



## Original Research Article

# Effect of dietary inclusion of sugar syrup on production performance, egg quality and blood biochemical parameters in laying hens

Ahmed S. Hussein<sup>a,\*</sup>, Mostafa A. Ayoub<sup>a</sup>, Ahmed Y. Elhwetiy<sup>a</sup>, Jamal A. Ghurair<sup>b</sup>,  
Mohsin Sulaiman<sup>a</sup>, Hosam M. Habib<sup>a</sup>

<sup>a</sup> College of Food and Agriculture, United Arab Emirates University, Al Ain 15551, United Arab Emirates

<sup>b</sup> Al-Khaleej Sugar CO (L.L.C.), Dubai 13315, United Arab Emirates

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## ABSTRACT

The effects of dietary inclusion of sugar syrup on quality of egg, cholesterol level, production performance, serum total protein and blood biochemical parameters were evaluated in laying hens. A total of 300 commercial Lohmann LSL hens (30 weeks of age) were randomly distributed into 3 dietary treatments which consisted of a normal corn diet containing corn–soy and 2 diets containing 5% and 10% sugar syrup. Each treatment was replicated 5 times ( $n = 20$ ). Egg production, feed intake, body weight and egg weight of laying hens fed different diets were recorded. The experiment lasted for 20 weeks. The Haugh unit scores of hens fed diets with sugar syrup were significantly increased ( $P < 0.05$ ) compared with the control treatment. The sugar syrup had no significant effect on liver enzymes, total protein, blood glucose and creatinine in all treatments. The eggs laid by hens fed sugar syrup diets had lower cholesterol level ( $P < 0.05$ ) compared with those laid by hens fed the control diet. Electrophoresis analysis showed that comparable electrophoretic patterns were noticed between serum proteins of treatment groups. From the results, it can be concluded that sugar syrup diets and corn diets have similar effects on feed intake, body weight, production of eggs and blood biochemical parameters in layer hens, which suggests sugar syrup can be used as an energy source for replacing part of corn in poultry layer diets.

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## 1. Introduction

Dietary carbohydrates constitute 60% to 65% of metabolizable energy in the poultry ration, and cereals such as corn, sorghum and maize are the widely used energy sources (Hotz and Gibson, 2007). The supplementation of fat and oil in poultry diets is a prevailing system to upgrade the dietary energy in feeds. In the Middle East, corn for animal/poultry feed is imported and the price of these raw materials has elevated by virtue of competition with the human

food industry and increased production of biofuels (USDA, 2015). The enhanced price of daily used raw materials leads to search for another suitable feed resource which can substitute a percentage of corn in poultry diets at a lower cost of production.

Sugar syrup, a high-quality molasses with 76% sugar, composed of major monosaccharides like glucose, fructose and sucrose. Sugar syrup obtained as a byproduct of molasses from refineries. In comparison to starch, sugar is a prominent energy reservoir and the total metabolizable energy of sugar syrup is 15.6 MJ/kg (John, 2008); however, cereals contained mainly starch, with total metabolizable energy of 14.1 MJ/kg (NRC, 1994). Sugar syrup is an energy rich supplement that could be well incorporated in to animal feeds. The fructose content which generates most of the sweetness varies between 42% and 55% of the syrup. The enzyme sucrase hydrolyzes sucrose into fructose and glucose, and the net energy of sucrose is higher than those of starch. Glucose is known to be more actively absorbed than starch and utilized by the chicken for tissue multiplication and egg production. Glucose is

\* Corresponding author.

E-mail address: [ahusseain@uaeu.ac.ae](mailto:ahusseain@uaeu.ac.ae) (A.S. Hussein).

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considered as an energy as well as economical substitute for corn in poultry feeds due to its similar energy value. Sugar syrup acts as an instant energy feed and it contains no indigestible material. The formation of cholesterol in eggs and meat could be minimized by adding sugar syrup in diets due to its high energy without the addition of lipids. This property of sugar syrup can bring a change in poultry feed formulations.

Limited research's papers were published about the use of sugar and sugar syrup in animal feed, the poultry feed in particular. Previous studies showed that cane condensed molasses were added in the diets of broilers to improve the growth performance (Waldroup, 1981; Waliszewski et al., 1997). Studies in our laboratory suggest that adding 15% sugar syrup in broiler diets results in the production of high-quality thigh and breast meats (Hashim et al., 2013). Recently, it was also found that broilers fed diets with 5% sugar syrup had similar feed efficiency to the control corn diet. Furthermore, adding 5% sugar syrup to broiler diets decreased cholesterol and triglycerides levels in blood and had no significant effect on creatinine, total protein, blood glucose and liver enzymes (Hussein et al., 2016). Therefore, it may be of interest to elucidate the effect of substituting a portion of the dietary corn with sugar syrup as a source of energy on production and quality of egg, egg cholesterol content and serum protein levels in layers.

## 2. Materials and methods

### 2.1. Sugar syrup

Sugar syrup produced by Al Khaleej Sugar Company, Dubai, United Arab Emirates was used for the study.

### 2.2. Birds and treatments

Commercial Lohmann LSL hens ( $n = 300$ ), 30 weeks of age were randomly divided into 3 dietary treatments. Birds within each group were designated to 5 replicates ( $n = 20$ /group). Laying hens were housed 5 birds per cage (50 cm  $\times$  45 cm  $\times$  45 cm) in an environmentally controlled house. Each replicate of 4 cages shared one feeder, and water was provided to each cage individually by a water cup system. Layers were managed and handled according to animal welfare guidelines of the University Research Ethics Committee. The experiment lasted for 20 weeks. Diets were prepared according to Table 1. All diets were isonitrogenous and isocaloric. The production of egg and egg weights of all egg were

measured daily and calculated periodically (every 28 days) from 31 to 50 weeks of age. Haugh unit scores were calculated by the procedure of Bish et al. (1984). Hen day egg production was the average of daily egg production of the 5 replicates (20 birds per replicate). Egg mass production per hen per day was calculated as egg production percentage multiplied by average egg weight of the hen. The feed intake and body weight of experimental groups were calculated every 28 days from weeks 31 to 50. Feed conversion ratio was calculated as grams of feed consumed per gram of egg mass produced.

### 2.3. Dietary treatments

The 3 dietary treatments consisted of control, 5% sugar syrup and 10% sugar syrup diets.

### 2.4. Blood serum

Blood sera were collected from wing veins of the hens in each replicate (2 birds/replicate), 3 times during the laying period. The first period lasted 90 days, the second 105 days and the third 120 days of egg production. After formation of clot, blood samples were centrifuged for 2 min at  $1,000 \times g$  at  $4^\circ\text{C}$ , after which sera were separated, pooled within replicates and kept frozen below  $-20^\circ\text{C}$  until protein analysis was done. Blood samples were also collected in test tubes with heparin as an anticoagulant from 2 hens at the end of the experiment. Plasma was then separated from the samples after centrifugation at  $1,000 \times g$  for 10 min at  $4^\circ\text{C}$  and stored at  $0^\circ\text{C}$  for biochemical analysis.

### 2.5. Biochemical analysis

The total calcium, iron, phosphorus and copper in plasma were measured by Inductively Coupled Atomic Emission Spectrometry (ICP-OES) described by the ICP-OES Spectrometers operation manual (2002) of Varian, Inc. High-density lipoprotein – cholesterol and triglycerides, creatinine, total protein, plasma glucose and total cholesterol were measured using commercial systems (Udi-chem Elite, United Diagnostics Industry, Dammam, Kingdom of Saudi Arabia) and based on methods used by Wissam et al. (2008). Creatine kinase activity was measured by the method of Dinovo et al. (1973). Alanine aminotransferase and Aspartate amino transferase activity were measured by the method of Reitman and Frankel (1957). Activity of Lactate dehydrogenase and Gamma glutamyl transferase were measured using a commercial assay kit from Sigma Aldrich.

### 2.6. Total protein estimation

Serum total protein was estimated by the biuret colorimetric method according to Doumas et al. (1981) using a commercial kit from Sigma Aldrich.

### 2.7. Analysis of protein profile electrophoresis

Serum samples collected from hens in each treatment were thawed and pooled. Fifteen microliters of serum were added to a 40- $\mu\text{L}$  sample buffer (10% glycerol, 10% sodium dodecyl sulfate [SDS], 0.1% bromophenol, 0.5 mol/L Tris-HCl [pH 6.8], and 4%  $\beta$  mercaptoethanol) and placed in a boiling water bath for 5 min. Five microliters from each sample were loaded into 4% stacking gel, and then sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) was performed on a 12% resolving gel. A constant voltage of 160 V was used to run the gel for 1 h until the dye reaches the bottom of the gel. Proteins were stained with Coomassie blue

**Table 1**  
Composition of diets for laying hens (DM basis).

Ingredients, %	Control diet <sup>1</sup>	5% sugar syrup diet <sup>2</sup>	10% sugar syrup diet <sup>3</sup>
Corn	63.04	57.34	51.50
Ground soybean meal	25.00	25.80	26.77
NaCl	0.38	0.36	0.33
Limestone	7.68	7.59	7.47
CaHPO <sub>4</sub>	1.80	1.77	1.77
Vitamin-mineral mix <sup>4</sup>	1.00	1.00	1.00
DL-methionine	0.10	0.14	0.16
Corn oil	1.00	1.00	1.00
Sugar syrup	0.00	5.00	10.00

<sup>1</sup> Calculated diet composition is protein, 17.50%; ME, 2.80 Mcal/kg; Met, 0.39%; Met + Cys, 0.69%; Lys, 0.91%; calcium, 3.5% and available phosphorus, 0.45%.

<sup>2</sup> Calculated diet composition is protein, 17.50%; ME, 2.80 Mcal/kg; Met, 0.42%; Met + Cys, 0.72%; Lys, 0.93%; calcium, 3.5% and available phosphorus, 0.45%.

<sup>3</sup> Calculated diet composition is protein, 17.50%; ME, 2.80 Mcal/kg; Met, 0.43%; Met + Cys, 0.73%; Lys, 0.94%; calcium, 3.5% and available phosphorus, 0.45%.

<sup>4</sup> Vitamins and mineral composition were provided as previous reported in Hussein et al. (1989).

solution for overnight and then destained with 10% ethanol and 2% orthophosphoric acid. Molecular weights of serum protein bands were determined by plotting them against molecular weight of standard proteins (10 to 225 ku) using a semi-log scale. The protein bands were scanned using a high performance ultraviolet trans-illuminator (BioImaging system, UVP Inc. Upland, CA, USA) and images were saved for analysis. The light transparencies of protein band images were measured by Software Program Doc IT 2.4.3 (Image Acquisition and 1 D analysis, UVP Inc. Upland, CA, USA).

## 2.8. Statistical analysis

A one-way analysis of variance using the general linear model (GLM) according to Miller and Haden (2006), was used for statistical analysis and performed using a program for microcomputers (Statistix, V. 4.0, analytical software, Tallahassee, FL, 32317).

## 3. Results

### 3.1. Effect of dietary treatments on egg production of layers

The effect of different treatments on egg production of laying hens is shown in Table 2. The results showed that the egg productions of hens fed 5% and 10% sugar syrup diets were higher than those of the control ( $P < 0.05$ ) during weeks 31 to 34 and weeks 35 to 38. There was no significant difference in overall egg production among the 3 treatments. Both during weeks 31 to 34 and weeks 47 to 50, the Haugh unit scores of hens fed 5% and 10% sugar syrup diets were significantly higher ( $P < 0.05$ ) than those of hens fed the control diet. However, there was no significant difference in overall Haugh unit scores among the 3 treatments. There was no significant difference in overall egg weight among the 3 treatments. The thickness of eggshell was higher ( $P < 0.05$ ) in 5% and 10% sugar

**Table 2**  
Effect of dietary treatments on laying hen performance during weeks 31 to 50.

Variable	Dietary treatments		
	Control	5% sugar syrup	10% sugar syrup
Egg production <sup>1</sup> , %			
Weeks 31 to 34	92.00 ± 0.02	92.00 ± 0.02	94.00 ± 0.02
Weeks 35 to 38	92.00 ± 0.01	89.00 ± 0.03	92.00 ± 0.01
Weeks 39 to 42	91.00 ± 0.01	89.00 ± 0.02	90.00 ± 0.02
Weeks 43 to 46	88.00 ± 0.02	87.00 ± 0.02	89.00 ± 0.02
Weeks 47 to 50	83.00 ± 0.02	83.00 ± 0.02	82.00 ± 0.02
Overall 31 to 50	89.2 ± 1.71	88.00 ± 1.48	89.4 ± 2.04
Haugh unit scores			
Weeks 31 to 34	84.23 ± 0.55 <sup>b</sup>	88.45 ± 1.04 <sup>a</sup>	87.42 ± 1.19 <sup>a</sup>
Weeks 35 to 38	85.42 ± 1.09	86.87 ± 0.77	86.53 ± 0.57
Weeks 39 to 42	88.39 ± 0.83	90.01 ± 0.55	89.42 ± 0.89
Weeks 43 to 46	88.13 ± 0.29	89.66 ± 0.51	89.47 ± 0.60
Weeks 47 to 50	91.25 ± 0.74 <sup>b</sup>	93.26 ± 0.48 <sup>a</sup>	93.86 ± 0.67 <sup>a</sup>
Overall 31 to 50	87.48 ± 1.23	89.65 ± 1.06	89.34 ± 1.26
Egg weight, g			
Weeks 31 to 34	62.43 ± 0.19	62.07 ± 0.61	61.91 ± 0.23
Weeks 35 to 38	58.38 ± 1.13	56.84 ± 2.04	57.79 ± 0.70
Weeks 39 to 42	60.18 ± 0.96	57.33 ± 1.45	58.52 ± 1.11
Weeks 43 to 46	63.27 ± 3.99	58.18 ± 0.83	59.17 ± 1.34
Weeks 47 to 50	54.94 ± 1.06	54.66 ± 1.09	54.15 ± 1.16
Overall 31 to 50	59.84 ± 1.49	57.81 ± 1.21	58.30 ± 1.25
Eggshell thickness, mm			
Weeks 31 to 34	40.47 ± 0.38	42.01 ± 1.38	40.65 ± 0.29
Weeks 35 to 38	37.54 ± 0.49	37.04 ± 0.24	38.18 ± 0.57
Weeks 39 to 42	37.31 ± 0.15	36.62 ± 0.29	37.49 ± 0.26
Weeks 43 to 46	36.74 ± 0.29	36.13 ± 0.25	36.43 ± 0.26
Weeks 47 to 50	35.12 ± 0.27	34.22 ± 0.21	34.87 ± 0.19
Overall 31 to 50	37.43 ± 0.86	37.20 ± 1.29	37.52 ± 0.96

<sup>a,b</sup> Means ± SE bearing different superscripts within a row are significant ( $P < 0.05$ ).

<sup>1</sup> Hen day egg production is the average of daily egg production of the 5 replicates (20 birds per replicate).

syrup diets group during weeks 31 to 34 compared with the control. There was no significant difference in the overall egg shell thickness among the 3 treatments.

### 3.2. Effect of dietary treatments on feed intake and body weight of layers

The effect of dietary treatment on feed intake of laying hens is shown in Table 3. There were no significant difference in feed intake and body weight among the 3 treatments.

### 3.3. Effect of the dietary treatments on blood biochemical parameters of layers

The effect of dietary treatments on laying hens blood biochemical parameters is shown in Table 4. The supplementation of sugar syrup to laying hens diets had no significant effect on activity of enzymes like alanine amino-transferase (ALT), aspartate aminotransferase (AST), creatine kinase, lactate dehydrogenase, gamma glutamyl transferase and blood plasma glucose, creatinine, calcium, phosphorus, copper and iron. In the eggs laid by hens fed sugar syrup diets the cholesterol level was significantly reduced ( $P < 0.05$ ) compared with the eggs laid by hens fed the control diet. In hens fed the control diet the cholesterol level in egg yolk was higher than that of hens fed 5% and 10% sugar syrup diets. The cholesterol level present per gram egg of hens fed control diet was also higher than that of hens fed 5% and 10% sugar syrup diets (Table 5).

### 3.4. Effect of the dietary treatments on serum protein level in layers

The concentration of total protein in serum samples is shown in Table 6. Serum protein level in hens fed 5% and 10% sugar syrup diets were significantly higher than those found in the control group hens at the day 105. However, higher concentration ( $P < 0.05$ ) in serum protein was noticed only in the 10% sugar syrup diet group compared with the control group at the day 120. Serum protein levels were elevated in sugar syrup groups with advancement of egg production (days 105 and 120) when compared with the control.

### 3.5. Electrophoretic profile of serum proteins in layers

Protein separation methods revealed 4 protein bands appeared to differ between layer groups at 90, 105 and 120 days of laying.

**Table 3**  
Effect of dietary treatments on feed intake and body weight of laying hens.<sup>1</sup>

Variable	Dietary treatments		
	Control	5% sugar syrup	10% sugar syrup
Feed intake, g			
Weeks 31 to 34	3,630 ± 0.03	3,610 ± 0.01	3,600 ± 0.00
Weeks 35 to 38	3,430 ± 0.03	3,470 ± 0.03	3,470 ± 0.02
Weeks 39 to 42	3,470 ± 0.04	3,520 ± 0.06	3,510 ± 0.04
Weeks 43 to 46	3,740 ± 0.08	3,770 ± 0.07	3,600 ± 0.03
Weeks 47 to 50	3,550 ± 0.17	3,400 ± 0.11	3,400 ± 0.11
Overall	3,564 ± 55.82	3,554 ± 63.92	3,516 ± 38.54
Body weight, g			
Weeks 31 to 34	1,713 ± 0.02	1,710 ± 0.02	1,674 ± 0.01
Weeks 35 to 38	1,830 ± 0.02	1,820 ± 0.01	1,780 ± 0.02
Weeks 39 to 42	1,850 ± 0.03	1,850 ± 0.03	1,820 ± 0.02
Weeks 43 to 46	1,870 ± 0.02	1,850 ± 0.04	1,880 ± 0.02
Weeks 47 to 50	1,830 ± 0.02	1,810 ± 0.01	1,810 ± 0.02
Overall	1,818 ± 27.42	1,808 ± 25.76	1,792 ± 33.85

<sup>1</sup> Hens within each group were designated to 5 replicates ( $n = 20$  per replicate).

**Table 4**  
Effect of dietary treatments on biochemical parameters of laying hens.<sup>1</sup>

Parameter	Dietary treatments		
	Control	5% sugar syrup	10% sugar syrup
Glucose, mg/dL	240.00 ± 4.58	241.33 ± 8.09	247.67 ± 2.03
Creatinine, mg/dL	0.20 ± 0.00	0.20 ± 0.00	0.20 ± 0.00
Total protein, g/dL	4.57 ± 0.27	4.97 ± 0.28	4.57 ± 0.20
Creatine kinase, IU/L	1,996 ± 479.68	1,535 ± 476.51	1,800 ± 398.88
Alanine amino-transferase, IU/L	4.33 ± 0.33	4.67 ± 0.67	3.67 ± 0.33
Aspartate aminotransferase, IU/L	166.3 ± 14.84	194.3 ± 30.15	143.3 ± 10.37
Lactate dehydrogenase, IU/L	756.0 ± 375.02	647.7 ± 291.29	432.7 ± 77.26
Gamma glutamyl transferase, IU/L	44.67 ± 0.67	47.00 ± 2.52	44.67 ± 2.19
Calcium, mg/dL	20.13 ± 0.23	20.17 ± 2.31	22.63 ± 0.54
Phosphorus, mg/dL	5.90 ± 0.12	5.03 ± 0.09	5.84 ± 0.46
Iron, µg/dL	704.3 ± 37.76	709.0 ± 48.8	742.3 ± 12.47
Copper, µg %	29.6 ± 2.73	27.0 ± 1.00	36.0 ± 1.15

<sup>1</sup> Hens within each group were designated to 5 replicates ( $n = 20$  per replicate).

The calculated molecular weights of the pointed protein bands were 50, 45, 28 and 12 ku, respectively (Fig. 1). The light transparency of protein bands slightly varied between treatments (Table 7). The protein band No. 4 disappeared with advancement of egg production while other band (bands 2 and 3) increased in their intensities.

#### 4. Discussion

Chicken meat and eggs contain high-quality protein with minimum fat. Compared with the egg, no other food of animal origin is prepared in a variety of ways, and egg is the second most widely consumed food all over the world (Surai and Sparks, 2001). The poultry feed constitutes a major role in maintaining the egg composition. The type of the feed and its ingredients contribute alterations in the cholesterol level and fatty acid profile of the laying hens' egg yolk (Bourre, 2005; Fraeye et al., 2012). Mature grains such as corn or oats are now widely used as ingredients in animal feeds. Sugar syrup produced by crystallization from molasses is a good source of sugar which is used as poultry feed.

The quality of produced eggs directly influences the economic income in the poultry industry. The result of egg production by the layers showed no significant difference between corn diet groups and sugar syrup diet groups. In laying hens fed 5% and 10% sugar

**Table 5**  
Effect of dietary treatments on egg cholesterol content in laying hen.

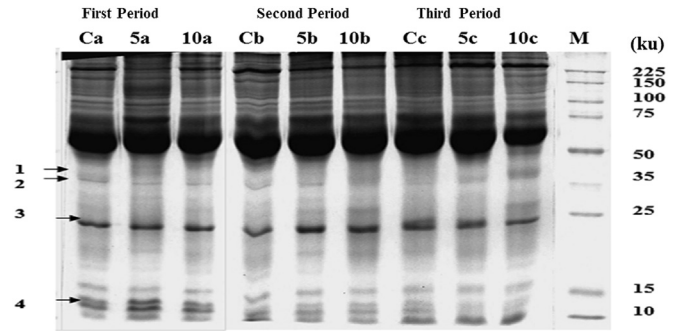
Parameter	Dietary treatments			Pooled SEM
	Control	5% sugar syrup	10% sugar syrup	
Cholesterol, mg/g yolk	15.22 <sup>a</sup>	11.15 <sup>b</sup>	8.81 <sup>c</sup>	0.046
Cholesterol, mg/g egg	4.86 <sup>a</sup>	3.12 <sup>b</sup>	2.56 <sup>c</sup>	0.103

<sup>a-c</sup> Means ± SE bearing different superscripts within a row are significant ( $P < 0.05$ ).

**Table 6**  
Effect of dietary treatments on total protein (g/dL) in blood serum of laying hen.

Treatments	First period	Second period	Third period
Control	5.37 ± 0.03 <sup>a</sup>	4.75 ± 0.32 <sup>b</sup>	4.63 ± 0.10 <sup>b</sup>
5% sugar syrup	5.18 ± 0.05 <sup>a</sup>	5.60 ± 0.03 <sup>a</sup>	4.52 ± 0.15 <sup>b</sup>
10% sugar syrup	4.67 ± 0.10 <sup>b</sup>	5.85 ± 0.25 <sup>a</sup>	5.30 ± 0.15 <sup>a</sup>

<sup>a,b</sup> Means ± SE within a column with different letters differ significantly ( $P < 0.05$ ).



**Fig. 1.** Electrophoretic profile of serum proteins of layers at 3 periods of egg production. First period: Ca - control, 5a - 5% sugar syrup, 10a - 10% sugar syrup. Second period: Cb - control, 5b - 5% sugar syrup, 10b - 10% sugar syrup. Third period: Cc - control, 5c - 5% sugar syrup, 10c - 10% sugar syrup. M: Marker Protein 1,2,3,4 represents protein bands.

syrup diets, the egg production were similar when compared with hens fed the corn diet. Supplementation of sugar syrup to layer diets significantly increased Haugh unit scores of hens when compared with hens fed corn diets. There was no significant difference in egg weight and eggshell thickness of hens fed sugar syrup diets when compared with hens fed the corn diet. Sugar syrup diets enhanced the egg production in layers and the production performance was comparable to hens fed corn diets. Thus, layer diets formulated with sugar syrup as a source of energy were sufficient for hen egg production. Author did not find studies regarding use of sugar syrup in laying hens' diets and the results suggest the supplementation of layer diets with 5% or 10% sugar syrup can replace part of dietary corn without affecting the production performance of hens. The metabolizable energy of starch present in corn diet is less when compared with simple sugars, and the sugar syrup diet is a better supplement for laying hens than corn diet. The egg production performance can be increased by supplementing the diets with substituents (omega-3 rich microalgae species), and the nutritionally fortified eggs can enhance the utilization of favorable substituents without altering human normal diets (Bruneel et al., 2013; Sim and Sunwoo, 2000). The use of sugar syrup is much less expensive when compared with ordinary sources of energy, such as corn and wheat. Supplementation of sugar syrup increases shell weight and its thickness which may be associated to its active constituents. It could be hypothesized that sugar syrup increased thickness and weight of egg shell more than the control treatment. Eggshell relative weight, eggshell thickness and eggshell strength are important indicators of eggshell quality, which is important for the storage and transportation of eggs. The improved eggshell weight and Haugh unit scores in hens fed sugar syrup diets showed that sugar syrup may increase the stability and safety of eggs. The Haugh unit score is related to shelf life and is an indicator of egg freshness (Williams, 1992).

The preliminary findings of using sugar syrup in the layers growth performance are encouraging. The results showed that layer diets substituted with sugar syrup has no difference in feed intake, feed conversion ratio and body weight of hens when compared with hens fed corn diets and sugar syrup can be included in the layer diets instead of corn. Although poultry diets are not usually formulated for a specific sugar concentration, almost all feedstuffs used in poultry diets contain some form of sugar, and some feedstuffs have very high sugar content. Fiber and starch are the prominent storage polysaccharides fed to poultry, but simple sugars are excellent energy sources and their impacts on animal productivity are of interest among poultry nutritionists. Hussein et al. (2016) reported that supplementation of sugar syrup to the

**Table 7**  
Effect of dietary treatments on light transparency (%) for protein bands in blood serum of laying hens.

Band number (approximate molecular weight)	First period			Second period			Third period		
	Control	5% sugar syrup	10% sugar syrup	Control	5% sugar syrup	10% sugar syrup	Control	5% sugar syrup	10% sugar syrup
Band 1 (50 ku)	0.09	0.12	0.09	0.11	0.11	0.09	0.14	0.14	0.12
Band 2 (45 ku)	0.10	0.11	0.15	0.12	0.11	0.10	0.11	0.11	0.09
Band 3 (28 ku)	0.11	0.11	0.12	0.12	0.11	0.10	0.11	0.11	0.11
Band 4 (12 ku)	0.09	0.07	0.08	0.11	0.12	0.12	0.12	0.14	0.15

starter diets of broilers at 5% to replace portion of yellow corn and more than 50% of the added fat resulted in similar body weight gain compared with the control treatment, and was significantly higher than birds fed 10% sugar syrup diets only. The feed intake of broiler chicks fed the control diet was significantly less when compared with chicks fed diets supplemented with 5%, 10% or 15% sugar syrup at 3 weeks of age and no significant effect on average feed intake by the finisher diets. Studies showed that adding sugar diets in ruminant feeds increased feed intake. The dry matter intake was increased linearly in ruminants as sucrose supplementation in the diet was increased to 7.5% of dietary dry matter (Broderick et al., 2008). In early lactating cows, feeding sucrose at 4.7% of dietary dry matter increased dry matter intake (Penner and Oba, 2009).

For assessing the health status of poultry fed diets with unconventional feeds, serum biochemical parameters play an important role in providing useful information about the metabolic alterations of organs and tissues (Kudair and Al-hussary, 2010). Several factors were reported to cause a considerable influence on serum biochemical parameters of chickens including feed additives, genotype and environmental temperature (Sirvydis et al., 2006; Melesse et al., 2011). Sugar syrup treatment increased total proteins and reduced the egg cholesterol levels in laying hens. It has been reported that the serum protein level in birds is less than that of mammals (Kaneko, 1997). In mammals, the protein level is 50 to 70 g/dL, while in birds the protein level is approximately 40 g/dL (Griminger and Scanes, 1986). Maintaining the osmotic pressure in birds is fulfilled by blood glucose (14 mmol/L), a substitute for low protein concentration. It is known that particular proteins characterize each animal and the genetic relationships are reflected in the protein structure. Moreover, the functional, metabolic and health status of individuals can be reflected by the relationship between individual fractions of proteins. In hens fed 10% sugar syrup diets, a significant decrease was noted in AST and ALT activity. Enzymes like ALT and AST are present in liver and these enzymes are released to the blood when liver get damaged (Kaplan et al., 2003). Due to certain disease conditions such as hypoxia in circulatory system, inflammation and hepatocyte proliferation, the permeability of hepatocellular membrane get altered which leads to elevated levels of AST and ALT in serum. Aspartate amino transferase and ALT activities were also increased in broiler chickens with stunting syndrome which was correlated to damage of intestine and liver (Prameela et al., 2011). In the present study, among hens fed different diets there was no significant difference in the level of serum ALT, AST and creatinine. The results showed that layers fed sugar syrup diet have normal liver and intestinal functions.

Most egg lipids consist of phospholipids, triacylglycerols, lipoproteins and cholesterol, which are concentrated in the yolk. Nutritional factors may affect the deposition of cholesterol in the yolk of egg. The lipid profile and cholesterol content of egg were reduced by the supplementation of specific feed additives in diets of layers (Hargis et al., 1991; Weggemans et al., 2001). The results showed that a decrease in cholesterol content was observed in the egg yolk of sugar syrup diet fed hens. In domestic fowl, the lipid

content of egg was influenced by age of the bird (Hall and McKay, 1993).

Plasma proteins present in blood are indicators of animal health and performance due to a number of physiological functions. Plasma protein acts as a rapid substitute for essential amino acids and provides glucose to animal body through gluconeogenesis. They play an important role in the transport of hormones, minerals and help to maintain osmotic pressure and regulate immune system of the organism. In the present study, the electrophoretic profile of hens' serum proteins showed multiple bands during the 3 laying periods. During the laying period, proteins in serum like vitellogenin, very low-density lipoprotein (VLDL) and some precursors in egg white are detected in blood stream of hens (Schneider, 1995; Ito et al., 2003). There was an association between some serum proteins and egg production at a later stage of production in Taiwan red-feathered chickens (Liou et al., 2007). Results showed that there was no correlation between total serum protein concentration and egg production. However, it was found that some association of specific protein bands with sugar syrup level and stages of egg production. One of the major factors affecting the protein profile in blood is nutrition. In birds, the major cholesterol transporters are high-density lipoprotein ( $\alpha$ -2 globulin fraction) and LDL ( $\beta$ -globulin fraction) and these transporters carried majority of the total serum proteins (Zantop, 1997).

## 5. Conclusion

There is a continuous demand for alternative energy sources for poultry due to insufficient supply, high prices and competition with the biofuel industries. In the present study, no significant differences were found between layer groups treated with corn diets and sugar syrup diets. The feed intake, body weight, egg production performances, blood biochemical parameters and electrophoretic profile of serum proteins were similar in all dietary treatments. In hens fed 10% sugar syrup diet, the cholesterol levels of eggs were significantly reduced when compared with hens fed the control diet. Results demonstrated normal production and growth performance of hens fed sugar syrup, providing sugar syrup as a promising substitute in poultry diets. This study suggests for the utilization of a new by-product from sugar refinery in the form of sugar syrup in poultry production. Sugar syrup can be included in layer diets to replace corn in poultry diets in the Middle East, where an abundance of sugar refinery by-product is available. Utilization of this by-product can reduce the budget for feed in poultry sector. Also, its high metabolizable energy makes sugar syrup as an economical substitute for corn and fat in poultry diets. Future research needed to explain the mechanism, significance and the innovative use of sugar syrup as a viable source of energy for the animal feed industry.

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