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Original research article

Graded levels of sugar syrup in broiler rations and its effect on growth performance and blood biochemical parameters

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ABSTRACT

Dietary energy for chickens normally includes cereal grains and fat. This innovative study investigated the effect of replacing part of the corn and fat in broiler chicken rations with graded levels of sugar syrup on growth performance and biochemical parameters. Experimental treatments consisted of feeding a corn-soy basal diet alone, or with graded levels of sugar syrup in increments of 5%, 10% and 15%. All starter diets were isonitrogenous and isocaloric. Body weight gain and efficiency of feed utilization of chicks fed the control diet alone were not significantly ($P < 0.05$) different from chicks fed diets supplemented with either 5% or 15% sugar syrup. Supplementation of sugar syrup to broiler diets had no significant effect on blood glucose, creatinine, total protein, or liver enzymes. Adding 5% sugar syrup to broiler rations significantly decreased blood cholesterol and triglycerides in chickens fed the sugar syrup diet compared with birds fed the control diet. In conclusion, the results shows sugar syrup can be used in poultry ration to replace part of the corn as a source of energy. These results allowed the authors to recommend the safe usage of sugar syrup in broiler rations.

1. Introduction

The most vital nutrient in the poultry ration is considered "dietary energy" even though energy itself is not converted into glucose in meat or eggs except for liponeogenesis. Moreover, it is used as fuel for the synthesis of meat and eggs. Therefore, 60% to 65% of metabolizable energy in the poultry ration is imputed to carbohydrates. Dietary carbohydrates are important sources of energy for poultry. Cereal grains such as corn, sorghum, wheat, and barley contribute most of the carbohydrate component to poultry diets. The majority of the carbohydrate content in cereal grains occurs as starch, which is readily digested by poultry (Franco et al., 1995). Therefore, in poultry rations, cereal grains are the most acceptable source of energy. The physiological mechanisms by which poultry respond to different dietary energy concentrations are not known, although several possible mechanisms have been proposed (NRC, 1984). In order to increase dietary energy, the addition of oil and fat is commonly practiced. A number of studies suggest the use of fatty acids in the diet for increasing energy (Guo et al., 2004; Hosseini-Mansoub and Bahrami, 2011; Fritsche et al., 1991b; Leeson and Summers, 1976; Fuller and Dale, 1982; Ketels and De Groote, 1987). Very little research has involved the use of sugar in animal feed (Jimenez-Moreno et al., 2011, 2013; Gonzalez-Alvarado et al., 2010; Burritt et al., 2005; Lumpkins et al., 2004; Hall, 2002; Iji et al., 2011; Chamberlain et al., 1993) although the NRC suggested a poultry ration using up to 15% pure sucrose (NRC, 1994).

The saliva and crop of the chicken contain some α-amylase enzyme, but little starch digestion has been demonstrated in the crop and proventriculus gizzard. Digestion of most polysaccharides into monosaccharide and their subsequent absorption, takes place in the small intestine. Alpha-amylase is secreted from the pancreas

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into the duodenum and this hydrolyses the α-1,4-linkages on both sides of the 1,6-branching points in starch, producing mainly maltose and some branched oligosaccharides (isomaltose). The enzyme maltase, also called α-glucosidase, splits maltose, while oligo-1, 6-glucosidase (isomaltase) produced by the intestinal mucosa hydrolyses the branched oligosaccharides into glucose. The brush border membrane of the jejunum contains other disaccharidases that complete the digestion of complex dietary polysaccharides into monosaccharide. Sucrose is hydrolyzed by sucrase into glucose and fructose, while lactase converts any lactose into glucose and galactose (Mahagna and Nir, 1996). It is known that sugar is a better energy source than starch in the animal system. The greatest maltase activity is in the jejunum, followed by the ileum, with the lowest value in the duodenum (Sklan and Noy, 2003). It is therefore seen that the metabolizability of sucrose is significantly higher than starch.

A recent advance in feed technology and animal nutrition is the development of sugar syrup, an intermediary product of sugar refining as energy feed for poultry (John, 2008). In the Middle East where the cost of grain is increasing exponentially, the ready availability of sugar syrup has been considered a recourse to poultry feed. Molasses is the last residual produced by sugar mills. It is highly viscous (<100,000 cP at 25°C) with 48% sugar and more than 20% ash. Because of repeated boiling (about 13 times) the sugar is caramelized and binds to organic substances like glue and polysaccharides, which depresses the digestibility of dry matter. In fact, sugar companies have not shown an interest in increasing the quality of molasses since its main use has been for alcohol production, and therefore, was not measured as an energy source in animal feeds. As well, it is often used as a binder, dust reducer and sweetener with a low inclusion rate, so the demand for use of molasses in animal rations has been low. Al Khaleej Sugar Co, the largest sugar refinery in United Arab Emirates decided to focus on improving the quality of molasses as a suitable feed ingredient and defined the process parameters at 76% sugar. The resulting product, termed "Sugar Syrup" (referred to hereafter as "sugar syrup"), provides an instant energy feed and is a better substitute for starch/grains and vegetable oil. Sugar syrup has no physical limitations on incorporation in ration and maintains the binding effect while being more aromatic and palatable. It is also heavily incorporated in mash feeds and contains no aflatoxin.

Chickens need glucose for tissue multiplication, egg production and maintenance. Instead of glucose, metabolizable energy was used in nutritional requirement calculations. Today, nutritionists specify the need to use 2 kg feed per 1 kg meat and 4 kg per one dozen eggs. The normal poultry ration consists of about 60% grain. Out of 2,900 kcal ME, the requirement for poultry is about 2,000 kcal which comes from grain or starch. Therefore, glucose is a vital nutrient in the ration (Kocher et al., 2002). The success of introducing sugar syrup depends on its wider acceptance as a glucogenic feed. The above information encourages animal scientists to examine and further refine sugar syrup as a future energy feed in the Middle East. In order to investigate the efficacy of sugar syrup as a dietary energy for poultry, a feeding trial was carried out to investigate the effect of using graded levels of sugar syrup to replace part of the corn and fat in chicken rations on the growth performance of broilers, and blood biochemical parameters.

2. Materials and methods

2.1. Birds and dietary treatments

Triplicate groups of 100 chicks (one-day-old Hubbard commercial broiler chicks, straight run), were randomly assigned to 4 dietary treatments. The chicks were housed on floor pens, 100 per pen, with 3 groups of 100 birds per dietary treatment. The calculated nutrient composition of the dietary treatments (Tables 1 and 2) was based on the ingredients composition tables of Hashim et al. (2013). The experiment was conducted over a five-week period. Feed and water were given on an *ad libitum* basis.

2.1.1. Starter and finisher diets

All starter diets were isonitrogenous (22% CP) and isocaloric (3,000 cal/kg), and fed to birds for 3 weeks. Diet 1 (control) was a corn-soybean starter diet with no added sugar syrup. Diets 2, 3, and 4 were corn-soybean rations containing 5%, 10%, and 15% sugar syrup, respectively (Table 1). The finisher diets were isonitrogenous (20% CP) and fed birds for 2 weeks. Diet 1 (control) was corn-soybean finisher with no added sugar syrup. Diets 2, 3, and 4 were corn-soybean finisher rations containing 5%, 10%, and 15% sugar syrup, respectively (Table 2).

2.2. Blood samples

Blood samples were collected in test tubes with heparin as an anticoagulant. On day 35, 2 chicks were selected at random from each replicate group. Samples were centrifuged for 10 min at 1,000 × *g*. Plasma was then separated, pooled and stored in eppendorf tubes at −20°C until analysis.

2.3. Tissue and liver samples

At the end of the experiment, 3 chickens (of average weight) from each replicate group were slaughtered, processed and the eviscerated carcasses were weighed. Tissue and liver samples were collected; liver samples underwent histopathological examination (fatty liver syndrome) at the Al-Ain Municipality Animal Veterinary Hospital, Al Ain, UAE. The conventional slaughterhouse procedure was used, with carcass yield determined according to methods outlined and reported by AOAC (1984). Growth performance parameters were measured, and live body weight, feed intake at 21 and 35 days of age, mortality rate and feed conversion ratio were calculated.

2.4. Biochemical analysis

Plasma total calcium, phosphorus, sodium, potassium and iron were determined using procedures for the Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-OES) described by Varian, Inc. ICP-OES Spectrometers operation manual (2002). Blood plasma glucose, creatinine, total protein, alanine aminotransferase, asparatate aminotransferase, gamma glutamyl transferase, cholesterol, HDL-cholesterol and triglycerides were measured using commercial systems (Udichem Elite, United Diagnostics Industry, Dammam, Kingdom of Saudi Arabia) and based on methods used and outlined by Wissam et al., 2008.

2.5. Statistical analysis

The collected data were subjected to a one-way ANOVA (Snedecore and Cochran., 1980) and performed using a program for microcomputers (Statistix, V. 4.0, Analytical Software, Tallahassee, FL., 32317). Also, certain data were subjected to analysis of variance testing with sub-sampling for the effect of the level of sugar syrup as well as linear, quadratic and cubic effects. A probability level of <0.05 was required for significance.

Table 1
Composition of experimental starter diets (dry matter basis) for broiler chicks.

Ingredients, %	Control diet[1]	5% sugar syrup diet[2]	10% sugar syrup diet[3]	15% sugar syrup diet[4]
Corn	57.89	53.92	48.680	42.60
Soybean meal (480 g CP/kg)	35.10	35.49	35.800	36.850
NaCl	0.48	0.39	0.35	0.33
Limestone (400 g Ca/kg)	1.32	1.25	1.25	1.20
Dicalcium phosphate	1.72	1.70	1.67	1.67
Vitamin-mineral mix[5]	1.00	1.00	1.00	1.00
DL-methionine	0.19	0.25	0.25	0.28
Corn oil	2.30	1.00	1.00	1.10
Sugar syrup	0.00	5.00	10.00	15.00

[1] Calculated nutrient composition is: protein, 22.00%; ME, 3.00 Mcal/kg; Met, 0.54%; Met + Cys, 0.91%; Lys, 1.22%; calcium, 1.0% and available phosphorus, 0.46%.
[2] Calculated nutrient composition is: protein, 21.92%; ME, 2.95 Mcal/kg; Met, 0.59%; Met + Cys, 0.96%; Lys, 1.22%; calcium, 1.0% and available phosphorus, 0.46%.
[3] Calculated nutrient composition is: protein, 21.62%; ME, 2.95 Mcal/kg; Met, 0.59%; Met + cys, 0.94%; Lys, 1.22%; calcium, 1.0% and available phosphorus, 0.45%.
[4] Calculated nutrient composition is: protein, 21.61%; ME, 2.95 Mcal/kg; Met, 0.59%; Met + Cys, 0.94%; Lys, 1.24%; calcium, 1.0% and available phosphorus, 0.45%.
[5] Provided the following per kilogram of diet: vitamin A 8,820 IU; vitamin D_3, 2,822 ICU; vitamin E, 26 IU, menadione dimethylpyrimidinol bisulfite, 2.0 mg; thiamin, 5.94 mg; riboflavin, 6.2 mg; pantothenic acid, 15 mg; niacin, 44 mg; pyridoxine, 4.5 mg; biotin, 0.23 mg; choline, 1,450 mg; folacin, 0.88 mg; vitamin B_{12}, 0.14 mg; ethoxyquin, 125 mg; Se, 0.24 mg; Cu, 8 mg; I, 1.5 mg; Fe, 120 mg; Mn, 83 mg; Zn, 60 mg; and Co, 5 mg.

Table 2
Composition of experimental finisher diets (dry matter basis) for broiler chicks.

Ingredients, %	Control diet[1]	5% sugar syrup diet[2]	10% sugar syrup diet[3]	15% sugar syrup diet[4]
Corn	61.20	56.74	52.00	47.10
Soybean meal (480 g CP/kg)	30.31	31.00	31.70	32.64
NaCl	0.43	0.39	0.36	0.33
Limestone (400 g Ca/kg)	1.39	1.30	1.28	1.28
Dicalcium phosphate	1.22	1.22	1.200	1.20
Vitamin-mineral mix[5]	1.00	1.00	1.00	1.00
DL-methionine	0.19	0.25	0.25	0.25
Corn oil	4.26	3.1	2.21	1.20
Sugar syrup	0.00	5.00	10.00	15.00

[1] Calculated nutrient composition is: protein, 20.00%; ME, 3.19 Mcal/kg; Met, 0.51%; Met + Cys, 0.85%; Lys, 1.07%; calcium, 0.9% and available phosphorus, 0.36%.
[2] Calculated nutrient composition is: protein, 20.00%; ME, 3.12 Mcal/kg; Met, 0.56%; Met + Cys, 0.90%; Lys, 1.09%; calcium, 0.9% and available phosphorus, 0.36%.
[3] Calculated nutrient composition is: protein, 19.95%; ME, 3.07 Mcal/kg; Met, 0.56%; Met + Cys, 0.90%; Lys, 1.10%; calcium, 0.9% and available phosphorus, 0.36%.
[4] Calculated nutrient composition is: protein, 19.97%; ME, 3.01 Mcal/kg; Met, 0.56%; Met + Cys, 0.89%; Lys, 1.12%; calcium, 0.9% and available phosphorus, 0.36%.
[5] Provided the following per kilogram of diet: vitamin A 8,820 IU; vitamin D_3, 2,822 ICU; vitamin E, 26 IU, menadione dimethylpyrimidinol bisulfite, 2.0 mg; thiamin, 5.94 mg; riboflavin, 6.2 mg; pantothenic acid, 15 mg; niacin, 44 mg; pyridoxine, 4.5 mg; biotin, 0.23 mg; choline, 1,450 mg; folacin, 0.88 mg; vitamin B_{12}, 0.14 mg; ethoxyquin, 125 mg; Se, 0.24 mg; Cu, 8 mg; I, 1.5 mg; Fe, 120 mg; Mn, 83 mg; Zn, 60 mg; and Co, 5 mg.

3. Results

3.1. Growth performance

3.1.1. Starter period

The effect of adding graded levels of sugar syrup (5%, 10% and 15%) to the starting rations upon body weight gain, average feed intake and the efficiency of feed utilization (feed:gain) ratio is shown in Table 3. The addition of sugar syrup to the starter diet at a level of 5% to replace part of yellow corn, and more than 50% of the added fat, resulted in similar body weight gain compared with the control treatment, and significantly ($P < 0.05$) higher than birds fed the dietary treatment supplemented with 10% sugar syrup only. Similar trends were observed regarding feed:gain ratio, and chicks fed a diet supplemented with 5% sugar syrup had a similar feed: gain ratio to the control treatment and significantly ($P < 0.05$) better feed conversion ratio than birds fed the starter diet with 10% sugar syrup only. However, the data showed that feed intake of birds fed the control diet was significantly lower than birds fed diets supplemented with 5%, 10% or 15% sugar syrup at 3 weeks of age.

3.1.2. Finisher period

The effect of adding graded levels of sugar syrup to the finishing rations on body weight average feed intake and the efficiency of

Table 3
Effect of dietary treatments on growth performance of broiler chicks at 3 and 5 weeks of age.[1]

Treatment	Body weight, g	Feed intake, g	Feed: gain
Growth performance during the starter period			
Control	719^{d}	$1,050^{e}$	1.46^{f}
5% Sugar	700^{de}	$1,110^{d}$	1.59^{ef}
10% Sugar	605^{f}	$1,140^{d}$	1.88^{d}
15% Sugar	666^{e}	$1,120^{d}$	1.68^{e}
Pooled SEM	18	18	0.06
Growth performance during the finisher period			
Control	830^{d}	1,490	$1,80^{e}$
5% Sugar	890^{d}	1,470	1.67^{e}
10% Sugar	690^{e}	1,540	2.25^{d}
15% Sugar	780^{de}	1,500	1.94^{e}
Pooled SEM	44	18	0.11
Overall growth performance			
Control	$1,550^{de}$	$2,540^{ef}$	1.64^{e}
5% Sugar	$1,600^{d}$	$2,580^{ef}$	1.63^{e}
10% Sugar	$1,290^{f}$	$2,670^{d}$	2.07^{d}
15% Sugar	$1,440^{e}$	$2,620^{de}$	1.82^{e}
Pooled SEM	48	25	0.07

[d–f] Means within a column with no common superscript differ significantly ($P < 0.05$).
[1] Each value is the mean of 3 replicate groups of 100 chicks each.

feed utilization (feed:gain) ratio is shown in Table 3. Dietary sugar syrup added to finishing rations at a 5% level significantly ($P < 0.05$) increased body weight compared with birds fed diet containing 10% sugar syrup during the finishing period only. Similar trends were observed regarding feed:gain ratio; chicks fed a diet supplemented with 5% sugar syrup had a similar feed:gain ratio compared with the control or 15% sugar syrup treatments and significantly ($P < 0.05$) better feed conversion ratio than birds fed the finisher diet with 10% sugar syrup only. There was no significant effect of dietary treatments on average feed intake.

3.1.3. Overall growth performance

The overall effect of adding graded levels of sugar syrup to poultry rations upon the growth performance of broilers at 5 weeks of age is shown in Table 4. Adding 5% sugar syrup to broiler rations to replace part of the corn in the diet, and about 55% of the fat in the starter and 72% in the finisher diets increased body weight (1,600 g) compared with birds fed the control diet (1,550 g). In addition, body weight gain of birds fed the 5% sugar syrup diet was significantly higher ($P < 0.05$) than birds fed either a diet containing 10% or 15% sugar syrup (1,290 and 1,440 g, respectively). Also, the average body weight gain of birds fed either the control or the 15% sugar syrup diets was not significantly different. The average feed intake of birds fed either the control or the 5% sugar syrup diets were similar and not significantly different from birds fed the 15% sugar syrup diet, but were significantly different from birds fed the 10% sugar syrup diet. The efficiency of feed utilization (feed: gain ratio) data showed that birds fed the control, 5% and 15% sugar syrup diets had similar feed:gain ratios and were significantly different from birds fed the 10% sugar syrup diet.

3.2. Tissue samples

The pathological finding of liver samples in all treatments indicated little change in the fat tissue, and no fatty liver syndrome cases were observed in any treatment group.

3.3. Biochemical parameters

The effect of dietary treatments on chicken blood biochemical parameters is shown in Table 4. In this present study, supplementation of sugar syrup to broiler diets had no significant effect on blood plasma glucose, creatinine, total protein, alanine amino-transferase, asparatate aminotransferase, gamma glutamyl transferase, calcium, phosphorus, sodium, potassium or iron. However, the addition of sugar syrup to broiler rations significantly ($P < 0.05$) decreased blood cholesterol in 197 chickens fed sugar syrup diets compared with birds fed the control diet (Table 4). A significant negative linear and quadratic effect of sugar syrup on blood cholesterol level was observed. In addition, adding 5% sugar syrup to poultry rations significantly reduced blood triglycerides compared with the control treatment. Furthermore, a significant negative quadratic effect of sugar syrup on blood triglycerides level was observed. The HDL-cholesterol level was significantly higher in birds fed the control diets compared with the sugar syrup treatments. Also, a significant negative linear and quadratic effect of sugar syrup on blood HDL-cholesterol level was observed. The addition of sugar syrup to broiler rations numerically decreased blood LDL-cholesterol in chickens fed sugar syrup diets compared with birds fed the control diet (Table 4).

4. Discussion

There is no research published to date regarding use of sugar syrup in animal or poultry feed. However, this study modified data of sugar syrup chemical analysis (Table 5) based on the composition of sugar syrup as reported by John (2008). Syrup used in these experiments was produced by Al Khaleej Sugar Co. LLC, Dubai (the largest sugar refinery in the Middle East with 5,000 TPD). Separated by crystallization and centrifuge of sucrose, total sugar content in sugar syrup is estimated at around 76%. Compared with corn, which is the dominant poultry feed, with total metabolizable energy at 14.1 MJ/kg (Scott et al., 1982), sugar syrup has 15.6 MJ/kg. The higher metabolizability of sugar in comparison with starch raises its

Table 4
The effect of dietary treatments on chicken's blood biochemical parameters.[1]

Parameters	Control	Dietary treatments			Pooled SEM
		5% sugar	10% sugar	15% sugar	
Cholesterol, g/dL[2,3]	157.12^{d}	135.30^{e}	132.80^{e}	128.60^{e}	3.60
Triglyceride, mg/dL[3]	80.28^{d}	68.10^{e}	72.98^{de}	77.20^{de}	3.76
LDL cholesterol, mg/dL	49.23	48.56	42.00	37.38	6.50
HDL cholesterol, mg/dL[2,3]	92.03^{d}	73.12^{f}	72.02^{f}	80.00^{e}	0.37
Glucose, mg/dL	269.7	297.7	276.3	304.7	10.1
Creatinine, mg/dL	0.367	0.267	0.367	0.433	0.052
Total protein, g/dL	2.33	1.83	2.10	2.63	0.194
Alanine amino-transferase, IU/L	4.67	4.67	5.00	4.33	0.58
Asparate amino-transferase, IU/L	202.7	174.0	204.3	195.0	11.4
Gamma glutamyl transferase, IU/L	25.0	21.0	26.3	26.7	2.0
Calcium, mg/dL	13.1	14.8	12.2	12.8	1.6
Phosphorus, mg/dL	4.9	4.1	5.1	6.5	1.0
Sodium, mmol/L	147.7	145.0	146.0	151.0	1.8
Potassium, mmol/L	6.3	8.0	6.8	7.5	0.5
Iron, μg/dL	93.3	112.7	86.7	117.5	21.8

LDL = low density lipoprotein; HDL = high density lipoprotein.
$^{d–f}$ Means within a column with no common superscript differ significantly ($P < 0.05$).
[1] Each value is the mean of 3 replicate groups. Each blood replicate was collected in test tubes with heparin as an anticoagulant, on day 35 from 2 chicks selected at random from each replicate group. The samples were centrifuged for 10 min at 1,000 × *g*. The plasma was then separated, pooled within replicates, and stored at <0°C until analysis.
[2] Significant linear effect ($P < 0.05$).
[3] Significant quadratic effect ($P < 0.05$).

Table 5
Comparative analysis of sugar syrup[1] and yellow corn.[2]

Item	Corn	Sugar syrup
Dry matter, %	89.0	80.0
Crude protein, %	9.6	4.6
Fiber, %	2.5	0.0
Fat, %	4.1	0.2
Ash, %	1.5	3.0
NDF, %	14.5	0.0
ADF, %	2.6	0.0
Starch, %	75	0.0
Sugar, %	0.0	76.0
Glucose + Fructose, %	0.0	76.0
Metabolizable energy, MJ/kg	14.1	15.6
Calcium, %	0.1	0.92
Phosphorus, %	0.3	0.2
Magnesium, %	0.1	0.17
Potassium, %	0.4	0.85
Sodium, %	0.1	0.1
Lysine, %	0.8	0.02

[1] Typical analysis of sugar syrup was reported by John (2008).
[2] NRC (1994).

ME value (Leeson and Zubair, 1994). In addition, it is an instant energy feed as it contains no ingestible material, has a pleasing aroma and is more palatable. Also, adding sugar syrup could help in eliminating the dust hazard of ingredients and enhance the general appearance of poultry feed. The higher ME availability in feed makes sugar syrup a cheaper economic substitute not only for starch, but for vegetable oil/fat in poultry ration as well. The increase in fatty acids absorption into blood by feeding vegetable fat to poultry causes higher cholesterol in meat and eggs. Adding sugar syrup to feed could lower the cholesterol levels in eggs and meat. Sugar syrup is also low in protein and fat compared with corn, and has no fiber or starch. It is high in ash (4.5%) and has higher levels of calcium and potassium (Table 5).

The results of feeding broiler chicks diets (starter and finisher) containing sugar syrup at a low level of 5% showed growth performance comparable to the conventional corn-soybean meal diet. Also, the preliminary findings of using the higher level of sugar syrup (15%) in the finisher ration are encouraging (Table 3). While there is no research data published until now regarding the utilization of sugar syrup in poultry feed, Preston (1988) indicated that there are studies still in the early stages regarding the substitution of cereal grains with sugarcane juice in poultry rations. Of course, sugarcane juice has similar but not the same chemical composition as sugar syrup. Also, the results of preliminary experiments in Colombia using sugarcane juice to replace part of the cereal grains in the poultry diet showed that growth and feed conversion rates are only marginally lower than those using a common cereal-based diet. He also indicated that the sugarcane juice carbohydrates (sucrose, glucose and fructose) are completely digestible by non-ruminant animals and thus viable alternatives for starch in commonly use cereal grains.

Sugar syrup supplementation to poultry rations did not affect broiler ration, glucose, creatinine, protein, liver enzymes, Ca, P, Na, K and Fe (Table 4). These blood biochemical levels were within the normal average levels reported earlier (Rupley, 1997). Replacing part of the cereal grain and fat in broiler ration with 5% sugar syrup significantly reduced blood cholesterol and triglyceride levels compared with birds fed the conventional cereal-based (control) diet. In this study, blood cholesterol level in the control treatment was similar to the control group obtained by Crespo and Esteve-Garcia (1993), in which they fed birds a similar corn-soybean meal diet. Some signs of watery sticky ends were observed with chicks fed higher levels of sugar syrup (10% to 15%) compared with the control groups. On the other hand, Waliszewski et al. (1997) reported a staining of broiler chicks with black and watery excreta when fed rations containing 4% or 6% of soluble cane condensed molasses. Recent developments in the area of poultry nutrition focus on feed conversion efficiency of broiler chickens. The breeding of high conversion efficient strains in broiler breeds also necessitates the evolution of conversion efficient feeds. Low fiber and high energy/protein feed would go a long way in ameliorating the metabolism in chickens, which converts feed nutrients more to tissue structure by minimizing the nutrient loss in the system. The advent of feeding fatty acids increased the conversion efficiency; however, it also increased triglycerides in the blood stream, resulting in high cholesterol, fatty liver syndrome and high adipose fat deposition. Counter to that, this study showed the improvement of broiler chicks' growth syndrome, supporting the suggested advantages of feeding broilers diets containing 5% sugar syrup. In addition, sugar syrup could be a better option as it is an instant energy feed with higher ME value when compared with starch, similarly borne out by other studies using various forms of sugar. Leeson and Zubair (1994) and Mahagna and Nir (1996) have indicated that the ME value of sucrose is significantly higher than that of starch. In animal systems, sugars (sucrose) have been accepted as a better energy source than starch (Chamberlain et al., 1993; Burritt et al., 2005). The innovation of sugar feeding introduced the supply of glucose as dietary energy which could substitute part of the fatty acids feeds.

5. Conclusions

The present study suggests utilizing a new by-product of processed sugar–sugar syrup in poultry production. Sugar syrup can be included in broiler diets to enhance growth performance in areas where an abundance of this sugar mill by-product is available, such as in the Gulf region. Also, its high ME value makes it an economical substitute for corn and fat in poultry rations. Whereas more definitive research work needs to be done to explain the mechanism and significance of these observations, and the innovative use of "Sugar Syrup" has generated a viable option for the feed industry.

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