# Effect of Roasted and Unroasted Date Palm Seeds on Egg Production and Chemical Characteristics of Laying Hen Eggs

Noor Nashaat Bahjat [1] and Mohammed Sabah Baha Al-Din[2]

Department of Animal Production, College of Agriculture, University of Kirkuk, Iraq.
Department of Animal Production, College of Agriculture, University of Kirkuk, Iraq.

Corresponding Authors' Emails: akam24039@uokirkuk.edu.iq

## Abstract

The aim of this study was to determine the effects of dietary supplementation of date palm seeds (roasted and unroasted) on productive performance and egg chemical composition of Lohmann White laying hens. A total of 140 laying hens, 22 weeks of age, were randomized by dietary treatment and five replicates per treatment were used, with four hens per replicate. This experiment lasted for 91 days. The treatments included a control diet, diets containing unroasted date palm seeds at 5%, 7.5%, and 10%, and diets containing roasted date palm seeds at 5%, 7.5%, and 10%. Productive traits, such as egg production percentage, egg mass, feed conversion ratio, and body weight, were measured. Furthermore, the chemical composition of egg yolk and albumen, including moisture, protein, fat, ash, and carbohydrates, was measured. The results showed that the overall means of egg production percentage, egg mass, and feed conversion ratio were not significantly affected by the dietary treatments. However, the inclusion of 7.5% roasted date palm seeds showed the best numerical improvement in egg mass and feed conversion ratio. Significant differences were observed in some chemical characteristics of egg yolk, particularly moisture, ash, fat, and carbohydrate percentages, while yolk protein was not significantly affected. In albumen, only ash percentage was significantly influenced by dietary treatments. In conclusion, roasted and unroasted date palm seeds can be used as partial feed ingredients in laying hen diets without adverse effects on overall productive performance. Roasted date palm seeds at 7.5% may be considered the most suitable level under the conditions of this study.

**Keywords:** Date palm seeds; roasted seeds; unroasted seeds; laying hens; egg production; egg chemical composition.

## Introduction

Feed cost is one of the major economic constraints in poultry production, as it represents a large proportion of the total cost of egg production. Therefore, improving feed efficiency and reducing dependence on expensive conventional feed ingredients are important goals in laying hen nutrition. The use of alternative and locally available feed resources has become a practical approach to

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reduce production costs while maintaining productive performance and egg quality [1], [2].

Agricultural by-products are increasingly used in poultry feeding because they may provide useful nutrients and reduce environmental waste. Among these by-products, date palm seeds are of particular importance in Iraq and other date-producing countries because they are produced in large quantities as residues from date processing and consumption. Poultry diets can be supplemented by date palm seeds as a potential feed ingredient due to their nutritional characteristics, including carbohydrates, lipids, minerals, dietary fiber, and other functional compounds, when used at suitable inclusion levels [3], [4].

In addition, date palm seeds might contain phenolic compounds and natural antioxidants that could contribute to improving the oxidative stability and product quality. These bioactive compounds may help protect lipids from oxidation and may have positive effects on the chemical characteristics of animal products, including eggs [5], [6]. However, the nutritional value of date palm seeds depends on their chemical composition, processing method, and inclusion level in the diet.

Several studies have reported that date palm seed meal or date by-products can be included in poultry diets without causing negative effects on productive performance when used at moderate levels [7], [8]. In laying hens, dietary inclusion of date palm seeds may affect egg production percentage, egg weight, egg mass, feed conversion ratio, and some egg quality traits. However, high inclusion levels may limit nutrient utilization because date palm seeds contain relatively high amounts of fiber, which can reduce digestibility and feed efficiency if the diet is not properly balanced [9], [10]. Heat treatment may contribute to improving energy availability by breaking down some of the complex bonds in fiber, thereby increasing the efficiency of nutrient utilization .In addition, roasting may reduce the effects of non-starch polysaccharides (NSPs), which are considered one of the limiting factors for the use of date pits in poultry diets[24].

Processing methods may improve the feeding value of date palm seeds. Roasting is a simple heat-treatment method that may improve palatability, reduce some anti-nutritional effects, and enhance nutrient availability. Heat treatment may also modify the physical and chemical properties of feed ingredients, making them more suitable for digestion and absorption by birds [10]. Therefore, comparing roasted and unroasted date palm seeds is necessary to determine whether roasting improves their nutritional value and their effect on laying hen performance.

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Egg production and egg chemical composition are influenced by dietary energy, protein, amino acids, minerals, fat content, and antioxidant availability. The chemical composition of egg yolk and albumen, including moisture, protein, fat, ash, and carbohydrate percentages, can reflect changes in dietary nutrient intake and metabolism. Since date palm seeds contain minerals, fats, carbohydrates, fiber, and antioxidant compounds, their inclusion in laying hen diets may influence both productive performance and the chemical characteristics of eggs [2], [4], [6].

Therefore, the present study was conducted to evaluate the effect of using roasted and unroasted date palm seeds at different inclusion levels in the diets of Lohmann White laying hens. The study aimed to determine their effects on egg production percentage, egg mass, feed conversion ratio, body weight, and the chemical composition of egg yolk and albumen. It also aimed to assess the possibility of using date palm seeds as an economical partial feed ingredient in laying hen diets without causing negative effects on production or egg quality.

## Material and Methods

The experiment was conducted at the poultry farm of the College of Agriculture, University of Kirkuk, Iraq, to evaluate the effect of roasted and unroasted date palm seeds on productive performance and egg chemical composition in laying hens. A total of 140 Lohmann White laying hens, 22 weeks of age, were used in the study. The experimental period lasted for 91 days. Birds were randomly assigned to seven dietary treatments according to a Completely Randomized Design. Each treatment included five replicates, with four hens per replicate. All birds were maintained under similar environmental and management conditions throughout the experimental period, and feed and water were provided according to the requirements of laying hens [1], [2].

There were seven experimental treatments, namely one control and six added diets of roasted and unroasted date palm seeds. Control diet without date palm seed supplementation were the first treatment. The second, third and fourth treatments are incubated with unroasted date palm seeds at 5%, 7.5%, and 10%, respectively. The 5th, 6th and 7th treatments were roasted date palm seeds at 5%, 7.5%, and 10%, respectively. Seeds of date palms were obtained from local date-processing sources. To include the seeds in the experimental diets, the seeds were cleaned and prepared. To prepare roasted seeds the date palm

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seeds were placed in an electric oven and roasted at 200°C for 15 minutes. Seed powder was obtained after roasting, cooling, and grinding seeds. The unroasted seeds were ground without heat treatment. The ground date palm seed powder was thereafter blended well with the experimental diets on the basis of required inclusion levels.

Productive performance traits were recorded during the experimental period. Egg production was recorded daily at 5:00 p.m. and expressed as hen-day egg production percentage according to the number of live hens in each replicate [11]. Egg mass was calculated based on egg production percentage and egg weight according to standard methods used in poultry production studies [12], [13]. Feed conversion ratio was calculated as the amount of feed consumed relative to the egg mass produced. Body weight was recorded to evaluate the effect of dietary treatments on the live body weight of laying hens.

Egg samples were collected for chemical analysis of yolk and albumen. The analyzed chemical traits included moisture, crude protein, fat, ash, and carbohydrate percentages. Moisture percentage was determined by drying 5 g samples of yolk and albumen in pre-weighed ceramic crucibles and calculating the percentage of weight loss after drying according to official analytical procedures [14]. Crude protein percentage was determined using the Kjeldahl method, in which 0.2 g of the egg sample was digested with concentrated sulfuric acid and a catalyst mixture. Protein percentage was calculated by multiplying nitrogen percentage by 6.25 [15]. Fat percentage was estimated using the lipid extraction method described by Folch et al. [16]. Ash percentage was determined by burning the dried samples in a muffle furnace at 500°C for 16–18 hours until a constant ash residue was obtained [14], [15]. Carbohydrate percentage was calculated by difference from the other determined components.

Statistical analysis based on a Completely Randomized Design was performed on the collected data. The SPSS statistical software was used, and Duncan's Multiple Range Test was performed on the treatments at a significance level of $P \leq 0.05$ [17]. The results were shown as means ± standard error. Within the same column, treatments were compared, and the significant differences were denoted using different letters.

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## Basal diet

Table. Experimental Diet and Its Chemical Composition

| Ingredients | Quantity |
|---|---|
| **wheat** | **15.80** |
| **corn** | **43.90** |
| **oil** | **1.00** |
| **Barley** | **4.00** |
| **soybean meal 48%** | **22.30** |
| **Laymix-2.5** | **2.50** |
| **lysine** | **0.00** |
| **Methionine** | **0.06** |
| **DCP** | **0.45** |
| **limestone** | **9.5** |
| **T.salt** | **0.20** |
| **Colin clorid** | **0.25** |
| **100.0Formula** | **100.0** |
| **ME/CP Ratio** | **160.532** |

## Results and Discussion

The results of the present study showed that the dietary inclusion of roasted and unroasted date palm seeds had variable effects on productive performance and egg chemical composition in Lohmann White laying hens. In general, most productive traits were not negatively affected by the inclusion of date palm seeds, particularly at moderate levels, indicating the possibility of using this agricultural by-product as a partial feed ingredient in laying hen diets. The control group and the treatment groups were T1–T7: group T1 (Control: Feed without DP), group T2 (5% unroasted DP), group T3 (7.5% unroasted DP), group T4 (10% unroasted DP), group T5 (5% roasted DP), group T6 (7.5% roasted DP), and group T7 (10% roasted DP).

## Egg Production Percentage

This study showed that the percentage egg production was affected by roasted and unroasted date palm seeds (Table 1). There were significant differences between the treatments during the first and fourth experimental periods, but no significant difference in terms of the second, third and fifth experimental period was observed and in the overall mean. Egg production overall mean has been 71.86% in T4 to 74.79% in T3. Although some numerical differences were observed among treatments, the absence of significant differences in the overall mean indicates that the inclusion of roasted or unroasted date palm seeds did not negatively affect egg production percentage.

The highest overall egg production percentage was recorded in T3, which received 7.5% unroasted date palm seeds, followed by T6, which received 7.5% roasted date palm seeds. This result suggests that moderate inclusion levels may be more suitable than higher levels. The lack of significant reduction in egg production may be related to the ability of date palm seeds to provide a portion of dietary energy and

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nutrients, particularly carbohydrates and lipids, when included at balanced levels. Previous studies have also indicated that date by-products can be used in poultry diets without major negative effects on productive performance when the inclusion level is moderate [3], [7], [8]. However, the slightly lower overall mean observed in T4 may be related to the higher inclusion level of unroasted date palm seeds. This may be due to the relatively high fiber content of date seeds, which can reduce nutrient digestibility and feed utilization when included at excessive levels [9], [10]. Therefore, the present results indicate that date palm seeds can be used in laying hen diets, but the inclusion level should be carefully controlled.

**Table 1. Effect of different levels of roasted and unroasted date palm seeds on egg production percentage (HD%)**

| Treatment | First | Second | Third | Fourth | Fifth | Overall mean | |
|---|---|---|---|---|---|---|---|
| T1 | 50.00 2.77 c | ± 76.79 3.70 | ± 80.00 3.85 | ± 82.50 1.04 a | ± 79.29 2.43 | ± 73.72 2.73 | ± |
| T2 | 52.86 3.12 bc | ± 71.78 6.35 | ± 79.64 1.45 | ± 80.36 0.98 a | ± 78.93 3.11 | ± 72.71 2.57 | ± |
| T3 | 60.71 1.87 ab | ± 72.14 4.54 | ± 81.43 1.92 | ± 78.93 1.99 a | ± 80.71 1.04 | ± 74.79 1.90 | ± |
| T4 | 63.21 1.21 a | ± 67.86 3.43 | ± 76.43 4.20 | ± 70.72 2.00 b | ± 81.07 2.30 | ± 71.86 1.73 | ± |
| T5 | 58.93 3.57 ab | ± 70.72 6.07 | ± 80.36 4.41 | ± 80.71 2.85 a | ± 78.21 2.90 | ± 73.79 2.39 | ± |
| T6 | 58.21 2.91 b | ± 73.93 3.51 | ± 81.43 1.84 | ± 79.64 2.23 a | ± 78.93 1.31 | ± 74.43 2.01 | ± |
| T7 | 62.50 1.79 a | ± 71.79 5.74 | ± 79.64 3.27 | ± 77.14 2.29 a | ± 77.86 2.37 | ± 73.79 1.88 | ± |
| Significance | * | N.S | N.S | * | N.S | N.S | |

Different letters within the same column indicate significant differences at $P \leq 0.05$.
N.S = not significant

**Egg Mass**

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The results of egg mass are shown in Table 2. Significant differences among treatments were recorded during the first and fourth experimental periods, whereas no significant differences were observed during the second, third, and fifth periods or in the overall mean. The overall mean of egg mass ranged from 76.35 g/bird in T4 to 83.25 g/bird in T6. Although the differences in the overall mean were not statistically significant, T6 showed the highest numerical value. This treatment included 7.5% roasted date palm seeds, indicating that roasting may have improved the utilization of nutrients in date seeds and supported egg mass production. Egg mass is a combined indicator affected by both egg production percentage and egg weight. Therefore, the numerical improvement in T6 may reflect a balanced effect between egg number and egg size. The absence of significant differences in the overall mean suggests that date palm seeds did not impair egg mass when included at the tested levels. This agrees with the idea that date by-products can be used as partial feed ingredients in laying hen diets when the diets remain nutritionally balanced [7], [8]. The lower numerical value in T4 may again be related to the higher level of unroasted date palm seeds and the possible effect of fiber on nutrient availability [9].

**Table 2. Effect of different levels of roasted and unroasted date palm seeds on egg mass (g/bird)**

| Treatment | First | Second | Third | Fourth | Fifth | Overall mean | |
|---|---|---|---|---|---|---|---|
| T1 | 53.41 3.72 c | ± 83.19 4.75 | ± 84.79 4.21 | ± 86.99 3.12 ab | ± 81.55 2.01 | ± 77.99 2.95 | ± |
| T2 | 52.45 2.92 c | ± 79.52 6.52 | ± 82.29 2.70 | ± 86.12 3.78 b | ± 85.73 4.62 | ± 77.22 3.13 | ± |
| T3 | 67.79 1.71 ab | ± 77.48 3.15 | ± 86.55 2.96 | ± 79.44 3.01 bc | ± 84.30 2.46 | ± 79.11 1.73 | ± |
| T4 | 71.68 2.84 a | ± 67.49 3.65 | ± 83.14 4.14 | ± 73.93 1.88 c | ± 85.49 3.85 | ± 76.35 1.96 | ± |
| T5 | 60.75 4.80 bc | ± 78.02 7.51 | ± 84.32 4.51 | ± 86.56 4.04 ab | ± 85.84 4.45 | ± 79.10 2.90 | ± |
| T6 | 62.36 3.08 b | ± 79.44 3.88 | ± 90.73 1.32 | ± 92.25 2.83 a | ± 91.48 2.22 | ± 83.25 2.60 | ± |
| T7 | 67.48 3.12 ab | ± 82.43 6.00 | ± 84.03 4.21 | ± 79.46 3.34 bc | ± 82.55 3.78 | ± 79.19 2.12 | ± |

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| Treatment | First | Second | Third | Fourth | Fifth | Overall mean |
|---|---|---|---|---|---|---|
| Significance | * | N.S | N.S | * | N.S | N.S |

Different letters within the same column indicate significant differences at $P \leq 0.05$.
N.S = not significant.

## Feed Conversion Ratio

The effect of different dietary treatments on feed conversion ratio is presented in Table 3. Significant differences were observed during the first and fourth experimental periods, while no significant differences were recorded in the second, third, and fifth periods or in the overall mean. The overall mean of feed conversion ratio ranged from 1.30 in T6 to 1.43 in T2.

The best numerical feed conversion ratio was observed in T6, which received 7.5% roasted date palm seeds. Since a lower feed conversion ratio indicates better feed efficiency, this result suggests that roasting may have improved the nutritional value of date palm seeds and enhanced feed utilization. Roasting may reduce some limiting factors and improve palatability and digestibility, which could explain the better feed conversion observed in the roasted treatments, especially at the moderate inclusion level [10]. The overall non-significant differences indicate that the inclusion of date palm seeds did not cause a clear negative effect on feed efficiency. However, the slightly poorer feed conversion ratio in T2 may suggest that low-level unroasted seed inclusion did not provide the same advantage as roasted seed inclusion. The results support the use of roasted date palm seeds at moderate levels as a possible strategy to improve feed utilization without compromising productive performance.

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**Table 3. Effect of different levels of roasted and unroasted date palm seeds on feed conversion ratio (g feed/g egg)**

| Treatment | First | Second | Third | Fourth | Fifth | Overall mean |
|---|---|---|---|---|---|---|
| T1 | 2.01 ± 0.17 a | 1.28 ± 0.07 | 1.25 ± 0.07 | 1.21 ± 0.04 bc | 1.29 ± 0.03 | 1.41 ± 0.07 |
| T2 | 2.03 ± 0.11 a | 1.36 ± 0.12 | 1.28 ± 0.04 | 1.23 ± 0.06 b | 1.24 ± 0.07 | 1.43 ± 0.07 |
| T3 | 1.55 ± 0.04 b | 1.37 ± 0.06 | 1.22 ± 0.04 | 1.33 ± 0.05 ab | 1.25 ± 0.04 | 1.34 ± 0.03 |
| T4 | 1.47 ± 0.06 b | 1.57 ± 0.09 | 1.28 ± 0.06 | 1.42 ± 0.04 a | 1.24 ± 0.05 | 1.40 ± 0.04 |
| T5 | 1.77 ± 0.14 ab | 1.40 ± 0.14 | 1.26 ± 0.08 | 1.22 ± 0.06 bc | 1.24 ± 0.07 | 1.38 ± 0.06 |
| T6 | 1.70 ± 0.09 ab | 1.33 ± 0.06 | 1.16 ± 0.02 | 1.14 ± 0.04 c | 1.15 ± 0.03 | 1.30 ± 0.05 |
| T7 | 1.57 ± 0.07 b | 1.30 ± 0.11 | 1.26 ± 0.07 | 1.33 ± 0.06 ab | 1.29 ± 0.06 | 1.35 ± 0.04 |
| Significance | * | N.S | N.S | * | N.S | N.S |

Different letters within the same column indicate significant differences at $P \leq 0.05$.
N.S = not significant.

## Body Weight

The results of body weight are shown in Table 4. Significant differences were recorded among treatments before and after the experimental period. The highest body weight was recorded in T5, followed by T6, while the lowest value was recorded in the control group. These differences may indicate variation among treatment groups in body weight response; however, the interpretation of this table should be made carefully because the values presented before and after the experiment are identical in the available data. In this regard, enhanced digestibility and palatability of the different date palm seed treatments may explain the higher body weight in the date palm seeds that were roasted in treatments T5 and T6. Heat treatment can improve the feeding value of some agricultural by-products by enhancing digestibility and reducing certain undesirable compounds [10].

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In addition, date palm seeds contain energy-yielding nutrients such as carbohydrates and lipids, which may contribute to maintaining body weight when incorporated into balanced diets [3], [4]. However, because significant differences were already present before the experimental period, body weight data should not be used alone as strong evidence of treatment effect unless initial body weight variation is statistically adjusted or corrected. Therefore, the original body weight data should be rechecked before final submission.

**Table 4. Effect of different levels of roasted and unroasted date palm seeds on hen body weight**

| Treatment | Before | After |
|---|---|---|
| T1 | 1305.95 ± 89.93 c | 1305.95 ± 89.93 c |
| T2 | 1438.80 ± 29.29 bc | 1438.80 ± 29.29 bc |
| T3 | 1425.20 ± 25.74 bc | 1425.20 ± 25.74 bc |
| T4 | 1373.85 ± 42.55 bc | 1373.85 ± 42.55 bc |
| T5 | 1546.65 ± 18.43 a | 1546.65 ± 18.43 a |
| T6 | 1460.80 ± 28.35 ab | 1460.80 ± 28.35 ab |
| T7 | 1444.75 ± 31.01 b | 1444.75 ± 31.01 b |
| Significance | * | * |

Different letters within the same column indicate significant differences at $P \leq 0.05$.

## Chemical Composition of Egg Yolk

The effect of dietary treatments on the chemical composition of egg yolk is presented in Table 5. Significant differences were observed in moisture, ash, fat, and carbohydrate percentages, while protein percentage was not significantly affected by the treatments.

Moisture percentage ranged from 78.68% in T2 to 82.49% in T3. The highest moisture values were recorded in T3 and T6, while the lowest value was observed in T2. These differences may reflect changes in yolk composition due to variation in nutrient intake and metabolism among treatments. Yolk ash percentage was significantly affected by the dietary treatments. The highest ash values were recorded in T7 and T4, while the lowest values were observed in the

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control and lower unroasted treatments. This may be related to the mineral content of date palm seeds, as date by-products are known to contain mineral elements that may influence the mineral fraction of animal products [3], [4]. Fat percentage also differed significantly among treatments. The highest fat percentage was recorded in T2, followed by T7, while the lowest values were observed in T4 and T6. These differences may be attributed to the lipid content of date palm seeds and the possible effect of roasting and inclusion level on lipid metabolism and deposition in egg yolk. Date seeds contain oils and functional compounds that may influence lipid composition and oxidative stability [4], [5]. Protein percentage was not significantly affected by dietary treatments, indicating that the inclusion of roasted or unroasted date palm seeds did not have a clear effect on yolk protein deposition. This may suggest that the protein supply of the basal diet was adequate and that date palm seed inclusion did not disturb protein metabolism in the egg. Carbohydrate percentage showed significant differences among treatments, with the highest value recorded in T7 and the lowest values recorded in T3, T4, and T6. This may be associated with differences in carbohydrate metabolism and the chemical composition of date palm seeds, which contain considerable carbohydrate fractions [18], [19].

**Table 5. Effect of different levels of roasted and unroasted date palm seeds on the chemical composition of egg yolk**

| Treatment | Moisture | Ash | Fat | Protein | Carbohydrates |
|---|---|---|---|---|---|
| T1 | 81.29 ± 0.86 ab | 0.15 ± 0.03 c | 2.52 ± 0.12 b | 15.20 ± 0.74 | 0.84 ± 0.07 c |
| T2 | 78.68 ± 0.69 c | 0.17 ± 0.03 c | 2.99 ± 0.10 a | 17.09 ± 0.57 | 1.08 ± 0.07 b |
| T3 | 82.49 ± 0.34 a | 0.18 ± 0.02 c | 1.66 ± 0.12 c | 15.25 ± 0.22 | 0.42 ± 0.05 d |
| T4 | 81.62 ± 0.37 ab | 0.80 ± 0.12 a | 1.30 ± 0.15 c | 15.73 ± 0.43 | 0.56 ± 0.03 d |
| T5 | 80.51 ± 1.05 b | 0.44 ± 0.14 b | 2.52 ± 0.17 b | 15.53 ± 1.15 | 0.98 ± 0.04 bc |
| T6 | 82.37 ± 0.42 a | 0.51 ± 0.03 b | 1.39 ± 0.17 c | 15.29 ± 0.23 | 0.45 ± 0.10 d |
| T7 | 79.66 ± 0.30 bc | 0.91 ± 0.06 a | 2.86 ± 0.12 ab | 15.20 ± 0.16 | 1.38 ± 0.04 a |
| Significance | * | * | * | N.S | * |

Different letters within the same column indicate significant differences at $P \leq 0.05$.
N.S = not significant.

## Chemical Composition of Egg Albumen

The chemical composition of egg albumen is shown in Table 6. No significant differences were observed among treatments in

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moisture, fat, protein, or carbohydrate percentages. However, ash percentage was significantly affected by dietary treatments. Albumen moisture percentage ranged from 80.66% in T2 to 83.26% in T4. Although numerical differences were present, they were not statistically significant, indicating that the dietary inclusion of date palm seeds did not markedly affect albumen water content. Similarly, albumen fat, protein, and carbohydrate percentages were not significantly changed by the treatments. The lack of significant effect on albumen protein percentage indicates that the tested levels of roasted and unroasted date palm seeds did not negatively influence albumen protein deposition. This result is important because albumen quality is closely related to protein nutrition and egg internal quality. Basal diet, which was balanced in protein and amino acid supply, may stabilize albumen protein level among the treatments [1], [2]. However, the percentage of albumen ash was significantly affected by treatments in contrast. The T6 recorded the highest percent ash and the least percent ash was recorded in T3. This may be associated with minerals present in date palm seeds, and the effect of dietary treatments on mineral deposition in albumen. The consumption of date palm seeds results in the alteration of mineral content in the egg, as they consist of various minerals, this depends on the type of process, e.g. roasting [3], [4]. Overall, the results of egg chemical composition suggest that date palm seeds, especially roasted seeds at moderate levels, can be included in laying hen diets without causing negative changes in the main chemical components of yolk and albumen. Some changes in ash, fat, and carbohydrate contents may reflect the natural chemical composition of date palm seeds and the effect of processing on nutrient availability.

**Table 6. Effect of different levels of roasted and unroasted date palm seeds on the chemical composition of egg albumen**

| Treatment | Moisture | Ash | Fat | Protein | Carbohydrates |
|---|---|---|---|---|---|
| T1 | 82.18 ± 0.40 | 0.36 ± 0.03 bc | 0.40 ± 0.23 | 16.67 ± 0.65 | 0.38 ± 0.12 |
| T2 | 80.66 ± 1.14 | 0.43 ± 0.02 ab | 0.89 ± 0.55 | 17.36 ± 0.38 | 0.66 ± 0.27 |
| T3 | 83.25 ± 1.29 | 0.29 ± 0.02 c | 0.27 ± 0.13 | 15.91 ± 1.09 | 0.28 ± 0.07 |
| T4 | 83.26 | 0.42 ± 0.02 | 0.23 | 15.76 ± | 0.33 ± 0.06 |

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| Treatment | Moisture | Ash | Fat | Protein | Carbohydrates |
|---|---|---|---|---|---|
| T5 | 82.36 ± 1.66 | 0.40 ± 0.02 b | 0.17 ± 0.09 | 16.77 ± 1.76 | 0.29 ± 0.03 |
| T6 | 82.70 ± 0.75 | 0.45 ± 0.04 a | 0.34 ± 0.03 | 16.12 ± 0.78 | 0.40 ± 0.01 |
| T7 | 82.49 ± 0.75 | 0.36 ± 0.02 bc | 0.21 ± 0.07 | 16.66 ± 0.71 | 0.29 ± 0.03 |
| Significance | N.S | * | N.S | N.S | N.S |

Different letters within the same column indicate significant differences at $P \leq 0.05$.
N.S = not significant.

## General Discussion

The findings of the present study indicate that roasted and unroasted date palm seeds can be used in laying hen diets without causing negative effects on the overall productive performance. Egg production percentage, egg mass, and feed conversion ratio were not significantly affected in their overall means, although some significant differences appeared during specific experimental periods. This indicates period of production, inclusion level, and processing method may affect the response of laying hens to date palm seed inclusion. In egg mass and feed conversion ratio, 7.5% roasted date palm seeds showed the most favorable numerical results. This might mean that thermal processing (roasting) of DP seeds has helped to increase the feeding value of these seeds, possibly through an increase in palatability, nutrient availability, and digestibility. Some feed ingredients have been reported to be benefited with heat treatment process because of its ability to overcome some anti-nutritional factors and improving the availability of nutrients [10]. Egg yolk was more influenced by the dietary treatments than was the albumen. The yolks moisture, ash, fat, and carbohydrates differed significantly without significant effect being seen on yolk protein. This could be attributed to the greater sensitivity of the yolk composition towards dietary fat, energy, minerals, and bioactive compounds. The lipid, mineral, dietary fiber, and carbohydrate content, along with antioxidant and phenolic constituents in date palm seeds might account for the aforementioned changes in the different percentages of ash, fat and carbohydrate of the yolk [18], [19]. The compositions of the albumen

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did not greatly differ among the treatments, except for ash percentage. The stability of albumen protein indicates that date palm seed inclusion didn't negatively affect protein deposition in the albumen. It is an important discovery as albumen protein is one of most important egg internal quality indicators, and is the indicator of sufficient protein and amino acid intake in the diet [1], [2]. Previous research on date waste in poultry diets showed the use of such by-products was possible, provided these diets fulfilled the nutritional requirements of poultry [20]. Additionally, the references in general nutrition for poultry stress its importance on providing adequate and balanced nutritional supply for productive performance, egg quality, and feed efficiency during prolific phase of laying hens [21]. Antioxidant and therapeutic properties of plant-derived bioactive compounds are slowly now getting importance. Recent reviews on *Crocus sativus* and its active compound crocin have highlighted the role of natural phytochemicals in reducing oxidative stress and supporting biological functions [22], [23]. Therefore, the presence of phenolic and antioxidant compounds in date palm seeds may partly explain the observed variations in some egg chemical characteristics. In conclusion, the results suggest that date palm seeds can be considered a useful agricultural by-product for partial inclusion in laying hen diets. Roasted date palm seeds at the level of 7.5% appeared to provide the best numerical response in egg mass and feed conversion ratio. However, higher inclusion levels, especially unroasted seeds at 10%, should be used with caution due to the possible effect of fiber on nutrient utilization. Further studies are recommended to evaluate digestibility, economic efficiency, egg sensory quality, and the fatty acid profile of eggs produced from hens fed roasted and unroasted date palm seeds.

## Conclusion

The results of this study indicate that roasted and unroasted date palm seeds can be used as partial feed ingredients in laying hen diets without negative effects on overall productive performance. The inclusion of date palm seeds did not significantly affect the overall means of egg production percentage, egg mass, or feed conversion ratio. The numerical improvement in the egg mass and feed conversion ratio was the highest for 7.5% roasted date palm seeds. In addition, some chemical properties of the egg yolk and albumen, such as ash, fat, and carbohydrate contents, were also influenced by dietary treatments. Therefore, it seems roasted date palm seeds, particularly at the 7.5% level, can be used as an economical alternative feed ingredient in laying hen nutrition.

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