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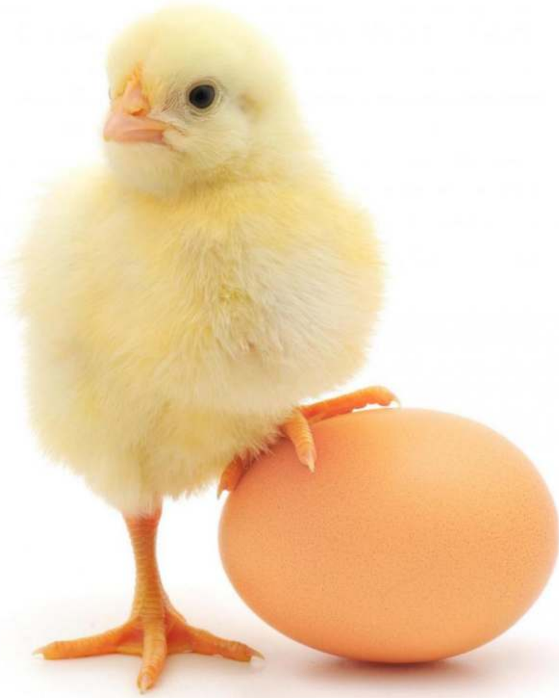

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# Effect of Adding Dietary Date (*Phoenix dactylifera*) Pits Meal With/or Without β-mannanase on Productive Performance and Eggshell Quality Parameters of Layer Hens

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**Abstract:** To study the effects of adding date pits meal supplemented with beta-mannanase into diets on the productive performance and eggshell quality parameters, a total of 324 Hisex layer hens were randomly divided into 81 cages. Nine iso-energetic and iso-nitrogenous experimental diets in a 3 x 3 factorial arrangement including three levels of date pits meal (0, 5 and 10%) supplemented with three levels (0 or 330, 660 g of beta-mannanase/ton feed). Each dietary treatment was fed to 9 cages (4 birds/cage) for 8 weeks trail period after production peak from 45 to 53 weeks of age. Results showed significant ($p \leq 0.05$) differences among treatments in feed consumption, feed conversion ratio, egg mass, egg production, eggshell weight, eggshell weight percentage, eggshell thickness and eggshell weight per surface area. It can be concluded that date pits meal could be partly added into diets as alternative feedstuffs up to 10% with supplementation of 660 g beta-mannanase/ton feed supplementation individually without negative effects on productive performance and eggshell quality characteristics of Hisex layer hen from 45 to 53 weeks of age. Further research on the effects of adding different levels of date pits meal supplemented with different levels of beta-mannanase at different ages on productive performance and eggshell quality parameters for layer hens are required to attain the optimal results.

**Key words:** Beta-mannanase, date pits meal, eggshell quality, layer hens, productive performance

## INTRODUCTION

The restriction and shortage of high-quality conventional poultry feed ingredients considered as major problems facing poultry industry development in many tropical and sub-tropical developing countries. Therefore, poultry nutritionists have been focused searching suitable poultry unconventional feed ingredients to replace some of the expensive common feed ingredients with locally available untraditional feedstuffs to reduce the poultry feed cost (Al-Harthi *et al*., 2009).

The date palm (*Phoenix dactylifera*, L.), is a drought-tolerant woody plant cultivated in the tropical and subtropical countries for human consumption (Moghaieb *et al*., 2011). Egypt, Saudi Arabia, Iran, Iraq, United Arab Emirates, Algeria and Pakistan produce more than 70-90% of the world date production (Al-Homidan 2003; El-Habba and Al-Mulhim, 2013). Saudi Arabia alone produces more than 25 million date palm tree with around one million ton date yearly and this is number expected to increase gradually in coming years. Date pit is a byproduct obtained after oil extraction, processing and manufacturing of the date factories. The date pit represents about 10% of whole date weight, which is inedible for human consumption. It contains a small amount of crude protein and nitrogen-free extract, which somewhat is similar to corn and barley (Kamel *et al*., 1981; Al-Homidan, 2003; Aldhaheri *et al*., 2004).

Date pits meal contain about 89.70-97.5% dry matter, 1,350-2,000 kcal metabolizable energy/kg, 56.0-68.9% total carbohydrates, 3.8-5.8% total sugars, 2.30-8.20% crude protein, 1.60-13.50% either extract, 13.0-80.20% crude fiber, 0.90-3.95% crude ash, 29.56-75.4% nitrogen free extract, 38.5-73.1% neutral detergent fiber, 17.2-51.0% acid detergent fiber, 0.08% methionine, 0.17% cysteine, 0.19-0.32% methionine and cysteine, 0.19-0.30% lysine, 0.021-0.91% calcium, 0.088-0.096% total phosphorus, 0.03% available phosphorus, 0.043-0.0087% phytate phosphorus and 0.155-0.179% phytic acid (Salem and Hegazi, 1971; Kamel *et al*., 1981; Attalla and Harraz, 1996; Hamada *et al*., 2002; Aldhaheri *et al*., 2004; Najib and Al-Yousef, 2012; Al-Saffar *et al*., 2013; Kashani *et al*., 2013; Ghasemi *et al*., 2014). Najib and Al-Yousef (2012) reported that the dates from different geographical area differed in their nutritional and chemical contents.

In the last few years, several studies reported that date pits meal can be partially used as alternative feed ingredient for poultry nutrition to overcome traditional poultry feedstuffs shortage and to reduce feed costs and to reduce pollution problems (Sawaya *et al*., 1984; Najib

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*et al.*, 1995; Hussein *et al.*, 1998; Perez *et al.*, 2000; Al-Homidan, 2003; Aldhaheri *et al.*, 2004; Al-Harthi, 2006; Najib and Al-Yousef, 2012; Ghasemi *et al.*, 2014).

Several studies reported that the high crude fiber content considered as a limiting factor for using date pits meal in poultry diets (Jackson *et al.*, 1999; Hamada *et al.*, 2002; Najib and Al-Yousef, 2012). The date pits contained about 71.8% mannose, 26.6% galactose and 9.8-22.3% beta-galactomannan polysaccharides (Magdel-Din Hussein *et al.*, 1998; Ishrud *et al.*, 2001; Hamada *et al.*, 2002). The crude fiber (non-starch beta-galactomannan polysaccharides) is recognized as anti-nutritional factor difficult to digests by poultry and required to be broken down by specific exogenous enzymes to improve the utilization and the nutritional value of the date pits meal (Almirall *et al.*, 1995; Cowieson and Ravindran, 2008). The beneficial effect of enzymatic degradation of beta-galactomannan polysaccharide by adding the beta-mannanase into poultry diets has been reported in layer hens (Lee *et al.*, 2003; Daskiran *et al.*, 2004; Wu *et al.* 2005; Kong *et al.*, 2011; Cho and Kim, 2013).

Little research had conducted to investigate the effect of adding beta-mannanase into diets containing different levels of date pits meal on the productive performance and eggshell quality parameters during the 2nd phase of the first laying cycle of layer hen. Therefore, this study was conducted to evaluate the effects of adding three levels (0, 5 and 10%) of date pits meal supplemented with three concentrations (0, 330 and 660 g beta-mannanase/ton feed) on the productive performance and eggshell quality parameters of layer hens during the 2nd phase of the first laying cycle from 45 to 53 weeks of age.

## MATERIALS AND METHODS

The beta-mannanase was obtained from Elnco Co. under a trademark Hemicell®. Date pits used in this study was purchased from local market in Al-Hassa, Saudi Arabia. Date pits was ground in a heavy-duty high rotation hammer mill to pass through 1.2 mm mesh sieve screen, producing a powder suitable for poultry nutrition and chemical analysis. Proximate chemical analysis including the moisture, crude fat, crude protein, crude ash and crude fiber of date pits meal were determined using standard analytical procedures according to AOAC (1995).

**Experimental design:** The current study was carried out in the period from January to March, 2015 at the Agriculture Research and Training Station belonged to King Faisal University, Al Hassa city, Kingdom of Saudi Arabia.

A total of 324 layer hens (Hisex White®, 45-week-old) with an average egg production rate of 59.65%±4.07 during the 2nd phase of the first laying cycle and 1403.13 g ±30.95 live body weight over of 8-week trial period from 45 to 53 week of age were used. Layer hens were weighed and randomly distributed in battery group cages (50 x 30 x 30 $cm^3$) separated by a 1.0 m aisle, equipped with galvanized-iron trough feeders covering the entire front length of metal cages and nipple drinkers. Hens fed nine different dietary treatments with three date pits meal levels (0, 5 and 10%) supplemented with three beta-mannanase levels (0, 330 and 660g beta-mannanase/ton feed) with nine replicates of four layer hens each.

Experimental diets were formulated to meet nutrients recommendation of layer hens based on Hisex management guide. The layer hen diets used in this study were calculated to be isocloric contained 2761 Kcal metabolizable energy per kg of feed and isonitrogenus contained 16.88% crude protein as shown in Table 1. At 45 weeks of age, each hen was fed 120 g once daily at 8 h and water was provided *ad libtum* and subjected to a 16L: 8D light program throughout the whole experimental period.

Body weight, egg production, egg weight, egg mass, feed consumption, feed conversion ratio per egg mass (kg feed per kg egg), egg specific gravity, eggshell weight, eggshell thickness, eggshell weight percentage, eggshell weight per surface area, Haugh unit and egg yolk colour were measured.

Initial body weight at the beginning and the final body weight at the end of the experiment for layer hens were measured and the average body weight gain was calculated by the differences between the two body weights.

Feed consumption and overall egg produced per hen were recorded on daily basis. The feed leftovers from feeders were weighed and the feed consumption was measured. Egg weight, egg mass, eggshell weight, eggshell thickness, egg specific gravity, Haugh units and egg yolk colour for each replicate were calculated at the last 3 consecutive days every 2 weeks. For egg mass calculation, the average daily egg production was multiplied by the average egg weight divided by 100. The feed conversion ratio per egg mass was obtained and calculated as kilogram by the ratio between total feed consumed per hen and total egg mass produced per hen.

Collected eggs were stored overnight in the same room before egg specific gravity was determined. Egg specific gravity was determined by using the saline flotation methods as described by Hempe *et al.* (1998) by immersing the eggs in graded saline solutions of density ranged from 1.065 to 1.120 g/$cm^3$ with interval incremental concentrations of 0.005 g/$cm^3$ between them. After determining egg specific gravity, the same eggs were subsequently broken, their components were separated and then eggshell with shell membranes were washed and left to dry in the air before being individually weighed.

The eggshell thickness including its membranes was a result from the three readings performed at three separate different sites (air cell, equator and sharp end) of the equatorial region of the same eggshell by using an electronic digital caliper scale (pachymeter) with 0.01 mm precision and calculating the average among the three sites. Eggshell weight per surface area expressed in mg/cm$^2$ was determined according to Abdullah *et al.* (1993). The following formula was used:

$$ESWSA = \{EGW / [3.9782 \times (EW0.7056)]\} \times 1000$$

where, ESW: Eggshell weight,
EW: Egg weight,
ESWSA: Eggshell weight/surface area.

Albumen height was measured with an Ames micrometer (model S-6428, Ames, Waltham, MA) at a point halfway between the yolk and the edge of the widest expanse of albumen. Haugh units were calculated as follows:

$$\text{Haugh unit} = 100 \times \log (H+7.57-1.7W^{0.37})$$

where, H is albumin height (mm) and W is egg weight (Panda, 1996). The egg yolk colour was measured using a Roche colorimetric fan (DSM nutritional products Co.). Colour scales ranged from 1 (pale yellow) to 15 (intense orange) according to Well (1968).

**Statistical analysis:** All data were subjected to one-way ANOVA using the GLM procedures of a statistical software package (SPSS 18.0, SPSS Inc., Chicago, IL). Treatment means were expressed as mean±standard error of means (SEM) and separated and compared by the F test ($p \leq 0.05$) using the Duncan's multiple range test (Duncan, 1955).

## RESULTS AND DISCUSSION

The date pits meal used in the present study contained about 97.45% dry matter, 6.40% crude protein, 2,699.5 kcal metabolizable energy, 5.58% crude fat, 46.08% nitrogen free extract (sugar+starch %) and 30.4% crude fiber/kg. The metabolizable energy content of date pits meal used was calculated according to Carpenter and Clegg (1956) equation as follows: metabolizable energy (kcal/kg) = 53+38 [crude protein (%) + (2.25* ether extract (%)+(1.1* nitrogen free extract (%)]. The chemical analysis of date pits meal used in the present study was typically in agreement with the findings of Najib and Al-Yousef (2012), who used the same source of the date pits meal used. The differences in chemical composition of date pits meal among the different studies might be attributed to the variety, stage of maturation, agronomic conditions and degree of dryness.

There were no significant interactions between adding dietary date pits meal and beta-mannanase levels into diets used in the present study on all the productive performance and eggshell quality parameters of the layer hen during the whole 8-week trial period from 45-53 weeks of age.

Results obtained from the present study showed that adding different dietary levels of date pits meal with different beta-mannanase supplementation levels had significant ($p \leq 0.05$) differences among treatments in feed consumption, feed conversion ratio, egg mass, egg production, eggshell weight, eggshell weight percentage, eggshell thickness and eggshell weight per surface area (Table 2 and 3).

Layer hen fed diets containing 10% date pits meal supplemented with either 330 or 660 g beta-mannanase/ton feed had significantly ($p \leq 0.05$) higher feed consumption than those fed diets containing 0, 5, or 10% date pits meal supplemented with 0 g beta-mannanase/ton feed and those fed diets containing 0% date pits meal supplemented with 330 g beta-mannanase/ton feed, but were not different from the other treatments. Also, layer hens fed diets containing 0 or 5% date pits meal supplemented with 660 g beta-mannanase/ton feed showed significantly ($p \leq 0.05$) lower (better) feed conversion ratio than those fed diets containing 5 or 10% date pits meal supplemented with 0 g beta-mannanase/ton feed, while were not different from the other treatments. On the other hand, layer hens fed diets containing 0, 5 or 10% date pits meal supplemented with 660 g beta-mannanase and those fed 10% date pits meal supplemented with 330 g beta-mannanase/ton feed showed significantly ($p \leq 0.05$) higher egg mass and egg production than those fed diets containing 5 and 10% date pits meal supplemented with 0 g beta-mannanase/ton feed, while were not different from the other treatments (Table 2).

The negative effect of adding up to 10% date pits meal without beta-mannanase into layer hen diet on feed consumption might be clearly associated with the presence of non-starch polysaccharide in date pits meal, which increase the viscosity of the gut contents (Ghasemi *et al.*, 2014). Some studies reported that adding date pits meal into layer hen diets decreased the metabolizable energy (Perez *et al.*, 2000) and amino acid availability (Radwan *et al.*, 1997) due to increasing feed passage rate through the gastrointestinal tract. In the other study, Roberts (2004) reported that the digestibility of nutrients and utilization of minerals, especially calcium were markedly reduced by increasing the date pits meal level. The worse feed conversion ratio of layer hen fed diets containing 10% date pits meal supplemented with 0 g beta-mannanase/ton feed exhibited in the present study might be due to the lower egg production and egg mass. Also, it may be related to the adverse effect of anti-nutritional substances as one component of the date pits meal.

El-Bogdady (1995) reported no significant effect on egg weight by adding different levels of date pits meal into

Table 1: Composition and calculated nutritional analysis of isocaloric and isonitrogenous layer diets containing 0.0, 5.0, or 10.0% date pits meal with 0, 330, or 660 g beta-mannanase/ton feed from 45-53 weeks of age

| | DP (%) in layer diet | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | | | 5 | | | 10 | | |
| Beta-mannanase (g/ton feed) | 0 | 330 | 660 | 0 | 330 | 660 | 0 | 330 | 660 |
| **Feed ingredients (%)** | | | | | | | | | |
| Yellow corn | 62.0 | 62.0 | 62.0 | 55.8 | 55.8 | 55.8 | 50.2 | 50.2 | 50.2 |
| Oil | 1.0 | 1.0 | 1.0 | 1.8 | 1.8 | 1.8 | 2.0 | 2.0 | 2.0 |
| Soybean meal (44.5% CP) | 26.4 | 26.4 | 26.4 | 26.8 | 26.8 | 26.8 | 27.2 | 27.2 | 27.2 |
| Date pits meal | 0.0 | 0.0 | 0.0 | 5.0 | 5.0 | 5.0 | 10.0 | 10.0 | 10.0 |
| Limestone | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 |
| Dicalcium phosphate | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Antioxidant | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| L-Lysine | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Choline | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| DL-Methionine | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Vitamin-mineral premix* | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Salt | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| **Calculated nutritional analysis** | | | | | | | | | |
| Energy (Kcal ME/kg feed) | 2762 | 2762 | 2762 | 2775 | 2775 | 2775 | 2748 | 2748 | 2748 |
| Crude protein (%) | 16.89 | 16.89 | 16.89 | 16.86 | 16.86 | 16.86 | 16.88 | 16.88 | 16.88 |
| Crude fat (%) | 2.65 | 2.65 | 2.65 | 2.69 | 2.69 | 2.69 | 2.76 | 2.76 | 2.76 |
| Crude fiber (%) | 3.30 | 3.30 | 3.30 | 4.72 | 4.72 | 4.72 | 6.15 | 6.15 | 6.15 |
| Linolenic acid (%) | 1.57 | 1.57 | 1.57 | 1.43 | 1.43 | 1.43 | 1.31 | 1.31 | 1.31 |
| Calcium (%) | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 |
| Available phosphorus (%) | 0.31 | 0.31 | 0.31 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |

*Vitamin-mineral premix at this rate yields: 149.60 mg Mn, 16.50 mg Fe, 1.70 mg Cu, 125.40 mg Zn, 0.25 mg Se, 1.05 mg I, 11,023 IU vitamin A, 46 IU vitamin E, 3,858 IU vitamin $D_3$, 1.47 mg minadione, 2.94 mg thiamine, 5.85 mg riboflavin, 20.21 mg pantothenic acid, 0.55 mg biotin, 1.75 mg folic acid, 478 mg choline, 16.50 µg vitamin $B_{12}$, 45.93 mg niacin and 7.17 mg pyridoxine per kg diet

Table 2: Productive performance parameters of Hisex white egg layer hens fed diets containing 0, 5, or 10% date pits meal with 0, 330, or 660 g beta-mannanase each from 45 to 53 weeks of age

| Treatment | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| DP | EZ | IBW | BWG | FC | FCR | EW | EM | EP |
| 0 | 0 | 1476.43±35.15 | 143.86±69.55 | 6.74±0.04$^{bcd}$ | 2.81±0.15$^{bc}$ | 65.57±1.34 | 2.44±0.13$^{abc}$ | 66.52±3.19$^{abc}$ |
| | 330 | 1422.50±32.04 | 202.86±67.38 | 6.76±0.04$^{bcd}$ | 2.76±0.09$^{bc}$ | 63.89±0.86 | 2.47±0.08$^{abc}$ | 69.01±2.52$^{ab}$ |
| | 660 | 1460.00±21.21 | 142.50±20.32 | 6.85±0.02$^{ab}$ | 2.59±0.05$^{c}$ | 65.46±0.88 | 2.65±0.05$^{a}$ | 72.39±1.27$^{a}$ |
| 5 | 0 | 1455.83±20.00 | 108.33±55.69 | 6.73±0.03$^{cd}$ | 3.44±0.47$^{a}$ | 65.75±1.08 | 2.12±0.02$^{c}$ | 57.59±6.55$^{c}$ |
| | 330 | 1495.71±20.00 | 121.79±51.93 | 6.85±0.03$^{abc}$ | 2.72±0.15$^{bc}$ | 69.07±3.29 | 2.55±0.11$^{ab}$ | 69.07±3.29$^{ab}$ |
| | 660 | 1408.13±18.10 | 192.19±49.55 | 6.83±0.05$^{abcd}$ | 2.58±0.09$^{c}$ | 62.94±0.86 | 2.67±0.09$^{a}$ | 75.59±2.22$^{a}$ |
| 10 | 0 | 1403.13±30.95 | 273.13±55.56 | 6.71±0.05$^{d}$ | 3.18±0.22$^{ab}$ | 65.50±1.14 | 2.19±0.16$^{bc}$ | 59.65±4.07$^{bc}$ |
| | 330 | 1451.11±138.42 | 214.44±55.87 | 6.93±0.03$^{a}$ | 2.67±0.15$^{bc}$ | 64.89±0.90 | 2.65±0.13$^{a}$ | 72.87±3.32$^{a}$ |
| | 660 | 1428.89±42.73 | 173.89±63.00 | 6.94±0.02$^{a}$ | 2.62±0.05$^{bc}$ | 63.22±0.47 | 2.66±0.05$^{a}$ | 75.10±1.28$^{a}$ |

$^{a-d}$Means±standard error of mean within a column that do not share a common superscript are significantly different ($p \leq 0.05$), DP: Date pits meal (%) into diet; EZ: g beta-mannanase/ton feed, IBW: Initial body weight (g), BWG: Body weight gain (g), FC: Feed consumption (kg/hen), FCR: Feed conversion ratio (kg FC/kg EM), EW: Egg weight (g), EM: Egg mass (kg), EP: Egg production (%)

hen layer diets. Perez *et al*. (2000) indicated that the date pits meal can be added into layer diets up to 50% without significant effect on egg production, egg weight and feed conversion ratio. Also, Kashani *et al*. (2013) found that body weight, egg production, feed consumption, feed conversion ratio and egg mass were not affected significantly by adding date pits meal up to 21% into layer hen diets. In contrast, Najib and Al-Yousef (1994) noted that adding date pits meal into layer hen diets up to 28% decreased the egg production and egg mass. Radwan *et al*. (1997) noted a negative effect of the adding the date pits meal into layer hen diets on productive performance parameters. Recently, Ghasemi *et al*. (2014) showed that adding date pits meal into layer hen diets yielded significant reduction in egg weight and feed conversion ratio.

On the other hand, Hermes and Al-Homidan (2004) found an improvement in the egg production, egg weight, egg mass and feed conversion ratio/egg mass (kg feed/kg egg) for layer hens fed diets containing 10% date pits meal. In addition, Najib and Al-Yousef (2012) noted that layer hens fed 10% date pits meal without enzymes improved the egg production, feed conversion ratio and egg mass, but reduced egg size and increased feed consumption compared to those fed 15% date pits meal without enzymes. Ghasemi *et al*. (2014) found an increase in feed consumption and egg mass of layer hens fed date pits meal. Also, Al-Saffar *et al*. (2013) observed that the adding of 0.1% phytase, multi enzymes (mixture containing protease, amyloglucosidase, xylanase, beta glucanase and

Table 3: Egg shell quality parameters of Hisex white egg layer hens fed diets containing 0, 5, or 10% date pits meal with 0, 330, or 660 g beta-mannanase each from 45 to 53 weeks of age

| Treatment | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| DP | EZ | ESW | ESWP | ESG | EST | HU | EYC | ESWSA |
| 0 | 0 | 8.75±0.18$^{bc}$ | 13.38±0.33$^{cd}$ | 1.078±0.00 | 0.371±0.01$^{cd}$ | 7.49±0.14 | 6.34±0.30 | 11.51±0.26$^{cd}$ |
| | 330 | 8.94±0.10$^{abc}$ | 13.80±0.18$^{bc}$ | 1.102±0.02 | 0.406±0.01$^{a}$ | 7.48±0.22 | 6.33±0.19 | 11.84±0.13$^{bc}$ |
| | 660 | 9.3±0.11$^{ab}$ | 14.73±0.21$^{a}$ | 1.082±0.00 | 0.420±0.01$^{a}$ | 7.48±0.19 | 6.39±0.37 | 12.55±0.16$^{a}$ |
| 5 | 0 | 8.42±0.15$^{c}$ | 12.81±0.24$^{d}$ | 1.074±0.01 | 0.370±0.01$^{cd}$ | 7.47±0.25 | 6.13±0.29 | 11.04±0.19$^{d}$ |
| | 330 | 9.32±0.30$^{ab}$ | 14.07±0.19$^{abc}$ | 1.080±0.00 | 0.400±0.01$^{ab}$ | 7.32±0.30 | 5.89±0.34 | 12.15±0.22$^{ab}$ |
| | 660 | 8.94±0.15$^{abc}$ | 14.20±0.12$^{ab}$ | 1.084±0.00 | 0.410±0.00$^{a}$ | 7.28±0.21 | 6.59±0.30 | 12.08±0.12$^{abc}$ |
| 10 | 0 | 8.54±0.18$^{c}$ | 13.03±0.28$^{d}$ | 1.075±0.00 | 0.355±0.01$^{d}$ | 7.54±0.21 | 6.21±0.33 | 11.22±0.22$^{d}$ |
| | 330 | 8.86±0.20$^{abc}$ | 13.86±0.17$^{bc}$ | 1.080±0.00 | 3.380±0.01$^{bc}$ | 7.70±0.43 | 6.32±0.21 | 11.84±0.17$^{bc}$ |
| | 660 | 9.43±0.25$^{a}$ | 14.41±0.37$^{ab}$ | 1.083±0.00 | 0.403±0.01$^{a}$ | 7.30±0.16 | 6.25±0.29 | 12.40±0.32$^{ab}$ |

$^{a-d}$Means±standard error of mean within a column that do not share a common superscript are significantly different ($p \leq 0.05$), DP: Date pits meal (%) into diet; EZ: g beta-mannanase/ton feed, ESW: Eggshell weight (g), ESWP: Eggshell weight percentage (%), ESG: Egg specific gravity (g/cm$^3$), EST: Eggshell thickness (mm), HU: Huagh unit, EYC: Egg yolk colour, ESWSA: Egghell weight per surface area

cellulose), or hemicellulose into layer hen diets supplemented with 15% date pits meal improved egg production by 12.9, 16.9 and 17.2%, respectively. While, they noted that the adding 0.1% multi-enzyme into layer hen diets containing 30% date pits meal produced similar productive performance to those fed diets containing 0% date pits meal supplemented with the same level of the multi-enzyme. Ghasemi *et al.* (2014) found an increase in feed consumption and egg mass of layer hens fed date pits meal.

Layer hens fed diets containing 10% date pits meal supplemented with 660 g beta-mannanase/ton feed were significantly ($p \leq 0.05$) heavier eggshell weight than those fed diets containing 0, 5, or 10% date pits meal supplemented with 0 g beta-mannanase/ton feed, but were not different from the other treatments. In addition, layer hens fed diets containing 0% date pits meal supplemented with 660 g beta-mannanase/ton feed had significantly ($p \leq 0.05$) higher eggshell weight percentage than those fed diets containing either 0, 5, or 10% date pits meal supplemented with 0 g beta-mannanase/ton feed and those fed diets containing either 0 or 10% date pits meal supplemented with 330 g beta-mannanase/ton feed, but were not different from the other treatments. On the other hand, layer hens fed diets containing 0% date pits meal supplemented with 330g beta-mannanase/ton feed and those fed diets containing either 0, 5, or 10% date pits meal supplemented with 660 g beta-mannanase/ton feed were significantly ($p \leq 0.05$) more eggshell thickness than those fed diets containing 0, 5, or 10% date supplemented with 0 g beta-mannanase/ton feed and those fed diets containing 10% date supplemented with 330 g beta-mannanase/ton feed, but were not different from those fed diets containing 5% date supplemented with 330 g beta-mannanase/ton feed (Table 3). However, layer hens fed diets containing 0% date pits meal supplemented with 660 g beta-mannanase/ton feed recorded significantly ($p \leq 0.05$) higher eggshell weight per surface area than those fed diets containing either 0, 5, or 10% date supplemented with 0 g beta-mannanase/ton feed and those fed diets containing either 0 or 10% date supplemented with 330 g beta-mannanase/ton feed, but were not different from the other treatments (Table 3). These improvements in the eggshell quality of layer hens fed diets containing date pits meal and supplemented with beta-mannanase might be attributed to the improvements in the nutrients utilization and digestion of the date pits meal supplemented with beta-mannanase.

The reason for the improvement of the eggshell thickness may be due to the improvement of the shell matrix composition. These results were supported by findings of Sawaya *et al.* (1984), who found higher potassium, phosphorus, magnesium, calcium, sodium, iron, manganese, zinc and copper contents in date pits meal might be improved the shell matrix composition.

Abd El-Rahman *et al.* (1999) found that adding date pits meal up to 30% into layer hen diets had no effect on eggshell thickness and eggshell weight percentage. Also, Kashani *et al.* (2013) found that Haugh unit and egg specific gravity were not affected significantly by adding date pits meal up to 21% into layer hen diets. On the other hand, Perez *et al.* (2000) also noted a significant reduction in eggshell weigh by adding date pits meal up to 30% into layer hen diets. Najib and Al-Yousef (2012) observed that egg specific gravity, yolk colour and Haugh unit were significantly affected by date pits meal level. Kashani *et al.* (2013) noted a reduction in eggshell weight, eggshell thickness and egg yolk colour by adding date pits meal up to 21% in layer hen diets.

In addition, Yakout *et al.* (2004) reported that enzyme supplementation to layer hen diets significantly improved egg production. Also, some studies reported an improvement in egg productive performance by adding the multi-enzymes into hen layer diets due to the enhancement in the nutrient supply (Gracia *et al.*, 2009), improvement in the gut absorptive capacity and a reduction in digesta viscosity (Wu *et al.*, 2005). Adding enzymes into diets have been reported to improve productive performance of layer hens including feed conversion ratio (Benabdeljelil and Arbaoui, 1994) energy utilization (Wyatt and Goodman, 1993). Hussein and Alhadrami (2003) reported that the lack of effect of adding beta-mannanase into layer diets containing 5 or 10% date pits meal on productive performance and eggshell quality parameters might be attributed to its content of the different type of non-starch polysaccharide. The variations between the effects of adding different date pits meal levels into layer hen diets supplemented with different beta-mannanase levels on the productive performance and eggshell quality parameters obtained in the present study and the other studies might be attributed to the differences in the breed, strain, age of layer hens, diet characteristics, feeding duration, physiological condition and variety, composition, level, type and origin of date pits meal and enzyme used. Moreover, another cause may be related to the fact that the low metabolizable energy of date pits meal diets for layer hens was compensated by dietary oil, which neutralizes their negativity.

Based on the results obtained from the present study, it can be concluded that date pits meal could be partly added into layer diets as alternative feedstuffs up to 10% with 660 g beta-mannanase/ton feed supplementation without negative effects on productive performance and eggshell quality characteristics of Hisex layer hen from 45 to 53 weeks of age. These findings justify further research on the effects of adding different levels of date pits meal supplemented with different levels of beta-mannanase at different ages on productive performance and eggshell quality parameters for layer hens are required to attain the optimal results.

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