28.60	29.0	1.02	NS
Albumen height (µm)	8.33	8.20	8.40	8.50	8.97	0.14	NS
Haugh unit	86.10[b]	93.0[a]	93.0[a]	93.4[a]	91.5[a]	1.06	**
Yolk weight (g)	14.40	15.00	14.07	14.53	14.73	0.28	NS
Yolk height (mm)	15.4	15.00	14.80	15.20	15.67	0.28	NS
Yolk diameter (cm)	3.73	3.86	3.93	3.60	3.37	0.07	NS
Yolk index (mm)	3.80	3.77	4.07	4.20	4.27	0.01	NS
Yolk color	2.33[c]	2.43[bc]	2.97[ab]	3.00[ab]	3.07[a]	0.18	*

[a-c]Mean values in the same row without common superscripts are significantly different; * = Significant (P< 0.05); **= highly significant (P<0.01); NS = Non-significant; SL = significant level; SE = standard error of mean; PKB = processed kidney bean; SBM = soybean meal; T1 = 100% SSBM:0% PKB);T2 = 75%SBM:25%PKB; T3 = 50%SBM:50%PKB; T4 = 25%SBM:75%PKB; T5 = 0%SBM:100PKB.

Table 5. The frequency of yolk color of layers fed processed kidney bean as a replacement to soybean meal on Roche color fan number reading.

Treatments	Roche color fan numbers						
	1	2	3	4	5	6	Total
T1	11	17	9	7	1	0	45
T2	9	18	10	6	2	0	45
T3	8	10	12	11	3	1	45
T4	5	10	16	9	5	0	45
T5	5	11	10	15	4	0	45
Total	38	66	57	48	15	1	225

PKB = processed kidney bean; SBM = soybean meal; T1 = 100% SBM: 0% PKB; T2 = 75%SBM: 25%PKB; T3 = 50%SBM: 50%PKB; T4 = 25%SBM: 75%PKB; T5 = 0%SBM: 100PKB.

significant, it is within the recommended range (81.0 - 93.4) in all treatments, which implies no quality differences in egg between treatments. This concurs with the previous reports of Lewko and Gornowicz (2009) who reported a range of 70-100 for HU as an indication of good quality eggs.

Yolk height, weight, diameter and index

There was no significant (P>0.05) difference among dietary treatments in yolk height, weight, diameter and index (Table 4), this in agreement with Sisay et al. (2015a) finding. There is no any obvious trend in magnitude exhibited in these parameters indicating no significant relation with the amount of PKB included in the diet. Nutrition does not contribute directly to the yolk height, weight, diameter, and yolk index, but is influenced by the weight of the egg, which is dependent on the nutrients consumed by the birds. Since high egg weight was not observed among treatments, variations in yolk traits were also not observed among treatments. The present finding are in agreement with those of Kaya et al. (2011) who did not detect any difference among yolk height, weight and yolk index by substituting common vetch for SBM at different proportions.

Yolk color

The yolk color of the birds in T4 was significantly (P<0.05) different from the birds in T1 and T2 similar to that of the birds fed T3 and T4. The Roche color fan reading of the eggs were within the range of 1 to 6, in which the majority of the eggs had readings of two (29.3%), three (25.3%), four (21.3%), one (16.9%), five

(6.7%) and six (0.4%) on percentage basis on Roche color fan (Table 5). Similarly the logistic regression results for yolk color showed significant difference (pr>chisq <0.0001 at α = 0.05) with Wald chi sq value of 85.2 among the treatments (Appendix Table 1). Furthermore logistic regression contrast rows estimation and testing results of yolk color in T 4 and T5 revealed that the improvement in yolk color as compared to group fed T1 and T2 (Appendix Table 2). The odd ratio value of T1 vs. T5, T2 vs.T5, T3 vs.T5 and T4 vs. T5 shows yolk color of T1, T2, T3 and T4 is one -third, two -fifth, three-fourth and seven -eighth as yellow as that of T5 respectively. This showed that the improvement of yolk color of the eggs increased with the level of PKB, which implies the richness of PKB in the beta- carotene compared to SBM. This agrees with that of Hassan (2013) who obtained more yellowish yolk than control diet as a result of incorporation of guar meal in the diets of layers. Contrary to this finding, Kaya et al. (2011) observed no difference in yolk color when Raw and Processed Common Vetch Seed (*Vicia sativa*) replaced SBM at 25%. Laudadio and Tufarelli (2010) Reported reduction in yolk color from 12.22 to 11.78 by feeding faba beans compared to SBM. The overall current study shown that the replacement of SBM by PKB has no any impact on all egg quality parameter as those indicating significant value is even within a range of quality egg, indicating that valuable replacement for both internal and external egg quality parameter.

Conflict of Interests

The authors have not declared any conflict of interests.

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Appendixes

Table 1. Logistic regression result of yolk color.

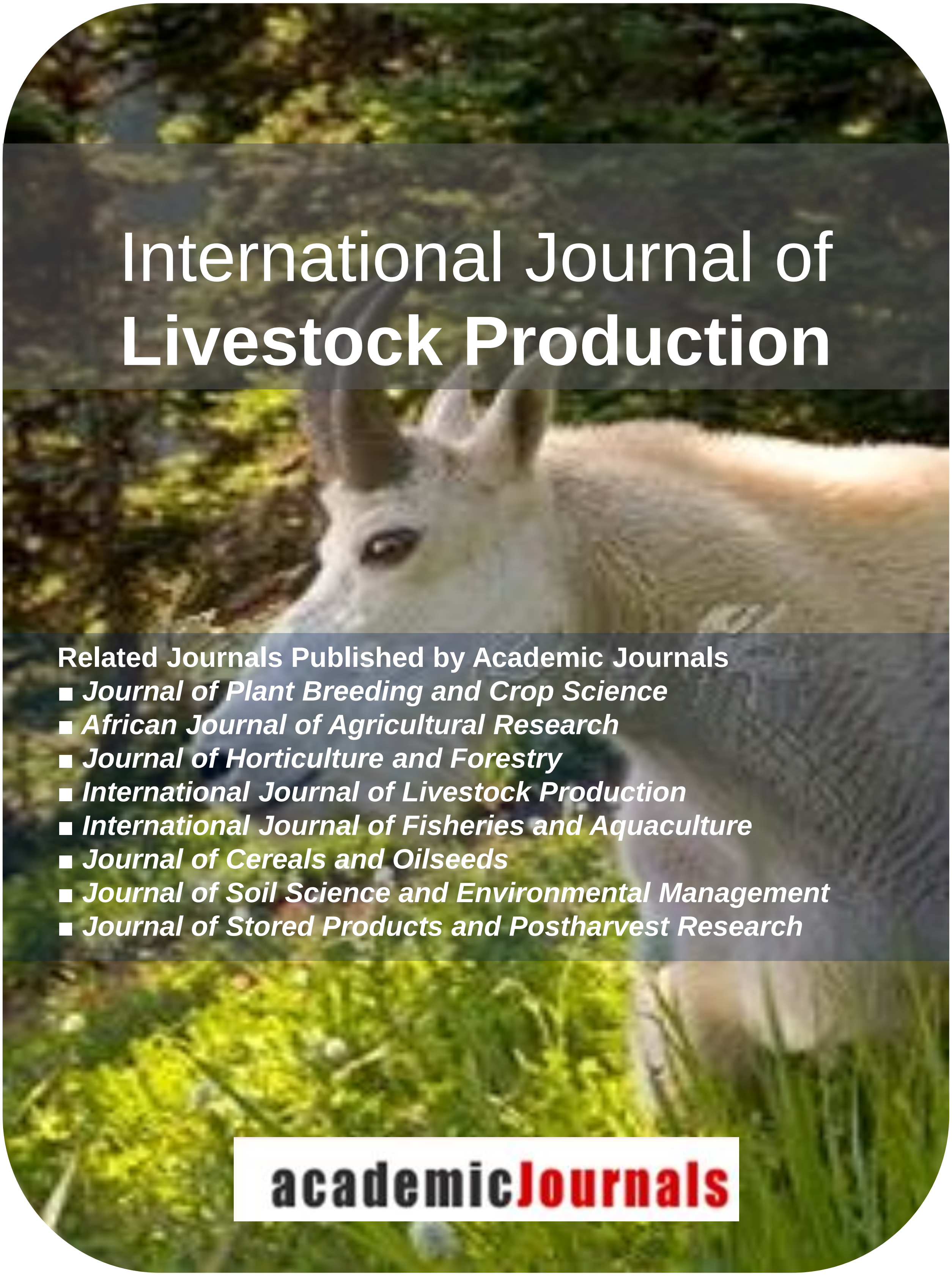
Parameter	Wald		
	DF	chi-square	pr>hiSq
Yolk color	4	85.2	<0.0001

DF= degree freedom; Pr= probability; ChiSq= chi-square.

Table 2. Logistic regression contrast rows estimation and testing results of yolk color of white leghorn hens fed different levels of processed kidney bean as replacements for soybean meal.

Parameter	Row	Estimate	Standard error	confidence	Limits	Wald Chi sqr	Pr> chi Sq
Trt 1 vs 2	1	-0.1359	0.3790	-0.8788	0.6071	0.1285	0.7200
Trt 1 vs 3	1	-0.8087	0.3809	-1.5554	-0.0621	4.5069	0.0338
Trt 1 vs 4	1	-0.9881	0.3824	-1.7376	-0.2386	6.6772	0.0098
Trt1 vs 5	1	-1.1189	0.3837	-1.8709	-0.3669	8.5037	0.0035
Trt 2 vs 3	1	-0.6729	0.3795	1.1467	0.7010	3.1434	0.076
Trt 2 vs 4	1	-0.8552	0.3808	-1.5985	-0.1060	5.0098	0.0252
Trt 2 vs 5	1	-0.9830	0.3819	-1.7316	-0.2344	6.6245	0.0101
Trt 3 vs 4	1	-0.1794	0.3763	-0.9170	0.5582	0.2272	0.6336
Trt 3 vs 5	1	-0.3102	0.3760	-1.0485	0.4282	0.6778	0.4103
Trt 4 vs 5	1	-0.1308	0.3763	-0.8684	0.6068	0.1208	0.7282

Trt= treatment; vs= verses.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