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Effects of Enzyme Supplementation on Productive Performance and Egg Quality of Laying Hens fed Diets Containing Graded Levels of Whole Date Waste

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Abstract

The objective of present study was to determine the effects of β-mannanase-based enzyme (Hemicell®) on productive performance and egg quality in diets containing graded levels of Whole date waste (WDW) fed to laying hens. A total of 336 Hy-line leghorn hens after production peak were randomly divided into 56 cages. Eight iso-energetic and iso-nitrogenous experimental diets in a 4 × 2 factorial arrangement including four levels of WDW (0, 10, 20 and 30%) and 2 concentrations of supplemental β-mannanase (0 or 0.06 %) were prepared. Each dietary treatment was fed to 7 cages (6 birds/cage) from 32 to 38 wk of age. During the experiment, daily egg production, egg weight and feed intake were measured. At the 6th wk, egg quality traits were also recorded. The results showed that there was no interaction between WDW inclusion and enzyme supplementation on performance and egg traits. Dietary supplementation of WDW more than 10% significantly decreased egg production and egg mass compared to no WDW recipient hens (control diet) during the entire experiment ($P<0.05$). Inclusion of 30% WDW to the diet, significantly increased overall feed conversion ratio compared to the control group ($P<0.05$). The treatment with 20 and 30% WDW also resulted in lower eggshell thickness as compared to 10% WDW ($P<0.05$). The dietary inclusion of 10% WDW also increased yolk index as compared to the control and 30% WDW groups ($P<0.05$). Enzyme supplementation had no significant effect on productive performance as well as egg quality characteristics. Based on the results of this experiment, it can be concluded that WDW could be included to laying hens diets up to 10% with no deleterious effects on performance and egg quality characteristics.

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Introduction

The date palm (*Phoenix dactylifera*, L.), an Arecaceae family member, is one of the most economically important woody plant cultivated in dry or semi-dry regions of the world (Moghaieb *et al*., 2011). Iran is considered to be the 4th date-producer country with an annual production of approximately 880,000 metric tons (FAO, 2008). Production of dates in this region leaves behind a sizable amount of date by-products as well as low quality discarded dates which are not suitable for packing. The discarded dates and date pits which are produced especially from the industry of date confectionery could be partly substituted for the imported corn or other cereals in animal feed (Zangiabadi and Torki, 2010). In the last few years, there were increasing attempts to use date wastes as an agricultural by-product in diets formulation for meat and egg production. It is reported that the higher nitrogen free extract of date waste with or without pit allows its usage as an energy source in poultry diets (Soliman, 1996; Hussein *et al*., 1998). Date pits up to 150 g/Kg added to chicks' diets supported growth similar to birds fed control diets (Kamel *et al*. 1980). The addition of date pits and date fruits to the diets significantly improved the body weight gain (BWG) of chicks compared to chicks fed the control diet, after the first 2 weeks of the trial (Hussein *et al*., 1998). Vandepopuliere *et al*. (1995) suggested that date pits at levels ranging from 50 to 150 g /Kg could be included in the laying quail diets with no deleterious effect on productive performance. Ghasemi *et al*. (2014) also suggested that date pits can be used at the level of 20% in the laying hens diets without negatively affecting their productivity.

Date-palm seeds are characterized by their higher and lower proportions of mannose and galactose, respectively. A wide rang (9.8-22.3%) yields of galactomannan from *P. dactylifera* seeds has been reported based on variations in plant origins and extraction conditions (Magdel-Din Hussein *et al*. 1998). Ishrud *et al*. (2001) demonstrated that acid hydrolysis of the date polysaccharides yielded galactose (26.6%) and mannose (71.8%). The galactomannan obtained from seeds of dates consists of a backbone of (1-4)-linked-ß-D-mannopyranosyl residues with α-D-galactopyranosyl groups attached to the 6-positions, a feature that is common to most galactomannans of leguminous seed (Smith and Montgomery, 1959). *β*-mannan has been found to be deleterious for productive performance in laying hens (Jackson *et al*., 1999). The beneficial effect of enzymatic degradation of *β*-mannan by addition of *β*-mannanase to corn-soybean meal diets has been documented in broilers and layers (Wu *et al*. 2005; Kong *et al*., 2011; Cho and Kim, 2013).

To our knowledge, no research has been conducted to investigate the effect of β-mannanase-based enzyme on productive performance of laying hens diets with varying levels of whole date wastes (WDW). Therefore, this trial was designed to evaluate the productive performance and egg quality of laying hens fed on corn–soybean meal-based diets including graded levels of WDW with or without enzyme supplementation.

Materials and Methods

Whole date wastes preparation

Mature whole dates were collected from mixed varieties of dates in Khuzestan, the tropical province of Iran. Whole date wastes used in this study consisted of sweet pulp surrounding the pit, and date pits, which are inedible for human consumption. For diet mixing, whole dates were rinsed with water; oven dried at 60°C for 24 hrs, and then crushed to 1 mm in size (Al-Harthi *et al*., 2009).

Preparation of the β-mannanase

The β-mannanase enzyme was provided by Chem Gen Co., Ltd (Gaithersburg, MD) under a trademark Hemicell®, it is a dried *Bacillus lentus* fermentation soluble with the activity of β-mannanase greater than 1.09×10^5 units/Kg.

Animals and housing

A total of 336 hens of the Hy-Line strain were housed in 56 cages (L×W×H=73×60×45 cm), allocating six hens per cage as the experimental unit. Based on two weeks of pre-experimental egg production, the treatment means for this trait were kept similar at the start of the experiment. Each of 8 dietary treatments was assigned to 7 replicates. Water and feed were provided *ad libitum* throughout the trial and diets were fed in mash form. A photoperiod of 16 h light in a day, including the natural daylight, was maintained. Birds were kept under similar environmental and managerial conditions. The experiment lasted for 6 weeks (32-38 wk).

Dietary treatments

Eight iso-energetic and iso-nitrogenous experimental diets (ME = 2800 Kcal/Kg and CP = 150 g/Kg) in a 4 × 2 factorial arrangement including four levels (0%, 10%, 20% and 30%) of WDW with and without a β-mannanase-based enzyme preparation (0.06%) were fed to hens with 7 replicates per diet during a 6-wk trial period. Proximate analysis of WDW was carried out according to AOAC (2000) procedures (Table 1). Experimental diets were formulated to meet nutrients recommendation of hens based on Hy-Line management guide (Hy-Line W-36, 2009). The ingredient and chemical composition of the experimental diets are shown in Table 2.

Table 1. Proximate analysis of WDW[1] (as fed basis)

Nutrients	Moisture	Crude protein	Ether extract	Crude fiber	Ash	NFE[2]	Calcium	Total Phosphorus	ME (Kcal/Kg)[3]
%	10.25	3.60	0.83	7.20	2.95	75.17	0.65	0.51	3403

[1]Whole date waste.

[2]Nitrogen Free Extract = 100 - (Moisture + crude protein + ether extract + crude fiber + ash).

[3]Metabolizable Energy (ME) was calculated according to the formula given by Carpenter and Clegg (1956): ME = 53 + 38 [% CP + (2.25 × % EE) + (1.1 × %NFE)].

Table 2. Ingredients and nutrient composition of experimental diets

Ingredients (%)	Control	10% WDW[1]	20% WDW[1]	30% WDW[1]
Corn	52.56	45.10	37.64	30.18
Ground date wastes	---	10.00	20.00	30.00
Soybean meal	18.01	20.24	22.48	24.71
Wheat bran	13.85	9.27	4.70	0.13
Corn oil	5.58	5.58	5.58	5.58
Dicalcium phosphate	0.66	0.63	0.60	0.57
Oyster shell	7.95	7.79	7.62	7.46
Common salt	0.35	0.35	0.35	0.35
Vitamin premix[2]	0.25	0.25	0.25	0.25
Mineral premix[3]	0.25	0.25	0.25	0.25
Lysine-HCl	0.25	0.24	0.22	0.21
DL-Methionine	0.29	0.30	0.31	0.31
Calculated analysis				
Metabolizable energy (Kcal/kg)	2800	2800	2800	2800
Crude protein (%)	15.0	15.0	15.0	15.0
Ether extract (%)	7.57	7.22	6.87	6.52
Calcium (%)	3.25	3.25	3.25	3.25
Available phosphorus (%)	0.35	0.35	0.35	0.35
Lysine (%)	0.82	0.82	0.82	0.82
Methionine + Cystine (%)	0.75	0.75	0.75	0.75

[1]Whole date waste.

[2]Vitamin premix supplied per Kg of diet: Vitamin A (Retinly acetate); 12000 IU; Vitamin E (all rac-α-Tocopheryl acetate), 10 IU; VitaminK_3 (Menadione dimethypyrimidinol bisulfite), 3 mg; Vitamin D_3, 2200 ICU; Riboflavin, 10 mg; Pantothenic acid (D-calcium pantothenate), 10 mg; Niacin, 20 mg; Choline chloride, 500 mg; Vitamin B_{12} (Cyanocobalamin), 10 µg; Vitamin B_6 , 105 mg; Thiamine (Thiamine mononitrate), 2.2 mg; Folic acid, 1 mg; D-Biotin, 50 µg.

[3]Minerals premix supplied per Kg of diet: Manganese ($MnSO_4$), 55 mg; Zinc (ZnO), 50 mg; Iron ($FeSO_4 . H_2O$), 30 mg; Copper ($CuSO_4 . 5H_2O$), 10 mg; Selenium, 1 mg and Ethoxyquin 3 mg.

Data collection

Four experimental periods were established: 32-34 wk, 34-36 wk, 36-38 wk and the overall period (32-38 wk). Individual egg production and egg weight were recorded daily throughout the experimental periods. Feed intake per cage was measured weekly and egg mass was determined by multiplying egg weight by egg production. Feed conversion ratio was calculated as feed consumed per egg mass produced (Tahmasbi *et al.*, 2012).

At the end of experiment, eggs were taken from each treatment in three consecutive days, weighed and egg quality parameters were measured. The yolk index was obtained by dividing the yolk height into the yolk width. Eggshell weight was obtained after cleaning adhering albumen and yolk and drying at room temperature. Eggshell thickness was determined by averaging measurements at three separate locations (air cell, equator, and sharp end) using an electronic digital caliper scale (Ghasemi *et al*., 2014). Specific gravity of eggs was determined by using the saline flotation method of Hempe *et al*. (1998). Salt

solutions were made in incremental concentrations of 0.005 in the range from 1.065 to 1.120.

Statistical analysis

All data was analyzed as 4 × 2 factorial arrangement using the GLM procedures of SAS (2008). The main effects included dietary WDW content, enzyme supplementation and their interaction. For all response criteria, the cage served as the experimental unit. Significant treatment differences were established using the LSMEANS statement in SAS (2008). Data was expressed as mean ± standard error of mean (SEM), and a $P<0.05$ was considered to be statistically significant.

Results

Productive performance

Egg production and egg mass of laying hens as affected by different inclusion levels of WDW and β-mannanase are presented in Table 3. The interaction between dietary treatments was not significant statistically for egg production and egg mass; therefore only the main effects are shown in Table 3. Dietary inclusion of WDW more than 10% decreased egg production and egg mass compared to the control group during weeks 32 to 34 and 36 to 38, as well as the whole experimental period ($P<0.05$). From 34 to 36 wk of age (second period), hens fed on 30% WDW diets had also less egg production and egg mass than those fed on control and 10% WDW diets ($P<0.05$). However, Enzyme supplementation did not affect egg production and egg mass during different experimental periods.

The effect of feeding different levels of WDW containing diets and β-mannanase supplementation on egg weight and feed intake are presented in Table 4. The highest value of egg weight was obtained in hens fed on the diet containing 10% WDW in the 2nd and 3rd periods ($P<0.05$). However, egg weight during the first period and during the total experiment was not influenced by dietary concentrations of WDW. In all weeks of experiment, egg weight was not also affected by β-mannanase supplementation and WDW × enzyme interaction. Moreover, main effects of dietary WDW inclusion and β-mannanase supplement and two-ways interaction effects of WDW × enzyme on feed intake were not significant during the 1nd, 2nd and 3rd periods. However, considering the total experimental period (32–38 wk), feed intake in hens fed 20 and 30% WDW was significantly lower than that in hens fed the control diet, where the hens fed 30% WDW had the lowest feed intake.

The results of feed conversion ratio (FCR) of laying hens are shown in Table 5. In the first period, higher levels of WDW (20 and 30% of diet) led to a higher ($P<0.05$) FCR compared with the control diet. Furthermore, hens fed on a diet with the highest WDW concentration (30%) had a higher ($P<0.05$) FCR than those fed on

the diet without WDW during the second period (34 to 36 wk of age) and during the entire experiment (32 to 38 wk of age). However, FCR during the third period was not influenced by dietary concentrations of WDW. No significant effects of β-mannanase and WDW × enzyme interaction were observed for FCR during different experimental periods.

Table 3. Effects of dietary inclusion of WDW[1] and β-mannanase enzyme on egg production and egg mass

	Egg production (%)				Egg mass (g egg/hen/day)			
	weeks				weeks			
	32-34	34-36	36-38	Overall	32-34	34-36	36-38	Overall
WDW[1] (%):								
0	77.28[a]	78.17[a]	76.79[a]	77.08[a]	51.22[a]	51.99[a]	50.13[a]	51.12[a]
10	73.61[ab]	74.01[a]	71.52[ab]	73.04[ab]	49.40[ab]	50.66[a]	48.82[ab]	49.62[ab]
20	69.44[b]	71.92[ab]	67.16[bc]	69.51[bc]	46.06[b]	48.52[ab]	45.04[bc]	46.54[bc]
30	69.04[b]	67.75[b]	64.18[c]	66.99[c]	46.38[b]	46.01[b]	43.82[c]	45.40[c]
SEM[2]	6.80	8.33	8.10	6.78	4.42	5.02	5.01	4.14
Enzyme:								
-	71.87	71.82	69.84	71.18	48.22	48.88	47.40	48.17
+	72.81	74.10	69.49	72.13	48.30	49.71	46.51	48.17
SEM[2]	6.63	8.05	8.01	6.53	4.27	4.84	4.83	4.03
P values								
WDW[1]	0.014	0.034	0.015	0.013	0.023	0.036	0.014	0.017
Enzyme	0.632	0.343	0.883	0.620	0.942	0.574	0.546	0.991
Interaction	0.106	0.632	0.630	0.547	0.077	0.538	0.617	0.412

[1]Whole date waste; [2]Standard error of means.

[a-c]Mean values within a column with different superscript letters were significantly different ($P<0.05$).

Egg quality

There was no interaction between dietary date inclusion and enzyme supplementation on egg quality parameters in this study; therefore only the main effects are illustrated (Table 6). The eggshell thickness in birds receiving the 10% WDW diet was significantly higher than that with 20 and 30% WDW groups ($P<0.05$). Including the diet with 10% WDW also increased yolk index compared with the control and 30% WDW diets($P<0.05$). However, dietary inclusion of WDW had no significant effect on eggshell weight and egg specific gravity. Moreover, enzyme supplementation had no significant effect on egg quality traits (shell thickness and weight, yolk index and specific gravity) in this experiment.

Table 4. Effects of dietary inclusion of WDW[1] and β-mannanase enzyme on egg weight and feed intake

	Egg weight (g)				Feed intake (g/hen/day)			
	weeks				weeks			
	32-34	34-36	36-38	Overall	32-34	34-36	36-38	Overall
WDW[1] (%):								
0	66.00	66.55^{b}	66.34^{b}	66.38	99.74	99.45	98.66	99.28^{a}
10	67.21	68.45^{a}	68.17^{a}	67.93	99.28	99.30	97.06	98.55^{ab}
20	66.34	68.83^{ab}	66.54^{b}	67.06	98.75	98.59	94.08	97.42^{bc}
30	66.59	67.34^{ab}	65.83^{b}	67.90	98.76	98.61	95.09	97.14^{c}
SEM[2]	1.41	0.75	3.44	1.16	1.35	1.97	1.73	1.45
Enzyme:								
-	66.94	67.83	67.08	67.79	99.29	99.21	96.49	98.33
+	66.13	66.76	66.36	66.84	98.79	98.76	95.96	97.87
SEM[2]	1.37	0.70	3.26	1.09	1.22	1.80	1.59	1.34
P values								
WDW[1]	0.061	0.045	0.012	0.094	0.325	0.147	0.590	0.028
Enzyme	0.183	0.109	0.153	0.174	0.18	0.119	0.591	0.112
Interaction	0.273	0.638	0.817	0.382	0.95	0.743	0.011	0.655

[1]Whole date waste; [2]Standard error of means.

[a-c]Mean values within a column with different superscript letters were significantly different (*P<0.05*).

Table 5. Effects of dietary inclusion of WDW[1] and β-mannanase enzyme on feed conversion ratio

	Feed conversion ratio (g of feed/g of egg mass)			
	Weeks			
	32-34	34-36	36-38	Overall
WDW[1] (%):				
0	1.95^{b}	1.92^{b}	1.97	1.94^{b}
10	2.03^{ab}	1.97^{b}	2.00	1.99^{ab}
20	2.16^{a}	2.05^{ab}	2.15	2.11^{ab}
30	2.15^{a}	2.18^{a}	2.17	2.16^{a}
SEM[2]	0.03	0.04	0.04	0.03
Enzyme:				
-	2.08	2.05	2.05	2.05
+	2.06	2.01	2.06	2.05
SEM[2]	0.03	0.04	0.04	0.03
P values				
WDW[1] (%)	0.212	0.234	0.703	0.285
Enzyme	0.081	0.109	0.080	0.636
Interaction	0.374	0.637	0.512	0.102

[1]Whole date waste; [2]Standard error of means.

[a,b]Mean values within a column with different superscript letters were significantly different (*P<0.05*).

Table 6. Effects of dietary inclusion of WDW[1] and β-mannanase enzyme on egg quality characteristics

	Shell thickness (0.01 mm)	Shell weight (%)	yolk index (unit)	Specific gravity (unit)
WDW[1] (%):	31.16[ab]	9.28	0.41[b]	1.066
10	32.33[a]	8.56	0.43[a]	1.067
20	28.91[b]	9.39	0.42[ab]	1.070
30	28.66[b]	8.97	0.41[b]	1.069
SEM[2]	3.53	1.41	0.008	0.008
Enzyme:				
-	30.29	8.98	0.42	1.064
+	30.25	9.12	0.42	1.072
SEM[2]	3.41	1.35	0.015	0.007
P values				
WDW[1] (%)	0.041	0.488	0.036	0.248
Enzyme	0.960	0.745	0.932	0.862
Interaction	0.942	0.733	0.197	0.184

[1]Whole date waste; [2]Standard error of means.
[a,b]Mean values within a column with different superscript letters were significantly different ($P<0.05$).

Discussion

The negative effect of using WDW on productive performance of laying hens was confirmed in this study, at a level of 20 and 30% WDW, but not at 10% WDW possibly because of lower levels of anti-nutritional factors. Hens fed either 0 or 10% WDW had a similar egg production and egg mass but were significantly higher when compared to all other dietary WDW levels up to 30 %. The negative effect of 20 and 30% WDW on productive performance indicated a deficiency of nutrients for the optimum egg number and egg size. Consistent results were reported by Najib *et al.* (1994) who reported that using date meal up to 28% in laying hens diet resulted in a statistically deteriorate hen-day production and egg mass in a linear trend. Al-Harthi *et al*. (2009) indicated that date waste meal could be used in Lohmann brown pullets and layers diets up to a 4 % inclusion without adversely affecting the laying hens performance. Egg weights and feed intakes among all experimental groups were similar during the whole 6 wk trial. These results are consistent with the previous results reported by other researchers (El-Bogdady 1995, Perez *et al*., 2000); who found that the average egg weight was not statistically affected by different dietary date pits levels. Overall FCR means for hens fed 10 and 20% WDW containing diet were similar to those fed the diet without WDW, while increasing the WDW inclusion level up to 30% impaired FCR values to even lower than that of the control group. These higher FCR values might be due to the lower egg production rate and egg mass of hens fed the highest WDW level. Also, it may be related to the adverse effect of anti-nutritional substances in date pits as one component of the WDW (Abd El-Rahman *et al*.,

1999). The inclusion of date pits has been reported to decrease ME and amino acid availability due to increasing feed passage rate through the gastrointestinal tract (Perez *et al.* 2000). Sklan *et al.* (2003) also showed that high dietary crude fiber intake adversely affects intestinal epithelium and, thus, their absorptive capacity.

In regard to enzyme supplementation, our results are in agreement with the results of Abd El-Ghany *et al*. (1997) and El-Full (2000) who reported that egg-laying performance was not affected by enzyme supplementation. In contrast, Yakout *et al*. (2004) reported that enzyme supplementation to laying hens diets significantly improved egg production. In another study, the addition of 0.1% multienzyme mixture supplementation (containing protease, amyloglucoidase, xylanase, β-glucanase, cellulase, and hemicellulase) to the layers diets with 30% date pits yields similar productive performance to that of the diet without DP (Al-Saffar *et al*., 2012). The improvement in laying performances with multienzymes can be attributed to improved nutrient supply to the hens (Gracia *et al*., 2009); to a reduction in pathogens, Gram-positive cocci, and enterococci in the intestines microbiota (Tabook *et al*., 2006); to an improvement in the gut absorptive capacity (Wu *et al*., 2005); and to a reduction in digesta viscosity (Choct, 2006). However, the variations in the performance values recorded in our study with other studies are also likely dependent on the strain and age of layers, diets characteristics, feeding duration, and the dose and form of enzyme used.

There was no significant interaction between dietary WDW level and enzyme supplementation for the evaluated performance variables. Although there is no record in literatures evaluating the effects of multienzyme supplementation, especially β-mannanase-based enzyme, in WDW-included diets on performance of laying hens, but some researchers reported the usage of enzymes in broiler diets containing date products. By conducting a 4-wk growth study**,** Hussein and Alhadrami (2003) reported that a commercial enzyme preparation containing xylanase, protease, alpha-amylase and pectinase did not affect performance parameters of broilers fed diets included with 10% cooked or uncooked date pits. In their second study, they found that adding 0.1% enzyme to the starter diets significantly increased body weight gain, but did not affect feed intake and FCR in broilers fed diets consisting of four levels (0, 10, 15, and 20%) of uncooked date pits. They explained the lack of effect of enzyme supplementation on the basis that the used date pits contained a different type of Non Starch polysaccharide (NSP) from that found in other dietary grains (Hussein and Alhadrami, 2003). By evaluating the inclusion of date fibre (5, 10 or 15%) in the broiler diets with or without enzyme (Avizyme-1500), Tabook *et al*. (2006) also reported decreased average daily body weight gain, feed intake and FCR except at 5%.

Although both shell weight and specific gravity were not affected by dietary WDW, shell thickness and yolk index were statistically influenced by dietary WDW content. Increase in shell thickness in 10% WDW group could be result of higher egg weights during second and third periods. Regarding shell thickness, the

results were also supported by findings of Sawaya *et al.* (1984), which indicated higher K contents in date seeds followed by P, Mg, Ca, Na, Fe, Mn, Zn and Cu, respectively, which could result in the improvements of shell matrix composition. The reason for the lower shell thickness of 20 and 30% WDW groups compared with the 10% WDW group may be due to the adverse effects of anti-nutritional factors such as NSP contained in date pits as one component of the WDW (Abd El-Rahman *et al.*, 1999). The decrease in shell quality due to the inclusion of WDW at 20 and 30% is consistent with the results of Perez *et al.* (2000). An important characteristic of NSP is their partial solubility in water, resulting in the formation of viscous gel solutions. These results with a dramatic increase in the viscosity of intestinal digesta, which may impair the action of digestive enzymes, decrease the rate of passage, and interfere with the absorption of nutrients (Broz and Ward, 2007). As a consequence, digestibility of nutrients and utilization of minerals, especially calcium, may be markedly reduced (Roberts, 2004). Therefore, the negative effect of higher levels of WDW on eggshell quality is clearly associated with the presence of NSPs in date pits, which increase the viscosity of the gut contents following impediment of the circulation and absorption of nutrients, especially Ca (Ghasemi *et al*., 2014). The dietary inclusion of WDW at the levels of 10% increased yolk index as compared to the control group. Moreover, the highest inclusion level (30%) of WDW in experimental diets also decreased yolk index, thus it is expected that anti-nutritional effect of date pits may induce negative effects on yolk quality.

In regard to β-mannanase supplementation, egg quality parameters were not influenced by 0.06% enzyme addition, which might be due to the lower level of enzyme to be able to promote degradation of NSPs and to improve the nutrients utilization. This observation on enzyme effect in the present experiment is consistent with those of the other study in laying hens (El-Deek *et al*., 2008), who reported that multi-enzyme supplementation (mixture of amylase, β-glucanase, xylanase, protease, lipase and cellulase) had no significant effects on egg quality parameters.

Conclusion

Based on the results of this experiment it can be concluded that WDW could be included in laying hens diets up to 10% with no deleterious effects on performance and egg characteristics. No significant effect of β-mannanase on performance and egg quality was observed. These findings justify further research on the effect of this enzyme in diverse dosages and situations on productive performance in laying hens fed with date products to attain more comprehensive results.

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