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Supplementing Laying Hen Diet with Gum Arabic (*Acacia senegal*): Effect on Egg Production, Shell Thickness and Yolk Content of Cholesterol, Calcium and Phosphorus*

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Abstract: This study was aimed to assess the effect of supplementing gum Arabic in the basal diet of the laying hens (Historic strain of single comb white leghorn) on egg production and quality. Seventy two White Leghorn laying hens (20 weeks of age) were randomly divided into four groups (A, B, C and D), 18 birds in each. Group A received the basal diet and group B to D received the basal diet supplemented with 5, 10 and 15% (w/w) *Acacia senegal* gum, respectively. Birds were allowed free access to feed and water and the feeding trial lasted for 8 weeks. Gum Arabic (15%) increased ($p<0.05$) feed intake and egg shell thickness by 5.98 and 31.58%, respectively as compared to the control. The significant ($p\leq 0.05$) increase in albumin, Ca and P was also noticed in blood serum and egg yolk. Increasing the ratio of the gum Arabic (from 5-15%) in the basal laying hen diet significantly ($p\leq 0.05$) reduced serum cholesterol in a gradual manner and consequently eggs with lowered yolk cholesterol were obtained.

Key words: White leghorn layers, gum Arabic, feeding experiment, egg production and quality

INTRODUCTION

Dietary fiber is the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine, with complete or partial fermentation in the large intestine. It includes polysaccharides, oligosaccharides, lignin and associated plant substances. Dietary fibers found to promote beneficial physiological effects including laxation and/or attenuation each of blood cholesterol and glucose and it also improves mineral availability. Gum Arabic (*Acacia senegal*) is a branched polymer of galactose, rhamnose, arabinose and glucouronic acid (Anderson, 1986; Anderson *et al*., 1991). It is a water soluble fermentable, by indigenous bacteria, polysaccharide resistant to gut enzymes in human and animals and thus can be described as a dietary fiber (Phillips, 1998). In birds, soluble dietary fibers, such as oligofructose and inulin were fermented in cecum (Chen *et al*., 2005a). However, there are no limitations to the effect of supplementing gum Arabic in diet of hen layers on serum and yolk albumin level. The use of gum Arabic as a food additive as the experimental evidence of safety demand by the international food safety has already been met (Anderson, 1986) and thus considered safe for consumption. In Sudan gum Arabic production covers a wide area as it considered as a principal national income product. Poultry production in Sudan has

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shown considerable expansion in recent years, which stimulates research in this field, mostly concerning egg production. Quality of the produced eggs was touched slightly. Feeding soluble dietary fibers, (inulin and oligofructose) to laying hens was found to alter digestion and metabolism (Chen *et al*., 2005c), thus promotes bird's health and improves egg production and egg shell quality (Chen and Chen, 2004; Chen *et al*., 2005a). Eggs have been widely known for their high cholesterol content. It was suggested that complete inhibition of cholesterol biosynthesis in the hen, by administrating drugs as an attempt to alter cholesterol content in egg, would result in failure to produce hormones needed to support egg production. On the other hand, Chen *et al*. (2005b) reported a decrease in egg yolk cholesterol in hens fed diets supplemented with soluble dietary fibers. In this context, the present study was aimed to assess the effect of supplementing Gum Arabic in the basal diet of the laying hens (Historic strain of single comb white leghorn) on egg production, shell thickness and yolk content of albumin, cholesterol, Ca, P.

MATERIALS AND METHODS

Feeding Experiment

Seventy two of White leghorn hens (20 weeks of age) were provided with the basal diet 2 weeks prior to the experiment for acclimatization. Birds were allowed free access to feed and water with exposure to 16 h incandescent light/day, during the experimental period which lasted 8 weeks. The Birds were selected and divided randomly into four equal groups (A-D). Birds in groups A were fed the basal diet (control). The birds in groups B, C and D were fed basal diet supplemented with gum Arabic at rates of 5, 10 and 15% (w/w). Diet ingredients are shown in Table 1. Mortality rate (Percentage of dead birds per total number of birds housed), daily egg production and egg shell thickness, serum and yolk albumin, cholesterol, Ca and P were recorded.

Proximate Analysis of the Basal Diets

Moisture (oven dry), protein (micro-Kjeldahl), oil (petroleum ether extract), ash (dry ashing) and crude fiber were determined according to AOAC (1984).

Calcium and Phosphorus

Calcium and phosphorus were determined in extracts prepared by digesting the ash with 5 N HCl (Pearson, 1981). Calcium was quantified by the titration method and phosphorus was determined by the ammonium molybdate/ammonium vandate method (Chapman and Pratt, 1961).

Table 1: Composition and chemical analysis of the basal diet fed to experimental birds

Parameters	Percentage
Composition	
Sorghum	53.5
Wheat bran	20
Groundnut cake	15.5
Concentrate*	5
Calcium source (Fish shell)	5
Salt	1
Chemical analysis**	
Moisture	3.9±0.31
Crude protein	22.8±0.53
Crude oil	3.9±0.18
Ash	8.7±0.44
Crude fiber	5.0±0.28
Carbohydrates	56.5±0.36

*Concentrate contains lysine (0.5%), methionine (0.8%), fish or meat meal and plant protein (19%).**Means of triplicate samples ±SD

Albumin

Albumin in egg and blood samples was determined by the method of AOAC (1984). A known sample weight was extracted with about 25% acetic acid and quantified by Kjeldahl procedure. Then 15 mL NaCl (9.7%) were added to 100 mL filtered extract, mixed well and the volume completed (after cooling) to 200 mL with alcohol and left to stand overnight. The water soluble N and the crude albumin were determined by Kjeldahl procedure. The albumin was obtained by subtraction of the crude albumin from the water soluble N.

Cholesterol

The determination of cholesterol level in egg yolk was made at weekly intervals and the data were averaged over the whole experimental period. One-gram samples of blended egg yolk were directly saponified for determination of cholesterol content and after extraction process, samples were quantified using the gravimetric method (AOAC, 1984). To determine serum cholesterol, blood samples from each individual hen were taken from the brachial wing veins into tubes at weekly intervals and let to stand in air for 10 minutes and then centrifuged at 3000 x g for 5 min to obtain serum. Serum total cholesterol was measured gravimetrically, according to AOAC, 1984. The results were averaged as before.

Statistical Analysis

Mean values of each parameter for various groups were computed. The data were subjected to the analysis of variance (one way-ANOVA) under a randomized design. Duncan's multiple range test was applied for multiple mean comparisons, when necessary, using the SPSS program (version 12.0). The level of significance was ($p \leq 0.05$).

RESULTS AND DISCUSSION

Proximate Composition of the Basal Diet

The diet contents from moisture, protein, oil, ash, crude fiber and carbohydrates were 3.9, 22.8, 3.9, 8.7, 5 and 56.5%, respectively (Table 1).

Feed Intake, Egg Production, Egg Shell Thickness and Mortality Rate

Feed intake significantly ($p \leq 0.05$) increased in birds of groups C and D compared with the control (group A), suggesting increasing effect of administering gum Arabic on the palatability of the diet fed with high levels (Table 2). Similarly, Supplementation of Gum Arabic in birds diet significantly ($p \leq 0.05$) increased thickness of egg shell in the three groups (B, C and D), which may be attributed to the increased calcium absorption in blood serum, which in turn reflected in the developed egg shell

Table 2: Feed intake (g), weekly egg production (No.), egg shell thickness (mm) and mortality rate (%) of the laying hens fed diets supplemented with gum arabic

	Laying hens group**			
Parameters	A	B	C	D
Feed intake/day/bird	78.60^{b}	72.20^{c}	83.30^{a}	83.30^{a}
	(2.08)	(2.69)	(2.56)	(5.16)
Egg production/week/bird	6.10^{a}	5.44^{ab}	5.20^{b}	5.30^{b}
	(0.39)	(0.32)	(0.53)	(0.50)
Egg shell thickness	0.38^{b}	0.48^{a}	0.54^{a}	0.50^{a}
	(0.03)	(0.07)	(0.04)	(0.05)
Mortality (%)	5.50	0.00	0.00	0.00

Means of triplicate samples. Values in parentheses are SD. Means having different letter(s) within a row are significantly different according to DMRT ($p \leq 0.05$). Calculations based on free moisture. **A: Basal diet; B: Basal diet with 5% gum Arabic; C: Basal diet with 10% gum Arabic; D: Basal diet with 15% gum Arabic

(Fig. 3). Improvement in eggshell quality due to supplementing laying hen basal diet with dietary fibers was reported (Chen and Chen, 2004). On the contrast, egg production significantly ($p \leq 0.05$) decreased by increasing the percentage of Gum Arabic in the basal diet. Results revealed a mortality rate of 5% in group A compared to nil mortality in group B, C and D.

Cholesterol

Figure 1 shows a significant ($p \leq 0.05$) gradual decrease in cholesterol level in the egg yolk with increasing the Gum Arabic levels in the basal diet. This decrease in yolk cholesterol may be related to the decrease observed in blood serum cholesterol of the laying hens (Fig. 1). Chen *et al*. (2005b) reported a decrease in yolk cholesterol due to feeding laying hens diets supplemented with dietary fibers. The last author attributed this lowered concentrations of yolk cholesterol to lowered serum cholesterol that results from more cholesterol excretion. In animal experiments, Gum Arabic was noticed to reduce serum cholesterol, suggesting gum interference with dietary cholesterol absorption. (Kelley and Tsai, 1978).

Albumin

Results found in Fig. 2 revealed that the albumin in egg yolk significantly ($p \leq 0.05$) increased with increasing the levels of gum Arabic in diet of the laying hens, simultaneously with a similar increase in blood serum albumin. Results indicated a positive correlation (0.822) between egg yolk and serum albumin. Serum proteins are mainly synthesized in the liver (Khan *et al*., 2006) and an increase

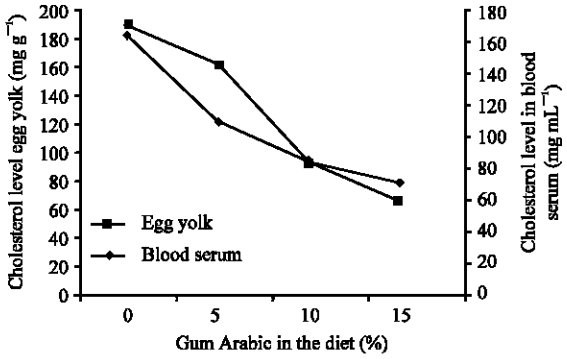

Fig. 1: Effect of supplementing gum Arabic in diet of hen layers on serum and yolk cholesterol level

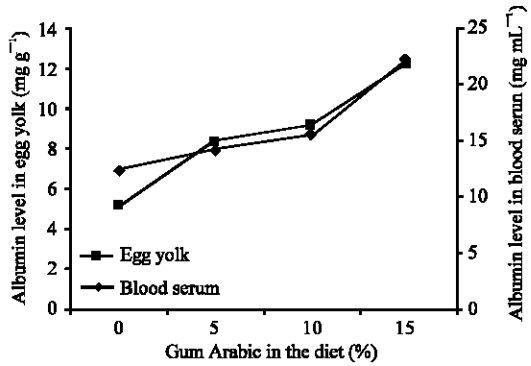

Fig. 2: Effect of supplementing hum Arabic in diet of hen layers on serum and yolk albumin level

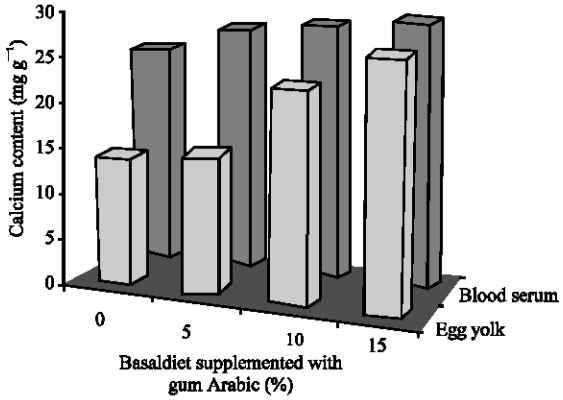

Fig. 3: Effect of supplementing gum Arabic in diet of hen layers on serum and yolk calcium content

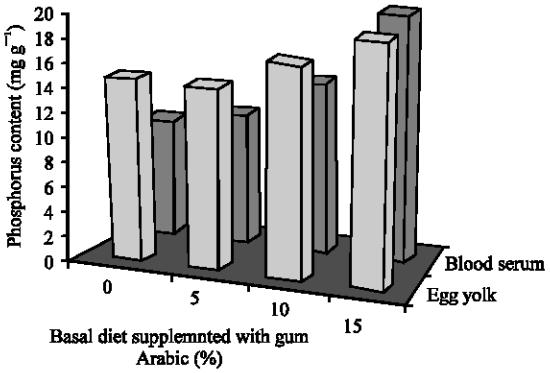

Fig. 4: Effect of supplementing gum Arabic in diet of hen layers on serum and yolk phosphorus content

in their levels is an indicator of a motivation in the function of this organ. Chen *et al*. (2005c) stated that dietary fibers (prebiotics) supplemented in the basal diet of laying hens increased the amount of the digested protein. This may increase serum proteins and consequently egg proteins.

Calcium and Phosphorus

Supplementing laying hens' diet with different levels of gum Arabic gradually increased Ca and P contents in egg yolk, i.e., Group D showed the highest percentage increase. This increase in Ca and P is probably due to the observable increase in both minerals in blood serum (Fig. 3, 4). Gum Arabic may promote absorption of Ca and possibly other minerals (Mee and Gee, 1997). However, the efficiency of Ca absorption in rats was improved by using 7.5% Gum Arabic (Kawase *et al*., 2007).

In conclusion, supplementation the basal diet of white leghorn laying hens with gum Arabic led to a reduction in blood serum and yolk cholesterol and an increase in each of blood serum and yolk albumin, Ca and P, as well as an increase in egg shell thickness. Egg production did not further improve.

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