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Effect of Dietary Inclusion of Soybean Hulls in the Diet on Feed Proximate Analysis, Egg Quality Parameters and Economics during Peak Egg Production Stages in Laying Hens

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ABSTRACT

The study was designed to determine the effect of varying levels of soybean hulls inclusion in the diet of brown layer on, feed proximate analysis, egg quality, and economies during peak egg production period with different phases (phase-1=week 29 to 32, phase-2=week 33 to 36, and phase-3=week 37 to 40). One hundred and sixty golden misri (Brown) laying hens of age 28 weeks were sourced and reared for 40 weeks. There were 4 groups with 4 replicates per group containing 10 birds each. Corn-soybean meal diet (Basal Diet) was offered to the control group (A), while groups B, C, and D were fed the basal diet with 3, 6, and 9 % soybean hulls (SH) respectively. Results showed higher($P<0.05$)crude fiber, ash, cellulose, and hemicellulose content for diets containing soybean hull (SH) at 3, 6, and 9% compared to the basal diet. Egg weight and egg quality parameters during different phases were not affected among the treatment groups. Total revenue and profit during all phases (phases 1, 2, and 3) while cost-benefit ratio during phase-1 and 2 were recorded significantly higher for the control group than all other treatment groups.It is concluded that the effect of different levels of soy hulls in diet did not affect egg weight and egg quality parameters during different phases but economic parameters were significantly higher ($P<0.05$) amount in the control group than all soybean hull treatment groups. Among soybean hulls groups, 3% and 6% SH group showed better results than 9%SH group.

INTRODUCTION

Soybean hulls, also known as soybean flakes, are the byproducts of the soybean milling industry. The chemical composition of soybean hulls may vary because of the efficiency of the de-hulling process (Rojas *et al*., 2014), and thus the soybean hulls may contain varying amounts of celluloses (29-51%), hemicelluloses (10-25%), proteins (11-15%), lignin (1-4%), and pectins (4-8%) (Mielenz *et al*., 2009). Cellulose, hemicellulose, and lignin amount of Soybean bean were recorded to be 48%, 24%, and 6% on a dry matter (DM) basis, accordingly (Neto *et al*., 2013). Soybean hull has an estimated feeding value of 74-80% of maize when incorporated in moderate to high quantities in maize-based finisher diets (Esonu, 1998). Fibrous feedstuffs in different poultry species' diets can be used at 3 to 5% without causing any negative effects on nutrient digestibility or growth performance (Cao *et al*., 2003; Sklan *et al*., 2003; Amerah *et al*., 2009; Jimenez-Moreno *et al*., 2009). Gonzalez-Alvarado *et al*. (2010) described that soy hulls (SH), oat hulls, rice hulls, and sunflower hulls are the sources of insoluble fiber that can affect nutrient utilization and live performances in broilers.The high fiber content of soybean hull is likely its limitation in poultry diets, yet (Van Soest, 1985) revealed that soybean hull is a case of no genuine lignifications. Soybean hulls are widely used these days, particularly for the welfare of laying, breeding, and feed restriction

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programs (Esonu *et al*., 2005).Laying hens produced eggs at a cheaper cost when fed 20% soybean hulls, which was increased to 30% with the addition of cellulolytic enzymes without impacting the birds' performance (Esonu *et al*., 2010). The use of crop leftovers in animal feed adds value to these products while reducing their environmental contamination potential. It may also be an alternative for the partial substitution of corn and soybean meal in non-ruminant diets. The growing number of processing units (mills) provides animal farmers with some confidence that soybean hulls will be available at a low cost.

Because of the growing concern about the environmental impact of egg production, nutritionists must face the problem of developing diets with alternative feedstuffs and lower protein levels, contributing to lower nitrogen excretion while preserving layer performance. Increasing the efficiency with which dietary protein and amino acids are utilized may allow for the adequate supply of nutritional requirements for chicken, regulate egg output, and reduce environmental pollution by lowering nitrogen excretion as well as production costs (Praes *et al*., 2014). Therefore, this research aimed to determine how fiber-rich feedstuffs with low crude protein levels affect the chemical composition of feed, egg quality, and economics in golden misri (brown) laying hens during peak egg production stages.

MATERIALS AND METHODS

Availability of experimental diets

The experiment was approved by the ethical committee of the Faculty of Animal Husbandry and Veterinary Science, The University of Agriculture Peshawar, Pakistan. Four types of experimental feed were prepared by Sadiq Brother Company, Rawalpindi. A control group containing basal diet (corn-soybean meal), while 3% SH, 6% SH, and 9% SH groups were formulated by replacing soybean meal in the basal diet with 3, 6 and 9 soybean hulls (SH), respectively. he chemical composition of the experimental diets are shown in Table I.

Housing and experimental birds

A total of 160, 28-week old Golden Misri (Brown) laying hens were distributed in a complete randomized design with 4 dietary treatments and 4 replicates of 10 birds each. All the birds were reared together in cages from 29 weeks up to the age of 40 weeks. All the birds in the experimental house were given the same environmental and management circumstances. The experimental diet was fed to birds in three phases i.e. week 29 to 32, week 32 to 36, and week 37 to 40. Each cage was equipped with one drinker and one feeder, providing *ad libitum* access to water. Routine vaccination schedules and uniform environmental and management conditions were provided to all birds in the experimental house.

Proximate analysis of feed

Proximate analyses were performed for feed samples. It was properly thawed and mixed to create a homogenous representative sample and then air-dried in an oven at 60°C for 3 days. The diet samples were ground in Thomas-Willey mill up to 1 mm particle size. According to the procedure laid by (AOAC, 2000) feed samples were subjected for the proximate analysis of dry matter (DM), crude protein (CP), crude fiber (CF), fat, ash, moisture, nitrogen-free extract (NFE).

Cellulose and hemicellulose

Cellulose and hemicellulose contents of the feed samples were determined by the gravimetric method explained by Augustine *et al*. (1989).

Egg quality traits

From each replicate four eggs weekly (a total of 64 eggs from 16 replicates) were randomly collected to determine egg quality parameters. Digital balance was used to determine egg weight and shell weight of individual marked eggs from each group. A screw gauge without zero error was used for the calculation of shell thickness (without shell membranes) at different places and averaged. First, the albumen and yolk were removed, and then in an incubator, the eggshell was dried off for a night, and then the digital balance was used to determine the egg shall weight. Egg yolk weight was determined using (Islam *et al*., 2021) method. The height of albumen was recorded by using a transparent plastic rod and compared with a ruler. The albumen weight of the eggs was calculated with digital balance. Haugh unit shows the height of egg white and was determined using (Silversides *et al*., 1993) method.

Economics parameters

Total revenue (TR) was calculated using the formula e.g. TR = total eggs produced × price per egg. Profit was calculated with the formula e.g. Profit= total revenue - total cost, while cost-benefit ratio (CBR) was determined by the formula e.g. CBR=total revenue / total cost.

Statistical analysis

Data were analyzed through analysis of variance (ANOVA) under a general linear model using randomized design with SPSS 21.0 (SPSS Inc., Chicago, IL). Means were separated for the significant difference using the Tukey test. The pen was considered as an experimental unit. P-Value less than 0.05 was considered statistically significant.

Table I. Experimental diet compostion.

Nutrient	Control	Soybean hull		
		3%	6%	9%
Corn meal (%)	53.12	53.18	50.9	48.46
Canola meal (%)	4.0	4.0	4.0	5.0
Soybean meal (%)	24.34	23.28	22.56	21.84
Guar meal (%)	1.0	0	0	0
Soybean hull (%)	0	3.0	6.0	9.0
PBM Hi fat (%)	2.0	1.02	1.02	0
Poultry oil/Fat (%)	2.79	2.79	2.79	2.97
Salt (%)	0.32	0.32	0.32	0.32
Sodium bicarbonate/Soda (%)	0.1	0.10	0.1	0.1
Limestone/Chips (%)	11.19	11.19	11.19	11.19
DCP (%)	0.77	0.77	0.77	0.77
DLM (%)	0.08	0.08	0.08	0.08
Choline chloride (%)	0.1	0.1	0.1	0.1
Vitamin premix[1] (%)	0.07	0.07	0.07	0.07
Mineral premix (%)	0.06	0.06	0.06	0.06
Phytase (%)	0.01	0.01	0.01	0.01
Enramycin (%)	0.02	0.02	0.02	0.02
Ethoxyquin/antioxident (%)	0.01	0.01	0.01	0.01
NSPs (%)	0.02	0	0	0

[1]To provide one kg of diet: Retinylacetaste, 4400 IU; DL-α-tocopheryl acetate, 12 IU; Cholecalciferol, 118µg; Thiamine, 2.5mg; Menadione sodium bisulphite, 2.40 mg; Niacin, 30mg; vit.B_2, 4.8 mg; D-pantothenic acid, 10 mg; vit. B_6, 5 mg; vit. B_7, 130 µg; Cyanocobalamine, 19 µg; vit. B_9, 2.5 mg; Mn, 85 mg; Zinc, 75 mg; Fe, 80 mg; Iodin, 1 mg; Selenium, 130 µg; Copper, 6 mg.

RESULTS

Effect of varying levels of soy hull on proximate analysis of feed

Results are presented in Table II regarding the proximate analysis of the feed. Dry matter and crude protein remained non-significant among all the groups. The crude fiber was (P<0.05) higher in the 9% group as compared to the control group. Fat % was not affected among all the groups using different levels of soybean hulls. Ash amount was (P<0.05) higher in the 9% SH group compared to the control and 6% SH group. Moisture remained non-significant among all the groups. NFE contents were (P<0.05) higher in Control group than all other groups. Cellulose and hemicellulose contents were (P<0.05) higher in the 9% SH group than control and 3% SH groups.

Egg weight, shell thickness, and shell weight

Results for eggs weight, shell thickness, and shell weight during different phases are shown in Figure 1. Egg weight remained unaffected during all phases among all groups with the use of soybean hulls in different concentrations, however higher egg weight during phase-1 was recorded in the 3% SH group, while during phase-2 in the 6% SH group and in phase-3 in the control group compared to all other treatment groups. Shell thickness remained unaffected in all phases among all groups but higher shell thickness during phase-1 was calculated for the control group, during phase-2 for the 6% SH group, and at phase-3 for the 9% SH group than all other treatment groups. During all phases and among all groups, shell weight was not affected, however 3% SH group during phase-1, 6% SH group at phase-2, and control groups during phase-3 had higher shell weight compared to all other treatment groups.

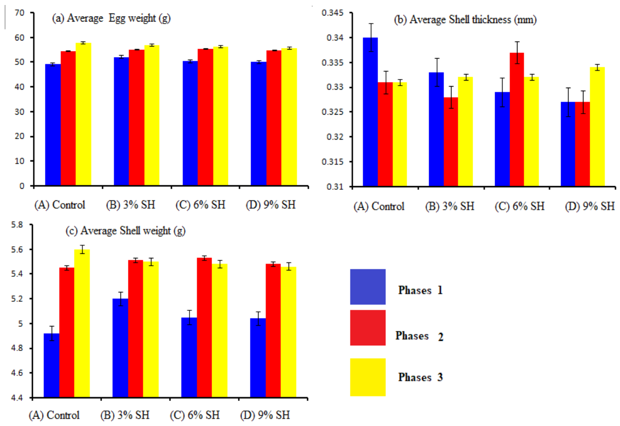

Fig. 1. Effect of dietary inclusion of soybean hull in the diet on egg weight, shell thickness and shell weight during different phases.

Egg yolk weight, albumen weight, and height and Haugh unit

The results regarding yolk weight, Albumen weight,albumen height, and haugh unit of laying hens with the use of soybean hulls at different levels and various phases are presented in Figure 2. Among all groups, egg yolk weight remained unaffected (P>0.05) in phase-1 but higher in the 9% SH group than all other groups. During phase-2 and 3 yolk weight was recorded as non-significant among the treatment groups but the control group had a higher yolk weight compared to all other groups. Egg albumen weight during phase-1 was calculated non-significant among the treatment groups but the 3% SH group had a higher value compared to all other treatment groups. In phase-2 and 3 albumen weight remained non-significant with the use of soybean hulls at various levels but recorded higher for the control group than all other groups. In phase-1 albumen height and haugh remained non-significant due to the use of different levels of soybean hulls, however during phase-1 albumen height and haugh unit value were recorded higher in the control group compared to all other groups. During phase-2, albumen height and haugh unit were not affected (P>0.05) among the treatment groups but higher albumen height and haugh unit value in the 3% SH group than all other groups. The albumen height and haugh unit among all groups during phase-3 were calculated non-significant however,the control group had higher albumen height and haugh unit as compared to all other treatment groups.

Economics parameters

The results regarding the use of soybean hulls at different levels and various phases on the economics of laying hens are presented in Table III. Total revenue and profit during phase-1 were (P<0.05) higher in the control group than that of all other groups while the cost-benefit ratio was (P<0.05) higher in the Control and 3% SH groups compare to 6% SH and 9% SH groups. During phase-2, total revenue, profit, and cost-benefit ratio were recorded (P<0.05) higher in the control group compared to all other treatment groups. Total revenue and profit in phase-3 were higher (P<0.05) in control and 3% SH groups than all other treatment groups while the cost-benefit ratio was recorded as non-significant among the groups.

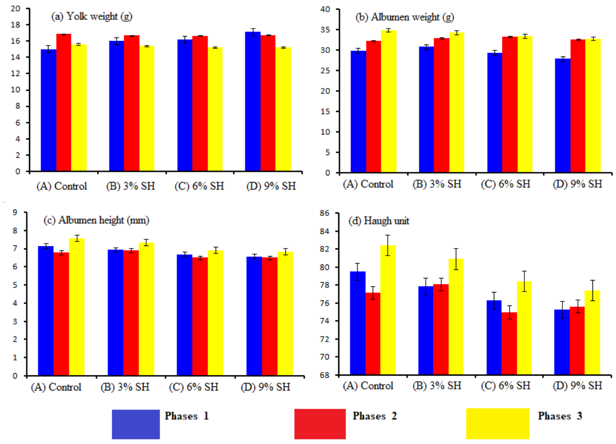

Fig. 2. Effect of dietary inclusion of soybean hull in the diet on egg yolk weight, Albumen weight, albumen height and Haughunit during different phases.

Table II. Proximate analysis of different soybean hull feeds.

Parameters %	Control	3% SH[1]	6% SH	9% SH	P-value
Dry matter	89.49±0.74	90.52±0.72	90.22±0.20	91.01±0.46	0.354
Crude protein	14.62±0.49	15.33±0.35	15.04±0.56	16.67±0.95	0.173
Crude fiber	4.22±0.07[c]	5.64±0.35[b]	5.89±0.61[b]	7.28±0.79[a]	0.012
Crude fat	4.83±0.18	4.65±0.03	4.61±0.25	4.52±0.23	0.163
Ash	14.18±0.35[b]	15.84±0.40[ab]	14.65±0.09[b]	16.89±0.64[a]	0.003
Moisture	10.51±0.74	9.48±0.72	9.79±0.20	8.99±0.46	0.354
Nitrogen free extract	51.63±0.68[a]	49.05±0.70[b]	49.66±1.10[b]	45.84±2.13[c]	0.052
Cellulose	52±0.91[c]	54.5±0.64[b]	55.2±0.85[ab]	57.2±0.83[a]	0.005
Hemicellulose	23.05[c]±0.24	24.74[b]±0.43	25.92[ab]±0.30	26.17[a]±0.10	0.023

Means in the same row with different superscripts are significantly different (P<0.05). [1]SH=Abbreviated for soybean hull.

Table III. Effect of dietary inclusion of soybean hull in the diet on economics during different phases.

Phases	Parameters	Control	3% SH	6% SH	9% SH	P. value
1	Total revenue (Rs)	330.7±1.78[a]	325.5±1.22[b]	319.8±2.15[c]	312±2.20[d]	0.001
	Profit (Rs)	118.4±2.20[a]	114.4±1.69[b]	107.8±3.19[c]	100.4±2.14[d]	0.009
	Cost benefit ratio	1.55±0.01[a]	1.54±9.41[a]	1.50±0.01[b]	1.47±0.01[c]	0.002
2	Total revenue (Rs)	317.2±2.25[a]	307.1±3.14[b]	299.6±1.12[c]	287.6±0.37[d]	0.001
	Profit (Rs)	105.7±1.97[a]	96.6±5.35[b]	90.4b±2.72[c]	81.5±1.04[d]	0.003
	Cost benefit ratio	1.49±0.08[a]	1.46±0.02[b]	1.43±0.02[c]	1.39±0.04[d]	0.010
3	Total revenue (Rs)	304.8±3.20[a]	301.8±1.42[a]	291.3±3.74[b]	279±1.62[c]	0.001
	Profit (Rs)	98.99±4.57[a]	97.91±2.62[a]	90.45±6.28[b]	79.61±2.42[c]	0.026
	Cost benefit ratio	1.48±0.02	1.46±0.01	1.45±0.03	1.43±0.01	0.154

Means in the same row with different superscripts are significantly different (P<0.05).

DISCUSSION

Proximate analysis of feed showed ($P<0.05$) higher crude fiber, ash, cellulose, and hemicellulose value for soybean hull (SH) containing feed groups than control group diet which is due to the different chemical composition of feed soybean hulls. Soybean hulls contain a high amount of crude fiber (cellulose and hemicellulose) (Mielenz *et al*., 2009) which is responsible for an increased quantity of crude fiber, cellulose, hemicellulose, and ash in soybean hulls containing groups diet than control group diet. Egg weight remained unaffected ($P>0.05$) in all phases among all groups with the use of soybean hulls in the diet. Similar to the present study Esonu *et al*. (2005) reported a non-significant effect on egg weight in the layer when fed 10 and 20% soybean hulls in feed. Praes *et al*. (2014) also reported a decrease in egg weight for the control group in the layer as compared to the soy hull-containing diet group. Higher egg weight was calculated during phase-1 and 2 in soybean hull-containing groups which is in agreement with the report of Esonu *et al*. (2010) who described higher egg weight in a group containing 30% soybean hull meal. Shell thickness and shell weight remained unaffected ($P>0.05$) in all phases among all groups with the use of soybean hulls in diet which is in line with the study of Praes *et al*. (2014) who documented non-significant effect for egg shell percentage and thickness in laying hens due to the use of different fiber source (soy hull, rice hull, cottonseed hull), which is explained by the fact that eggshell synthesis requires only a small amount of protein (Neves, 1998). Pavan *et al*. (2005) also did not find any significant differences in the eggshell percentage in brown layers after the peak of lay, fed 14 or 17% crude protein. Lower egg shell thickness during phase-1 and lower egg shell percentage during phase-3 were calculated which is similar to the result of Sousa *et al*. (2019) who recorded lower eggshell percentage and eggshell thickness for birds fed diet with coffee husks as a dietary fiber source.

Egg yolk and albumen weight remained unaffected during all the three phases among the treatment groups due to the use of soybean hull with different levels in the feed of laying hen which is according to the findings of Sousa *et al*. (2019) who described no effect of the fiber sources (soybean hulls, coffee husks, and wheat bran) on egg weight, yolk and albumen percentage in laying hens. Albumen height and haugh unit (HU) during all three phases were not affected ($P>0.05$) due to the soybean hulls inclusion in feed. Similar to the present study result Braz *et al*. (2011) in laying hens did not detect any differences in internal egg quality (Haugh units, eggshell percentage, etc.) fed diets with different neutral detergent fiber (NDF) levels. In support of our study Wang *et al*. (2021) demonstrated that both prime and California-type hulls can be fed to laying hens at dietary inclusion up to 15% without negative effects on egg quality. Egg production and quality were not affected in hens fed with high-fiber diets (Deaton *et al*., 1977; Roberts *et al*., 2007; Azizi and Moradi, 2017). Wang *et al*. (2021) also receded no effect of the prime and California types of hulls in different levels on egg weight, yolk and albumen weight, egg specific gravity, haugh unit, shell weight, and shell thickness in laying hens. The values recorded for internal characteristics of the egg were in line with the report for normal fresh eggs (Emenalom, 2001; Esonu *et al*., 2004; Dongmo and Fomunyam, 2005). Total revenue, profit, and cost-benefit ratio during different phases were recorded higher for the control group which is due to higher egg production as compared to the soy hull containing different groups. Gonzalez-Alvarado *et al*. (2010) had also described that soy hulls (SH), oat hulls, rice hulls, and sunflower hulls are the sources of insoluble fiber that can affect nutrient utilization and live performances in broilers.

CONCLUSION

The use of soybean hulls topartially replace soybean meal in feed with different levels did not affect the egg quality parameters. The Control group showed better economic parameters than all soybean hull groups while among soybean hull groups, 3% and 6% SH groups showed better results in terms of economics compared to the 9% SH group. Fiber type and level of inclusion play an important role in controlling the growth and production performance of the birds andsoybean hulls are the source of soluble fibers (i.e., pectin's, etc.) which increase the viscosity of the gut and result in low performances of the birds. Further research is needed to understand how different fiber components at different life periods affectlaying hens' performance from a physiological and nutritional viewpoint and this will produce economical diets using low price fibrous feedstuffs for poultry production.

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Statement of conflict of interest

The authors have declared no conflict of interest.

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