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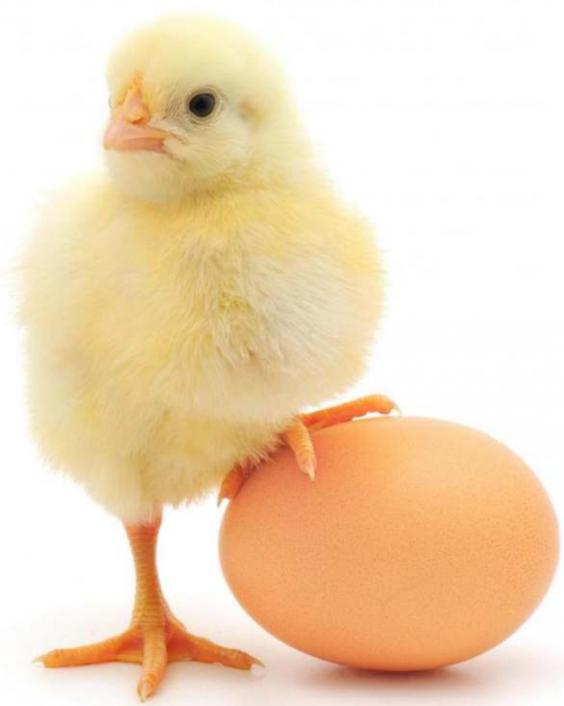

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308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

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Ground *Prosopis juliflora* Pod as Feed Ingredient in Poultry Diet: Effects on Laying Performance and Egg Quality

Meseret Girma[1], Mengistu Urge[2] and Getachew Animut[2]
[1]Department of Animal Sciences, Wollo University, P.O. Box 1145, Dessie, Ethiopia
[2]School of Animal and Range Sciences, Haramaya University, P.O. Box 138, Dire-Dawa, Ethiopia

Abstract: One hundred and eighty 26-week old Bovans Brown commercial layers were used to determine the performance and economic of layers fed with ration containing Ground Prosopis Juliflora Pods (GPJP) at levels of 0 (T_1), 10 (T_2), 20 (T_3) and 30% (T_4) of the total ration. The experiment was arranged in a Completely Randomized Design (CRD) with four treatments, each replicated three times with 15 birds per replicate. The experiment lasted 12 weeks. Hens were individually weighed at the start and end of the experiment. Data on Dry Matter Intake (DMI), Hen Day Egg Production (HDEP), egg weight and egg mass were recorded daily. Egg quality parameters (egg shell weight and thickness, albumen weight and height, Haugh unit and egg yolk weight and color) were determined at an interval of 3 days on 6 eggs per replicate. GPJP contained 12.1% CP, 7.3% ether extract, 14.4% crude fiber and 82.3 µg/100 g beta-carotene. DMI and HDEP was lower ($p<0.05$) for T_4 than T_1 and T_2 and that of egg mass was significantly lower ($p<0.05$) for T_4 than T_1 (DMI: 111.4, 111.8, 110.5 and 105.4 g/day (SEM = 1.92); HDEP: 67.2, 67.7, 62.7 and 60.0% (SEM = 0.02); egg mass: 44.0, 43.8, 41.3 and 39.6 g/day (SEM = 1.49) for T_1, T_2, T_3 and T_4, respectively). Body weight change and feed conversion ratio was not impacted ($p>0.05$) by treatment. Except for egg yolk color which was greater ($p<0.05$) for T_4 than other treatments, all quality parameters were similar among treatments. Therefore, based on the results of the current study, the 10% GPJP inclusion level in the ration of layers is more economical. Although 30% GPJP inclusion level in the ration of layers improved egg yolk color and it appeared to result in reduction of egg production and egg mass. Therefore, up to 20% GPJP inclusion in layers ration is recommendable based on the performance of the birds, although the treatment with 10% GPJP in the ration seems to be more economical.

Key words: Ground *Prosopis juliflora* pods, egg mass, egg quality, Bovans Brown

INTRODUCTION

Poultry meat and eggs are estimated to contribute 20 to 30% of the total animal protein supply in low income food deficient developing countries (FAO, 2004), indicating the role chicken can play in filling the gap for animal protein needs. However, feed among others is an important challenge for efficient poultry production in such countries. Feed cost accounts about 80% of the total animal production cost (El Boushy and Van Der Poel, 2000). Any attempt to improve poultry production and increase its efficiency therefore, needs to focus on the utilization of locally available and affordable new ingredients that are not in direct competition with human food (DZARC, 1997). Hence, there is a worldwide interest in the search for new feed resources capable of supplementing conventional crops and staples foods (Jurgen *et al*., 1998). In this context, ground *Prosopis juliflora* pods is a potential feed ingredient in poultry ration formulation.

Prosopis juliflora is a leguminous tree that is native to arid and semi-arid regions of the world (Harris *et al*., 2003). It is present in North America, Africa and Asia, having multi-seeded curved pods with hardened pericarp (Habit and Saavedra, 1988). In Ethiopia, *Prosopis juliflora* is considered as one of the invasive weeds rapidly invading the agro and silvo-pastoral land, making the rangelands inaccessible to livestock (Sertse and Pasiecznik, 2005). The eradication of *Prosopis juliflora* is posing a grave challenge because of the hardy nature of the plant. Eradication of *Prosopis juliflora* through cutting and burning has proven to be extremely difficult. As such, its exploitation as a resource was proposed to be a better approach to reduce its invasiveness (Pasiecznik, 2002). As a result, the use of the pod with the seed as animal feed after grounding was considered as a strategy to reduce its propagation in Ethiopia.

Prosopis juliflora pods have been used in poultry diets and produced encouraging results. Studies in Brazil showed that 100% replacement of wheat bran with *Prosopis juliflora* pod flour to have similar impact on most layers performance (Silva, 1984), although another study (Silva *et al*., 2002) reported that inclusion of *Prosopis juliflora* pod at 30% of the ration reduced egg

Corresponding Author: Meseret Girma, Department of Animal Sciences, Wollo University, P.O. Box 1145, Dessie, Ethiopia

Table 1: Chemical composition of ingredients used to formulate the experiment ration (% DM)

Nutrients	GPJP	Maize	Wheat short	Noug cake	Soybean meal
DM (%)	91.81	90.92	90.76	93.73	95.20
Crude protein	12.10	11.40	12.20	23.30	34.20
Ether extract	7.31	5.69	5.80	8.92	3.43
Crude fiber	14.40	2.69	6.21	12.99	11.25
Ash	5.80	3.05	5.27	13.46	23.33
Calcium	0.26				
Phosphorus	0.14				
Magnesium	0.10				
Potassium	1.30				
Sodium	0.001				
beta-carotene (μg/100 g)	82.31				

DM = Dry Mater; GPJP = Ground *Prosopis juliflora* Pod

Table 2: Percentage composition of experimental diets containing graded levels of ground *Prosopis juliflora* pod

Ingredients composition	Treatments			
	T_1	T_2	T_3	T_4
Maize	35.05	33.53	27.00	26.90
Wheat short	16.75	11.33	10.40	4.90
GPJP	0.00	10.00	20.00	30.00
Noug seed meal	19.52	18.52	14.49	13.50
Soyabean meal	18.75	17.03	19.28	16.50
Vitamin premix*	0.72	0.72	0.70	0.70
Salt	0.52	0.52	0.50	0.50
Limestone	7.68	7.53	7.00	7.00
Dicalcium phosphate	0.82	0.81	0.80	0.80
Total	100.00	100.00	100.00	100.00

GPJP = Ground *Prosopis juliflora* Pod; T_1 = diet containing 0% GPJP; T_2 = diet containing 10% GPJP; T_3 = diet containing 20% GPJP; T_4 = diet containing 30% GPJP; *Vitamin premix 50 kg contains, Vit A = 2000000iu, Vit D_3 = 400000 iu, Vit E = 10000 mg, Vit K_3 = 300 mg, Vit B_1 = 150 mg, Vit B_2 = 1000 mg, Vit B_3 = 2000 mg, Vit B_6 = 500 mg, Vit B_{12} = 4 mg, Vitpp = 60000 mg, Folic acid = 160 mg, Choline chloride = 30000 mg, Anti-oxidant = 500 gm, Manganese = 10000 mg, Zinc = 14000 mg, Iron = 9000 mg, Copper = 1000 mg, Iodium = 200 mg, Selenium = 80 mg, Calcium = 28.2%

mass, weight and feed to egg mass ratio. *Prosopis juliflora* bears its pods during the driest months of the year, making it possible to use the pods as animal feed, thereby offsetting high cereal prices. However, information on uses of *Prosopis juliflora* pod in layers ration is very limited and non-existing under Ethiopia condition to convince feed manufacturers and farmers to use it as a replacement for cereal grains in poultry ration formulation. The present study is therefore, designed to evaluate the effect of graded levels of *Prosopis juliflora* pod inclusion in layers ration on egg production and egg quality parameters.

MATERIALS AND METHODS

Ingredients and experimental rations: The study was conducted in Haramaya University poultry Farm, Ethiopia located at 42° 3` E longitude, 9° 26`N latitude and at an altitude of 1980 meter above sea level. The mean annual rainfall of the area is 780 mm and the average minimum and maximum temperatures are 8 and 24°C, respectively (Samuel, 2008). The ingredients used for ration formulation in this study were *Prosopis juliflora* pods, maize, wheat short, soybean meal, noug cake, salt, vitamin premix and dicalcium phosphate. Except wheat short, vitamin premix, dicalcium phosphate and soybean meal, the rest ingredients were ground at Haramaya University feed mill before mixing. The collected pods were hand broken and sun-dried and hammer milled to pass through 5 mm sieve to produce Ground *Prosopis juliflora* Pods (GPJP). The GPJP were hand sieved and intact seeds and large sized pods that did not pass through the sieve were reground. Samples of GPJP, maize, wheat short, noug cake and soybean meal were taken for chemical analysis (Table 1). Samples were analyzed for Dry Matter (DM), Crude Protein (CP), Ether Extract (EE), Crude Fiber (CF) and ash following the proximate method of analysis (AOAC, 1995). Calcium and magnesium content of GPJP were analyzed by atomic absorption spectrophotometer, total phosphorus content by SP75 UV/vis spectrophotometer, sodium by flame photometer (AOAC, 1995) and beta-carotene by spectrophotometer. Based on the analysis result, four treatment rations containing GPJP at levels of 0% (T_1), 10% (T_2), 20% (T_3) and 30% (T_4) of the total mixed ration were formulated (Table 2). The four treatment rations used in the present study were formulated to be isocaloric and isonitrogenous with 2800 kcal ME/kg DM and 16.0% CP to meet the nutrient requirements of layers (Leeson and Summers, 2005).

Management of experimental birds: The birds were kept in deep litter pens covered with sawdust litter material. Before the commencement of the actual experiment, the experimental pens, watering and feeding troughs and laying nests were thoroughly cleaned, disinfected and sprayed against external parasites. The hens were vaccinated against Newcastle disease, gumburo disease and fowl typhoid. The wet litter was changed with dry, disinfected and clean sawdust whenever necessary. Vitamins and anti-coccidiosis were given through drinking water according to the manufacturer's recommendation as preventive medications. One hundred eighty Bovans Brown 26 week-old hens with body weight of 1.33±0.022 kg (mean±SD) were divided into four dietary treatments in a Completely Randomized Design (CRD) experiment. There were 45 hens in each dietary treatment, which were further divided into three groups of 15 hens. The 15 birds were randomly assigned to one of the 12 pens. The birds were adapted to experimental diets for 7 days before the commencement of data collection.

Data collection and measurements: Feed was offered to the birds *ad libitum* twice per day at 0800 and 1700 h and clean tap water was available all the time. The amount of feed offered and refused per pen was recorded daily. The amount of feed consumed was determined as the difference between the feed offered and refused on DM basis. Feed offered and refused were sampled daily per pen and pooled per treatment for the entire experimental period for chemical analysis. The samples were analyzed for DM, CP, EE, CF, ash, calcium and total phosphorous following the proximate method of analysis (AOAC, 1995). Hens were individually weighed at the start and end of the experiment and body weight change was calculated as the difference between the final and initial body weight. Eggs laid by hens in a pen were collected three times a day at 0800, 1300 and 1700 h and daily egg production was calculated as the sum of the three collections. Eggs collected daily were weighed immediately after collection for each pen and average egg weight was computed by dividing the total egg mass to the number of eggs. Egg mass per hen was calculated as total egg mass divided by number of hens. Hen-day egg production as percentage was determined following the method of Hunton (1995) as:

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

Feed conversion ratio was calculated as gram of feed consumed per gram of eggs produced. Egg quality characteristics, such as albumen weight, albumen height, egg shell weight, egg shell thickness, egg yolk weight and egg yolk color were determined at an interval of 3 days on freshly laid 6 eggs per replicate after breaking and separating each of the components. Egg shell, albumen and yolk weights were measured using sensitive balance. Albumen height was measured with a tripod micrometer. Egg shell thickness was measured by eggshell thickness micrometer gauge. Measurements were taken from three regions (large end, small end and on the equator region of the eggshell) and the average value was considered. Yolk color was determined by comparing the color of properly mixed yolk sample placed on white paper with the color strips of Roche fan measurement, which consist 1-15 strips ranging from pale to orange yellow color. Haugh unit was calculated from the egg weight and albumen height using the formula suggested by Haugh (1937):

$$HU = 100 \log (H + 7.57 - 1.7 W^{0.37})$$

Where, HU = Haugh Unit, H = Albumen height, W = Egg weight (g).

Statistical analysis: Except yolk color, which was analyzed by logistic regression, all other parameters were statistically analyzed using the general linear model procedure of SAS (SAS, 2002). Differences between treatment means were separated using Tukey Test (SAS, 2002).

RESULTS

The CP content of GPJP is comparable with that of maize and wheat short used in the current experiment and the CF content of GPJP is somewhat higher than other major dietary ingredients used in this study (Table 1). Beta-carotene content of GPJP is quite high as compared to feed ingredients known for good beta-carotene content such as golden whole kernel and yellow corn which contains about 15.7 and 52.22 µg/100 g, respectively (Scott and Eldridge, 2005; Jegtvig, 2007). The four treatment rations were formulated to be isocaloric and isonitrogenous. As such the calculated CP and metabolisable energy contents for the treatment diets ranged 16.12-16.81% and 2800-2896 kcal/kg DM, respectively, indicating that the diets were somehow isocaloric and isonitrogenous as planned (Table 3). In the exercise of formulating treatment rations with similar energy and protein contents, the percentage composition of maize grain and wheat short decreased with increasing inclusion level of GPJP (Table 2) indicating that GPJP replaces mainly these two ingredients. The nutrient contents of treatment rations, including calcium and phosphorous are within the recommended values for layers.

Intake of DM was lower ($p<0.05$) for the highest level of GPJP inclusion (30%) treatment as compared to diets containing 0 and 10% GPJP, while DM intake for the

Table 3: Percentage composition, calculated and analyzed values of experimental diets containing graded levels of ground *Prosopis juliflora* pod

	Treatments			
Ingredients composition	T_1	T_2	T_3	T_4
DM (%)	92.04	92.22	92.10	91.69
CF (% DM)	5.92	5.86	6.69	7.90
EE (% DM)	5.05	5.68	5.69	6.39
NFE (% DM)	52.07	52.00	50.88	49.71
Ash (% DM)	13.10	13.48	13.14	12.69
Calcium (% DM)	3.93	3.98	3.72	3.92
Total Phosphorus (% DM)	0.59	0.57	0.59	0.53
Crude protein (% DM)	16.50	16.81	16.57	16.12
Calculated values				
ME (kcal/kg DM)	2895.95	2865.45	2800.93	2800.10

CF = Crude Fiber; DM = Dry Matter; EE = Ether Extract; GPJP= Ground *Prosopis juliflora* Pod; NFE = Nitrogen Free Extract; T_1 = diet containing 0% GPJP; T_2 = diet containing 10% GPJP; T_3 = diet containing 20% GPJP; T_4 = diet containing 30% GPJP

Table 4: Feed intake, body weight change and egg laying performance of Bovans Brown hens fed graded levels of ground *Prosopis juliflora* pods

	Treatments				
Parameters	T_1	T_2	T_3	T_4	SEM
DM intake (g/hen/d)	111.40^a	111.80^a	110.50^{ab}	105.40^b	1.920
Initial BW (kg)	1.30	1.35	1.32	1.33	0.022
Final BW (kg)	1.57	1.58	1.59	1.59	0.024
BW change (g/head)	267.60	237.00	277.20	263.80	29.070
HDEP (%)	67.20^a	67.70^a	62.70^{ab}	60.00^b	0.020
Egg mass (g/hen/day)	44.00^a	43.80^{ab}	41.30^{ab}	39.60^b	1.490
Egg weight (g)	57.90	57.20	57.00	58.40	0.670
FC (g of feed/g of eggs)	2.76	2.77	2.89	2.89	0.120

^{a,b}Means within a row with different superscripts differ ($p<0.05$); DM = Dry Matter; BW = Body Weight; FC = Feed Conversion Ratio; HDEP = Hen Day Egg Production; SEM = Standard Error of the Mean; GPJP= Ground *Prosopis juliflora* Pod; T_1 = diet containing 0% GPJP; T_2 = diet containing 10% GPJP; T_3 = diet containing 20% GPJP; T_4 = diet containing 30% GPJP

Table 5: Egg quality characteristics of laying hens fed graded levels of ground *Prosopis juliflora* pods

	Treatments				
Parameters	T_1	T_2	T_3	T_4	SEM
Sample egg weight (g)	58.98	58.25	58.03	59.43	0.670
Egg shell weight (g)	6.50	6.40	6.40	6.50	0.120
Egg shell thickness (μm)	0.29	0.30	0.29	0.29	0.004
Egg albumen weight (g)	34.80	34.70	33.90	35.60	1.320
Albumen height (mm)	9.59	9.61	9.65	9.70	0.257
Haugh unit	98.00	98.00	98.10	98.10	1.540
Egg yolk weight (g)	13.13	12.45	12.49	12.55	0.345
Yolk color (RSP*)	2.65^b	3.04^b	3.27^b	4.52^a	0.278

^{a,b}Means within a row with different superscripts differ ($p<0.05$); *RSP = Roche Scale Points; SEM = Standard Error of the Mean; GPJP= Ground *Prosopis juliflora* Pod; T_1 = diet containing 0% GPJP; T_2 = diet containing 10% GPJP; T_3 = diet containing 20% GPJP; T_4 = diet containing 30% GPJP

20% GPJP containing ration was similar ($p>0.05$) with all other treatments (Table 4). Similar treatment effect like that observed for DM intake was noticed for hen day egg production. Egg mass was greater ($p<0.05$) for the 0% than the 30% level of GPJP inclusion. There was no significant difference among treatments ($p>0.05$) in daily body weight change, egg weight and feed conversion ratio of the hens. Graded levels of GPJP inclusion in layers ration also failed to significantly impact ($p>0.05$) egg quality parameters except yolk color (Table 5 and 6). Yolk color as determined by Roche Scale Points (RSP) tended to increase with increasing levels of GPJP in the ration, but it was significantly higher ($p<0.05$) for the 30% than other treatments.

The economics of egg production determined from ratios of cost of the total feed consumed and the egg mass produced from that amount of feed indicated that the ration containing 10% GPJP is the least cost ration followed by 0%, 30% and the ration containing 20% GPJP (Table 7).

Table 6: Yolk color points of egg samples from different experimental diets

	*RSP								
Diets	1	2	3	4	5	6	7	8	Total
T_1	16	23	11	9	9	0	1	0	69
T_2	10	21	10	18	6	2	2	0	69
T_3	6	15	19	17	9	1	2	0	69
T_4	0	2	11	26	16	8	5	1	69
Total	32	61	51	70	40	11	10	1	276

*RSP = Roche Scale Points (Roche yolk color points: 1 = light yellow; 15 = orange); T_1 = diet containing 0% GPJP; T_2 = diet containing 10% GPJP; T_3 = diet containing 20% GPJP; T_4 = diet containing 30% GPJP

Table 7: Economics of feeding graded level of ground *Prosopis juliflora* pod

	Treatments			
Parameters	T_1	T_2	T_3	T_4
Total feed intake (kg/bird)	11.54	11.53	11.38	10.87
Total feed cost (Birr)	48.69	48.31	46.77	44.56
Feed cost per kg of egg mass	11.64	11.60	11.87	11.84

Birr = Ethiopia's unit of currency; US$1.00 = Birr 17.00; T_1 = diet containing 0% GPJP; T_2 = diet containing 10% GPJP; T_3 = diet containing 20% GPJP; T_4 = diet containing 30% GPJP

DISCUSSION

Shukla *et al.* (1984) reported contents of 7-10% preformed water, 9-17% CP, 1.2-4.3% EE, 16-34% CF, 4-5% ash, 0.3-0.5% calcium and 0.40-0.44% phosphorus for GPJP on a DM basis. Therefore, the DM and CP contents of GPJP measured in the present experiment were within the range, EE and ash contents were higher and CF, calcium and phosphorus levels were lower than that reported by Shukla *et al.* (1984). Various factors including the plant's growing environment, harvesting stage, storage condition and processing could possibly be responsible for the differences in chemical composition of GPJP observed in different studies.

A possible sign associated with high inclusion level of GPJP in the diet of broiler chicks were decreased feed consumption and depression of performance (Azevedo, 1987). In the present experiment, reduction in feed consumption was not apparent up to the 20% GPJP level of inclusion in the ration. However, 30% GPJP inclusion in the ration was able to significantly induce reduction in DM intake of birds compared to the ration containing no GPJP. Similar to the current study Oliveira *et al.* (2001) noted reduction in feed intake of quails when *Prosopis juliflora* pod meal was included at 25% of the ration as compared to the one that did not receive the pod meal. The ration in the present experiment contained nearly similar amounts of metabolizable energy, CP, calcium and phosphorus. But, CF content in the diets containing 30% GPJP was greater by about 34% as compared to the ones with 0 and 10% GPJP inclusion levels that might have contributed to the reduction in DM intake at the highest level of GPJP inclusion. Increased fiber level in poultry rations reduced nutrient digestibility and increased body temperature, both of which can negatively impact DM intake (Adeyanju, 1979; Krogdhal, 1986; Graham, 1991; Noblet and Le Goff, 2001; McDonald *et al.*, 2002). Decreased DM intake at high level of GPJP could be also attributed to the presence of heat labile anti-nutritional factors such as trypsin inhibitor and hemagglutinin, whose presence in *Prosopis juliflora* has been, reported (Del Valle *et al.*, 1983). However, Silva *et al.* (2002) did not found significant difference in feed intake between hens fed ration containing 30% *Prosopis juliflora* pods meal as compared to the diet without the pod meal. In the current experiment no hen mortality was observed, indicating that the maximum level of GPJP inclusion might not have possible effect on the health of poultry.

Lower hen day egg production and egg mass at 30% GPJP inclusion level in this study is consistent with the finding of Silva *et al.* (2002) who reported similar result in pullet fed ration containing 30% *Prosopis juliflora* meal. The reduction in the performance of hens at high level of GPJP inclusion might be due to the negative effects of the high non-starch polysaccharides (fiber) contents in the ground pods on feed intake as observed in this study and/or due to the possible effect of the fiber on nutrient digestibility that might have limited the supply of essential nutrients to satisfy the performance requirements of the birds. *Prosopis juliflora* meal contains adequate amount of essential amino acids, except lysine, methionine and cysteine (Bhatt *et al.*, 2011). The potential low level of such amino acids in the diet containing 30% GPJP might have in part contributed to the reduction in egg production and egg mass. Similar trend observed in DM intake and egg mass resulted to the lack of significant effect on feed conversion ratio in the current study, although Noy and Sklan (2002) noted that increase in fiber (cellulose) from 3 to 13% in the diet affected the feed efficiency of broiler chicks.

Except for egg yolk color, significant differences were not apparent in egg quality parameters in this study. Values for egg weight and egg quality parameters, including Haugh unit recorded in the present experiment were within the ranges reported for Bovans Brown breeds (Koreleski and Swiatkiewicz, 2010; Swiatkiewicz *et al.*, 2010). The absence of treatment differences in most egg quality measures suggest that at least up to 30% level of GPJP inclusion in the layers ration is possible without significant impact on such egg quality parameters. The reason for the increased Roche fan measurement for diet with the highest level of GPJP in the current study is obviously associated with the high beta-carotene content of the GPJP (Hasin *et al*., 2006). Thus, GPJP can be a potential ingredient for egg yolk coloration as many consumers prefer eggs with more yellow yolk color. Despite such possible advantages of GPJP as ingredient in the ration of layers, the potential of any dietary ingredient has to be determined by the price of the ingredients and its effect on laying performance. Therefore, based on the results of the current study, the 10% GPJP inclusion level in the ration of layers is more economical. The 30% GPJP inclusion level in the ration of layers has better egg yolk color, but it appeared to result in reduction of egg production and egg mass. Therefore, up to 20% GPJP inclusion in layers ration is recommendable based on the current research result.

Summary and conclusion: Although egg quality parameters except egg yolk, egg weight and body weight of the layers was not negatively impacted by inclusion of GPJP up to 30% level, egg production and egg mass is significantly reduced when the ration contained 30% GPJP. Layers fed 20% GPJP containing ration performed similar to the control and the ration containing 10% GPJP in all parameters measured. Therefore, up to 20% GPJP inclusion in layers ration is recommendable based on the performance of the birds and treatment with 10% GPJP in the ration appeared to be more economical.

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