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# Dried Date (*Phoenix dactylifera* L.) Meal Inclusion in the Diets of Broilers Affects Growth Performance, Carcass Traits, Nutrients Digestibility, Fecal Microbiota and Economics

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**Abstract:** The availability of suitable feedstuffs for poultry nutrition is a significant challenge faced by the global poultry production industry. This issue has been exacerbated by the shift towards using grains for biofuel production, leading to a subsequent rise in feedstuff prices. The study aimed to assess the impact of different levels of dried date wastes in the diet of broiler chicks on their growth, carcass characteristics, nutrient digestibility, fecal microbiota and economics. A total of 240 day-old broiler chicks (Ross 308/Ross 308 FF) were divided into five experimental groups and fed 0, 3, 6, 9 and 12% of dietary date meal (DDM). The formulated diets were provided to chicks for a duration of 35 days. The findings of the study indicated that chicks fed with a diet containing 9% dried dates exhibited a significantly ($p < 0.05$) higher increase in body weight compared to the control group by the end of the study period. Additionally, dressing percentage, carcass weight, leg weight and breast weight were notably higher ($p < 0.05$) among birds that consumed the 9% dried dates diet. Moreover, the digestibility of dry matter, crude protein and ether extract showed a significant ($p < 0.05$) increase in birds that were fed a 9% dried dates diet. Furthermore, DDM at 9% experienced significantly ($p < 0.05$) higher levels of *Lactobacillus* and decreased ($p < 0.05$) the level of *E. coli* count. Similarly, economically, birds supplemented with 9% DDM exhibited significantly ($p < 0.05$) higher profit compared to the control. In conclusion, the results of this study suggest that broiler chicks fed with a diet including 9% dried date waste experienced improved growth performance, enhanced carcass quality, supported digestibility of nutrients, elevated the count of fecal *Lactobacillus*, reduced *E. coli* count and economics.

**Keywords:** broilers; dried date meal; growth; carcass; nutrients digestibility

## 1. Introduction

The key factors influencing animal performance and productivity are the accessibility and effective utilization of feed resources. Ensuring a stable and reliable feed supply is crucial for managing, extending the use of, conserving and intensifying production to enhance productivity [1]. However, it is important to recognize that the current availability of animal proteins is insufficient to meet the growing demands of the human population, especially considering the dwindling resources [1,2]. The global poultry industry has historically encountered challenges in sourcing feed ingredients due to competition with other animal sectors [3,4]. D'Souza et al. [3] observed that the rising demand for poultry consumption has led to a substantial shortage of accessible feed grains for sustaining poultry meat production. However, as noted by Hinrichs and Steinfeld [4], in the competition for limited feed resources, poultry enjoys a competitive advantage over other livestock due to its superior feed conversion efficiency.

For decades, antibiotics have been extensively utilized in animal production. While some are administered for therapeutic purposes to enhance animal health and well-being, the majority were used prophylactically and to enhance growth rate and feed conversion efficiency, known as antimicrobial growth performance promoters [5,6]. In light of the emergence of antibiotic-resistant microbes impacting both human and animal health, the developed countries decided to progressively phase out the marketing and use of antibiotics from poultry feed. In the poultry industry, antibiotics have been utilized to augment meat production by enhancing feed conversion, accelerating growth rates and preventing diseases [7]. They can be administered at sub-therapeutic levels to achieve these goals and safeguard bird health by modifying the immune response of broiler chickens [8]. This is primarily accomplished by controlling gastrointestinal infections and modifying the composition of the intestinal microbiota [9,10].

A multitude of agriculture-based by-products are generated during their processing, potentially leading to environmental pollution. These by-products garnered significant attention during the COVID-19 crisis owing to lockdowns, border closures and transportation limitations [11]. Employing alternative feed sources and utilizing locally accessible feed components could offer a viable remedy. Date by-products, sourced from arid and desert regions, represent the most recognized among these by-products, occasionally finding application in livestock and poultry nutrition. The options for feedstuffs accessible for poultry nutrition are constrained, presenting a significant challenge to global poultry production. This challenge has been exacerbated by the inclination to utilize grains for biofuel production, leading to a subsequent surge in feedstuff prices [12].

Dates hold a significant status as a primary crop in arid and semi-arid regions [13]. The date palm's fruit consists of a succulent pericarp and an inedible seed. Several by-products stem from dates, including intact culled dates, date pits (date stone, seeds or kernels), fruit date pulp and pressed cakes, are recycled. These resources are valuable to the date industry [14]. Dates are characterized by low protein and fat content, but they are notably rich in sugars [15]. They serve as an excellent energy source, providing approximately 1.31 MJ per 100 g [11]. Additionally, dates offer essential minerals of health importance. A daily intake of 100 g can fulfill roughly 15% of the recommended mineral requirements [11]. While dates contain about 8.0 g of dietary fiber per 100 g, the majority of this fiber is insoluble [16]. In terms of vitamins, dates are abundant in vitamin C and various B-complex vitamins. Furthermore, they serve as a valuable source of antioxidants [11]. This suggests that dates can be incorporated effectively as their anti-nutritional content is minimal, ensuring no disruption to the absorption of essential nutrients like minerals and proteins in the body. Approximately 20% of dates are not suitable for human consumption [17]. In numerous regions across the globe, the availability of cost-effective feedstuffs for animal production is significantly constrained, often necessitating the importation of such feed materials. This predicament is further exacerbated by the adoption of various crops, like maize, for biofuel manufacturing, which consequently drives up the cost of energy sources in animal diets [17]. Tabook et al. [18] highlighted that incorporating date fiber into a broiler diet at a 5% level does not have an adverse impact on the performance of broiler chickens. Shaba et al. [19] reported that date palm fruits contain minimal quantities of anti-nutritional components. Despite variations among varieties, all of them serve as exceptional sources of fiber and can potentially be utilized as valuable sources of functional foods [20–22]. Date pits, also known as date seeds or date stones, constitute the largest by-product derived from date fruits. Consequently, a significant portion of research pertaining to broilers has been dedicated to exploring the incorporation of date stone meal (DSM) into their diets [23–26]. Due to its elevated fiber content, which poses limitations on its applicability in poultry diets, various methods of processing DSM have been employed to enhance both feed utilization efficiency and chicken performance. The addition of dates as a feed supplement has resulted in better economic output. For example, the highest net profit of 44.51 Rs. per bird was observed in broilers fed 4% date palm kernel [27]. These cost-effective feed ingredients have emerged as viable alternatives in poultry nutrition, capable of lowering ration costs.

Due to its high fiber content, utilizing dried date seed meal (DSM) in poultry diets has been challenging. However, studies have explored processing methods to enhance feed efficiency and chicken performance. In this context, certain researchers have also employed multienzyme complexes, encompassing enzymes such as myloglucosidase, protease, hemicellulose, cellulase, glucanase and xylanase [24,28] to counteract the adverse repercussions of excessive cellulose presence. Al-Saffar et al. [28] found that DSM could constitute up to 30% of diets when supplemented with multienzymes without compromising laying performance. Similarly, Hussein and Alhadrami [24] observed that incorporating date stone at various percentages had no significant impact on broiler performance during the starter and finisher phases. These findings suggest potential avenues for improving the incorporation of dates in poultry nutrition.

Therefore, the aim of the present study was to utilize the while dried date meal not consumable for human consumption on the production performance, carcass characteristics, nutrient digestibility, fecal microbiota and economics in broilers.

## 2. Materials and Methods

### *2.1. Preparation of Dried Dates Meal*

Mature dates were gathered from discarded date trees grown in Dera Ismail Khan, Pakistan. The dates used in this study comprised whole date fruits, constituting approximately 800 g per kilogram. These discarded dates were subjected to oven drying at 55.8 °C for 24 h and then crushed to achieve a maximum size of about 1 mm$^3$ using heavy-duty high-rotation hammer mills. A representative sample of the date waste was taken for proximate chemical analysis, including measurements for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), ash and amino acids (Table 1). Five isonitrogenous and isocaloric experimental diets with gradual inclusion levels of dried date meal 0% ($DDM_0$; control group), 3% ($DDM_3$), 6% ($DDM_6$), 9% ($DDM_9$) and 12% ($DDM_{12}$) were formulated (Tables 2 and 3) and fed to birds during the starter and finisher phases.

**Table 1.** Nutrient composition of dried dates included in broiler diet.

| | |
|---|---|
| Moisture (%) | 8.61 |
| Protein (%) | 4.37 |
| Lipids (%) | 1.06 |
| Fiber (%) | 5.68 |
| Ash (%) | 3.67 |
| Nitrogen-free extracts (%) | 76.43 |
| Amino acids (mg/100 g DM) | |
| Aspartic acid | 152 |
| Glutamic acid | 244 |
| Isoleucine | 46.2 |
| Leucine | 98.7 |
| Glycine | 107 |

**Table 2.** Diet formulation for broiler starter phase (1–21 days), including different levels of dried date meal.

| Ingredients | Diets | | | | |
|---|---|---|---|---|---|
| | **$DDM_0$** | **$DDM_3$** | **$DDM_6$** | **$DDM_9$** | **$DDM_{12}$** |
| Maize | 60.78 | 57.23 | 53.98 | 50.97 | 47.95 |
| Dried Dates | 0.00 | 3.00 | 6.00 | 9.00 | 12.00 |
| Soybean meal (48% CP) | 33.75 | 34.10 | 34.04 | 33.69 | 33.35 |
| Limestone | 1.71 | 1.70 | 1.68 | 1.66 | 1.65 |
| Monocalcium phosphate | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 |
| Salt | 0.35 | 0.36 | 0.36 | 0.36 | 0.36 |
| Soy oil | 1.68 | 1.90 | 2.00 | 2.00 | 2.00 |
| L-Lysine Sulphate | 0.24 | 0.23 | 0.42 | 0.76 | 1.08 |
| L-Methionine | 0.35 | 0.36 | 0.37 | 0.38 | 0.40 |
| L-Threonine | 0.07 | 0.07 | 0.08 | 0.09 | 0.10 |
| L-Isoleucine | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| L-Arginine | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| L-Valine | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 |
| Premix | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 |
| *Composition* | | | | | |
| Ether extract (%) | 4.26 | 4.37 | 4.37 | 4.28 | 4.20 |
| Crude fiber (%) | 2.47 | 2.60 | 2.72 | 2.83 | 2.95 |
| Ash (%) | 5.30 | 5.37 | 5.43 | 5.48 | 5.54 |
| Crude Protein (%) | 22.0 | 22.0 | 22.0 | 22.0 | 22.0 |
| ME (kcal/kg) | 3100 | 3100 | 3100 | 3100 | 3100 |
| Lysine (%) | 1.29 | 1.29 | 1.29 | 1.29 | 1.29 |
| Methionine (%) | 0.51 | 0.51 | 0.52 | 0.52 | 0.51 |
| Threonine (%) | 0.88 | 0.88 | 0.89 | 0.88 | 0.89 |
| Tryptophan (%) | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 |
| Ca (%) | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 |
| Available P (%) | 0.44 | 0.44 | 0.44 | 0.44 | 0.44 |

$DDM_0$—control diet, $DDM_3$—control diet with 3% date meal, $DDM_6$—control diet with 6% date meal, $DDM_9$—control diet with 9% date meal, $DDM_{12}$—control diet with 12% date meal. ME—Metabolizable energy. Each kg of premix was provided per kg of diet: 1200 IU Vitamin D3, 15,000 IU vitamin A, 12.0 IU Vitamin E, 2.3 mg thiamin, 1.2 mg Vitamin K, 14 mg Pantothenate, 6 mg Riboflavin, 0.12 mg d-biotin, 2.5 mg vitamin B6 1.68 mg; Vitamin B12, 260 mg; Folic Acid, 12.9 µg Nicotinic acid, 55 mg; Choline chloride, 47 mg; Mn, 5 mg; Zn, 65 mg; Co, 0.4 mg; Cu, 0.2 mg Fe; I, 35 mg 1.5 mg Se.

**Table 3.** Diet formulation for broiler finisher phase (21–35 days), including different levels of dried date meal.

| Ingredients | Diets | | | | |
|---|---|---|---|---|---|
| | **$DDM_0$** | **$DDM_3$** | **$DDM_6$** | **$DDM_9$** | **$DDM_{12}$** |
| Maize | 65.60 | 62.61 | 59.63 | 56.66 | 53.68 |
| Dried Dates | 0.00 | 3.00 | 6.00 | 9.00 | 12.00 |
| Soybean meal (48% CP) | 27.10 | 26.73 | 26.36 | 25.99 | 25.62 |
| Limestone | 1.59 | 1.57 | 1.56 | 1.55 | 1.50 |
| Monocalcium phosphate | 0.81 | 0.82 | 0.82 | 0.82 | 0.82 |
| Salt | 0.35 | 0.35 | 0.36 | 0.36 | 0.36 |
| Soy oil | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| L-Lysine Sulphate | 1.63 | 1.91 | 2.195 | 2.48 | 2.76 |
| L-Methionine | 0.38 | 0.39 | 0.40 | 0.42 | 0.43 |
| L-Threonine | 0.11 | 0.12 | 0.13 | 0.14 | 0.16 |
| L-Isoleucine | 0.05 | 0.06 | 0.07 | 0.09 | 0.10 |

**Table 3.** *Cont.*

| Ingredients | Diets | | | | |
|---|---|---|---|---|---|
| | **$DDM_0$** | **$DDM_3$** | **$DDM_6$** | **$DDM_9$** | **$DDM_{12}$** |
| L-Arginine | 0.05 | 0.07 | 0.09 | 0.10 | 0.12 |
| L-Valine | 0.05 | 0.06 | 0.07 | 0.09 | 0.10 |
| Premix | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 |
| *Composition* | | | | | |
| Ether extract (%) | 4.71 | 4.62 | 4.54 | 4.45 | 4.36 |
| Crude fiber (%) | 2.35 | 2.47 | 2.58 | 2.70 | 2.82 |
| Ash (%) | 4.92 | 4.92 | 5.02 | 5.07 | 5.12 |
| Crude protein (%) | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| ME (kcal/kg) | 3200 | 3200 | 3200 | 3200 | 3200 |
| Lysine (%) | 1.19 | 1.19 | 1.19 | 1.19 | 1.19 |
| Methionine (%) | 0.48 | 0.48 | 0.48 | 0.48 | 0.48 |
| Threonine (%) | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 |
| Tryptophan (%) | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 |
| Ca (%) | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 |
| Available P (%) | 0.41 | 0.41 | 0.41 | 0.41 | 0.41 |

$DDM_0$—control diet, $DDM_3$—control diet with 3% date meal, $DDM_6$—control diet with 6% date meal, $DDM_9$—control diet with 9% date meal, $DDM_{12}$—control diet with 12% date meal. ME—Metabolizable energy. Each kg of premix was provided per kg of diet: 1200 IU Vitamin D3, 15,000 IU vitamin A, 12.0 IU Vitamin E, 2.3 mg thiamin, 1.2 mg Vitamin K, 14 mg Pantothenate, 6 mg Riboflavin, 0.12 mg d-biotin, 2.5 mg vitamin B6 1.68 mg; Vitamin B12, 260 mg; Folic Acid, 12.9 µg Nicotinic acid, 55 mg; Choline chloride, 47 mg; Mn, 5 mg; Zn, 65 mg; Co, 0.4 mg; Cu, 0.2 mg Fe; I, 35 mg 1.5 mg Se.

### *2.2. Birds, Management and Treatments*

The dried waste obtained from Dhakki variety dates was sourced from a local market and subsequently finely ground into a date meal. Prior to the formulation of experimental diets, this date meal underwent proximate composition analysis in accordance with AOAC [29] standards. The findings are detailed in Table 1.

A total of 240 day-old male broiler chicks of the Ross 308 breed were procured from a local hatchery. The chicks were received during the nighttime, and their weights were measured on the first day. On the first day, the 480 broilers were divided by gender, resulting in 240 male birds with similar weights being selected for the experiment. The determination of the birds' sex was conducted by a single technician who was highly skilled and experienced in this task. Chicks were then divided randomly into five treatment groups, each consisting of four replicates (12 chicks per replicate). Each group of chicks within a replicate was accommodated in separate pens with dimensions of $4 \times 3 \times 2.5$ feet. The experimental diets were assigned at random to the four replicates within each specified treatment group.

Throughout the study, the birds were provided feed in accordance with the guidelines for Ross 308 broilers. Daily and weekly records were maintained for feed consumption and the live body weight of the chicks. The average temperature and humidity were $27.5 \pm 1.5$ C and $67.8 \pm 2.33\%$, respectively. The experimental period spanned 35 days and took place within a controlled environmental facility.

### *2.3. Growth and Carcass Data Collection*

The study involved daily and weekly recording of initial body weight, feed intake, body weight gain, feed conversion ratio (FCR) and any occurrences of mortality. These measurements were taken using a digital weighing balance. At the end of the trial, three randomly selected birds from each replicate were individually weighed before being processed for data collection on carcass yield, breast yield, thigh yield, wing yield and dressing percentage [30].

Mortality was recorded for each replicate and was excluded while calculating growth performance.

### 2.4. Nutrient Digestibility

Nutrient digestibility was assessed using the direct method. On day 33 of the feeding trial, three birds per replicate were separated. The growth performance data were adjusted accordingly after the removal of these birds for the digestibility trial. A polythene sheet was positioned on the floor. A single day was allocated for the birds to adapt, after which fecal samples were gathered on the 34th and 35th days of the trial. Fecal matter was collected at three-hour intervals throughout the day and subsequently labeled with respect to the replicates. These samples were then stored for the purpose of chemical composition analysis, including proximate analysis. The determination of Dry Matter (DM%) was conducted following the procedure outlined by AOAC [29]. Fecal and feed samples were weighed in pre-washed, oven-dried Petri dishes. The samples were then dried in an oven at 105 °C for 24 h, after which they were reweighed and returned to the oven for further drying until a constant weight was achieved. The crude protein content in feed and fecal samples was determined by using the Kjeldahl apparatus as described in AOAC [29]. The oil content or ether extract of the feed and fecal matter were determined by using a Soxhlet apparatus according to its procedure, as mentioned by AOAC [29].

### 2.5. Fecal Microbiota

Fresh fecal samples were directly collected from two birds per replicate at the conclusion (day 35) of the experiment for the purpose of analyzing fecal microbial counts. One gram of a fecal sample was then mixed evenly with 9 mL of 1% peptone broth (Becton, Dickinson and Company, Franklin Lakes, NJ, USA). To determine the total viable bacterial counts in the fecal samples, ten-fold serial dilutions were plated onto MacConkey agar plates and *Lactobacilli* medium III agar plates to isolate both *Escherichia coli* and *Lactobacillus*, respectively. *Lactobacilli* medium III agar plates were placed in an anaerobic incubator at 39 °C for 48 h, while MacConkey agar plates were incubated at 37 °C for 24 h. The colonies of *E. coli* and *Lactobacillus* were counted immediately upon removal of the plates from the incubator. The concentration of microflora was subsequently expressed as $\log_{10}$ CFU (colony-forming units) per gram of feces.

### 2.6. Economics of DDM Addition in Broiler Diet

The economics of the addition of DDM for revenue, profit and cost–benefit ratio were determined with the methodology outlined by Khan et al. [31].

### 2.7. Statistical Analysis

Data were passed through statistical analysis through the use of the ANOVA technique within a Completely Randomized Design framework. Data were organized in terms of treatments and replicates. Subsequently, the statistics software version 8.1 (Statistica) was utilized to perform the analysis. Treatment comparisons were conducted using Tukey's post-hoc test. The normality and homogeneity of the data were tested using the Kruskal–Wallis test.

## 3. Results

### 3.1. Growth Performance

Table 4 illustrates the impact of progressively substituting corn with dry date meal on parameters such as feed intake, weight gain and feed conversion ratio (FCR) in the birds over 1 to 7 days. No significant ($p > 0.05$) changes were recorded in the growth parameters during the first week of the study.

**Table 4.** Effect of gradual inclusion of dried date meal on growth traits during the 1st week of the trail (1–35 days).

| Treatment | Feed Intake, g | Weight Gain, g | FCR, g/g |
|---|---|---|---|
| **1–7 days** | | | |
| $DDM_0$ | 157.38 | 153.33 | 1.03 |
| $DDM_3$ | 158.01 | 158.81 | 1.10 |
| $DDM_6$ | 158.15 | 157.00 | 1.01 |
| $DDM_9$ | 156.62 | 163.13 | 0.96 |
| $DDM_{12}$ | 163.67 | 154.94 | 1.06 |
| SEM | 1.82 | 3.83 | 0.02 |
| *p*-value | 0.100 | 0.450 | 0.090 |
| **8–14 day** | | | |
| $DDM_0$ | 371.00 $^{bc}$ | 300.24 | 1.25 |
| $DDM_3$ | 370.69 $^{c}$ | 290.13 | 1.28 |
| $DDM_6$ | 372.22 $^{abc}$ | 296.50 | 1.26 |
| $DDM_9$ | 373.06 $^{a}$ | 306.25 | 1.22 |
| $DDM_{12}$ | 372.52 $^{ab}$ | 302.06 | 1.24 |
| SEM | 0.52 | 8.87 | 0.04 |
| *p*-value | 0.031 | 0.760 | 0.802 |
| **15–21 days** | | | |
| $DDM_0$ | 639.35 | 447.44 | 1.43 |
| $DDM_3$ | 638.75 | 456.43 | 1.40 |
| $DDM_6$ | 638.88 | 453.44 | 1.41 |
| $DDM_9$ | 640.93 | 461.06 | 1.39 |
| $DDM_{12}$ | 640.34 | 456.19 | 1.41 |
| SEM | 10.68 | 0.88 | 0.03 |
| *p*-value | 0.920 | 0.370 | 0.930 |
| **22–28 days** | | | |
| $DDM_0$ | 911.40 $^{b}$ | 593.31 $^{c}$ | 1.58 |
| $DDM_3$ | 911.77 $^{b}$ | 661.63 $^{b}$ | 1.35 |
| $DDM_6$ | 911.23 $^{b}$ | 598.94 $^{c}$ | 1.53 |
| $DDM_9$ | 913.82 $^{a}$ | 724.38 $^{a}$ | 1.47 |
| $DDM_{12}$ | 911.23 $^{b}$ | 622.38 $^{bc}$ | 1.47 |
| SEM | 0.50 | 20.51 | 0.11 |
| *p*-value | 0.011 | <0.001 | 0.640 |
| **29–35 days** | | | |
| $DDM_0$ | 770.87 | 554.94 | 1.40 |
| $DDM_3$ | 808.27 | 570.50 | 1.42 |
| $DDM_6$ | 817.27 | 573.63 | 1.44 |
| $DDM_9$ | 883.08 | 586.63 | 1.35 |
| $DDM_{12}$ | 707.25 | 565.81 | 1.24 |
| SEM | 58.86 | 21.43 | 0.11 |
| *p*-value | 0.340 | 0.870 | 0.540 |
| **1–35 days** | | | |
| $DDM_0$ | 2850.0 | 2097.3 $^{c}$ | 1.36 |
| $DDM_3$ | 2887.5 | 2185.5 $^{b}$ | 1.32 |
| $DDM_6$ | 2897.5 | 2127.5 $^{c}$ | 1.36 |
| $DDM_9$ | 2967.5 | 2289.4 $^{a}$ | 1.29 |
| $DDM_{12}$ | 2795.0 | 2149.4 $^{bc}$ | 1.30 |
| SEM | 59.29 | 18.36 | 0.03 |
| *p*-value | 0.370 | <0.001 | 0.400 |

$DDM_0$—control diet, $DDM_3$—control diet with 3% date meal, $DDM_6$—control diet with 6% date meal, $DDM_9$—control diet with 9% date meal, $DDM_{12}$—control diet with 12% date meal, FCR—feed conversion ratio, SEM—standard error of the means. Different superscripts in a column differ signficantly ($p < 0.05$)

Table 4 shows the effect of gradual replacement of corn with dry date meal on the feed intake, weight gain and FCR of birds over 8 to 14 days. Feed intake was significantly ($p < 0.05$) higher in the $DDM_9$ group compared to the $DDM_0$ and $DDM_3$. Table 4 shows the effect of gradual replacement of corn with dry date meal on the feed intake, weight gain and FCR of birds over 15 to 21 days. No significant changes were recorded in the growth parameters during the study period. Table 4 shows the effect of gradual replacement of corn with dry date meal on the feed intake, weight gain and FCR of birds over 22 to 28 days. In this period, feed intake was significantly ($p < 0.05$) higher in the $DDM_9$ and $DDM_{12}$ experimental groups compared to the control. However, weight gain was significantly ($p < 0.05$) higher in $DDM_9$ compared to the control and other treatment groups. Table 4 shows the effect of gradual replacement of corn with dry date meal on the feed intake, weight gain and FCR of birds over 29 to 35 days. No significant change was observed in the studied parameters during this period. Table 4 shows the effect of the gradual replacement of corn with dry date meal on the feed intake, weight gain and FCR of birds over 1 to 35 days. During this period, weight gain was significantly ($p < 0.05$) higher in $DDM_9$ compared to the control and other treatment groups.

### 3.2. Carcass Traits and Nutrient Digestibility

Table 5 shows the effect of the gradual replacement of corn with dry date meal on carcass characteristics in broilers fed with experimental diets. The results showed dressing percentage, carcass yield, breast and leg were significantly ($p < 0.05$) higher in $DDM_9$ compared to the control.

**Table 5.** Effect of gradual inclusion of dried date meal on carcass traits of broiler chicks.

| Treatment | Dressing, % | Carcass, % | Breast, % | Leg, % | Wings, % |
|---|---|---|---|---|---|
| $DDM_0$ | 78.87 $^{bc}$ | 65.19 $^{b}$ | 33.10 $^{b}$ | 26.53 $^{b}$ | 5.58 |
| $DDM_3$ | 82.35 $^{ab}$ | 64.58 $^{b}$ | 33.43 $^{b}$ | 25.69 $^{b}$ | 5.46 |
| $DDM_6$ | 80.03 $^{abc}$ | 66.56 $^{ab}$ | 35.69 $^{ab}$ | 25.65 $^{bc}$ | 5.22 |
| $DDM_9$ | 83.51 $^{a}$ | 73.58 $^{a}$ | 38.91 $^{a}$ | 28.92 $^{a}$ | 5.75 |
| $DDM_{12}$ | 76.11 $^{c}$ | 61.42 $^{b}$ | 32.93 $^{b}$ | 23.56 $^{c}$ | 5.16 |
| SEM | 1.46 | 2.39 | 1.12 | 0.69 | 0.21 |
| $p$-value | 0.021 | 0.031 | 0.010 | 0.011 | 0.312 |

Mean values showing the same superscript within each column are not significantly different from each other at a $p$-level of 0.05. $DDM_0$—control diet, $DDM_3$—control diet with 3% date meal, $DDM_6$—control diet with 6% date meal, $DDM_9$—control diet with 9% date meal, $DDM_{12}$—control diet with 12% date meal. SEM—standard error of the means.

Table 6 shows the effect of the gradual replacement of corn with dry date meal on the visceral organ weight of broilers. The results showed that the gizzard weight was significantly ($p < 0.05$) lower in $DDM_9$. However, $DDM_9$ and $DDM_{12}$ showed significantly ($p < 0.05$) lower shank weight in broilers. Table 7 shows the effect of the gradual replacement of corn with dry date meal on nutrient digestibility and mortality in broiler chickens. The DM, CP and EE digestibilities were significantly ($p < 0.05$) higher in $DDM_9$ and $DDM_{12}$ compared to the control. No significant difference was found in the mortality percentage between the control and DDM-treated birds.

**Table 6.** Effect of gradual inclusion of dried date meal on visceral organs in broiler chicks.

| Treatment | Liver, % | Heart, % | Gut, % | Gizzard, % | Shank, % |
|---|---|---|---|---|---|
| $DDM_0$ | 2.39 | 0.55 | 4.21 $^{b}$ | 2.63 $^{bc}$ | 3.91 $^{ab}$ |
| $DDM_3$ | 2.46 | 0.53 | 6.30 $^{a}$ | 2.94 $^{ab}$ | 3.98 $^{ab}$ |
| $DDM_6$ | 2.55 | 0.56 | 5.74 $^{a}$ | 3.06 $^{a}$ | 4.29 $^{a}$ |
| $DDM_9$ | 2.28 | 0.59 | 4.22 $^{b}$ | 2.58 $^{c}$ | 3.71 $^{b}$ |
| $DDM_{12}$ | 2.33 | 0.51 | 5.74 $^{a}$ | 2.76 $^{abc}$ | 3.63 $^{b}$ |
| SEM | 0.16 | 0.04 | 0.41 | 0.11 | 0.13 |
| $p$-value | 0.750 | 0.540 | 0.011 | 0.021 | 0.022 |

Mean values showing the same superscript within each column are not significantly different from each other at a $p$-level of 0.05. $DDM_0$—control diet, $DDM_3$—control diet with 3% date meal, $DDM_6$—control diet with 6% date meal, $DDM_9$—control diet with 9% date meal, $DDM_{12}$—control diet with 12% date meal. SEM—standard error of the means.

**Table 7.** Effect of gradual inclusion of dried date meal on the nutrient digestibility in broiler chicks.

| Treatment | Dry Matter, % | Crude Protein, % | Ether Extract, % | Mortality, % |
|---|---|---|---|---|
| $DDM_0$ | 70.44 $^c$ | 65.52 $^c$ | 76.96 $^c$ | 3.75 |
| $DDM_3$ | 70.98 $^{bc}$ | 69.61 $^{bc}$ | 77.08 $^c$ | 3.50 |
| $DDM_6$ | 72.82 $^{ab}$ | 72.80 $^{ab}$ | 78.62 $^{bc}$ | 3.66 |
| $DDM_9$ | 74.41 $^a$ | 74.97 $^a$ | 84.97 $^a$ | 3.61 |
| $DDM_{12}$ | 73.70 $^a$ | 73.73 $^{ab}$ | 82.16 $^{ab}$ | 3.80 |
| SEM | 0.70 | 1.47 | 1.57 | 0.12 |
| *p*-value | <0.001 | <0.001 | 0.010 | 0.765 |

Mean values showing the same superscript within each column are not significantly different from each other at a *p*-level of 0.05. $DDM_0$—control diet, $DDM_3$—control diet with 3% date meal, $DDM_6$—control diet with 6% date meal, $DDM_9$—control diet with 9% date meal, $DDM_{12}$—control diet with 12% date meal. SEM—standard error of the means.

The effects of different levels of DDM on the fecal microbiota of the control and treatment groups are given in Table 8. The result showed that $DDM_9$ increased the level of *Lactobacillus* significantly ($p < 0.05$) and decreased ($p < 0.05$) the level of *E. coli* compared to the control. In addition, $DDM_{12}$ was equally effective in $DDM_9$ in controlling the beneficial levels of the two microorganisms.

**Table 8.** Effects of gradual inclusion of dried date meal on fecal microbiota in broilers at the finisher phase ($Log_{10}$ CFU/g).

| Groups | *Lactobacillus* | *E. coli* |
|---|---|---|
| $DDM_0$ | 7.40 $^c$ | 4.56 $^a$ |
| $DDM_3$ | 8.12 $^b$ | 4.45 $^a$ |
| $DDM_6$ | 8.14 $^b$ | 4.39 $^a$ |
| $DDM_9$ | 8.23 $^a$ | 4.21 $^b$ |
| $DDM_{12}$ | 8.50 $^a$ | 4.11 $^a$ |
| SEM | 0.17 | 0.03 |
| *p*-value | 0.04 | 0.04 |

Mean values showing the same superscript within each column are not significantly different from each other at a *p*-level of 0.05. $DDM_0$—control diet, $DDM_3$—control diet with 3% date meal, $DDM_6$ —control diet with 6% date meal, $DDM_9$—control diet with 9% date meal, $DDM_{12}$—control diet with 12% date meal. SEM—standard error of the means.

Table 9 shows the feed price, total revenue, profit and cost–benefit ratio of DDM inclusion in broiler diets. When different concentrations of DDM were added to the birds' feed, cost was not affected significantly. The total revenue was significantly higher in $DDM_9$ and $DDM_{12}$ as compared to the control group ($DDM_0$). Profit was significantly ($p < 0.05$) higher in $DDM_9$ and $DDM_{12}$ as compared to the control group ($DDM_0$). Cost–benefit ratio was significantly ($p < 0.05$) higher in $DDM_9$ and $DDM_{12}$ compared to the control group ($DDM_0$).

**Table 9.** Effects of gradual inclusion of dried date meal in feed on the economics (INR) of broilers.

| Groups | Cost | Revenue | Profit | Cost–Benefit Ratio |
|---|---|---|---|---|
| $DDM_0$ | 72.00 ± 1.78 | 100.00 $^c$ ± 1.06 | 29.00 $^c$ ± 1.18 | 1.40 $^{bc}$ ± 0.02 |
| $DDM_3$ | 72.00 ± 1.028 | 102.00 $^{bc}$ ± 1.04 | 30.00 $^{bc}$ ± 1.08 | 1.41 $^b$ ± 0.03 |
| $DDM_6$ | 73.00 ± 1.58 | 105.00 $^b$ ± 1.06 | 31.00 $^b$ ± 1.11 | 1.41 $^b$ ± 0.02 |
| $DDM_9$ | 73.50 ± 1.18 | 110.00 $^a$ ± 1.01 | 35.00 $^a$ ± 1.12 | 1.46 $^a$ ± 0.01 |
| $DDM_{12}$ | 73.8 ± 1.58 | 112.65 $^a$ ± 1.09 | 36.99 $^a$ ± 1.18 | 1.47 $^a$ ± 0.01 |
| *p*-value | 0.096 | 0.0002 | 0.04 | 0.003 |

Mean values showing the same superscript within each column are not significantly different from each other at a *p*-level of 0.05. $DDM_0$—control diet, $DDM_3$—control diet with 3% date meal, $DDM_6$—control diet with 6% date meal, $DDM_9$—control diet with 9% date meal, $DDM_{12}$—control diet with 12% date meal. SEM—standard error of the means.

## 4. Discussion

The crisis of poultry feed significantly impacted the demand and pricing of feed and feedstuffs, leading to a heightened interest in local feed sources and a reduction in imported feed sources. The date stands out for its rich content of carbohydrates, fat and crude protein when compared to corn and barley [11]. Additionally, dates contain higher levels of calcium and phosphorus (0.76% and 0.52%, respectively) than barley and maize. The protein content of date seeds at 8.1% surpasses that of whole dates and closely approaches that of maize grains (8.6%) [23]. This trial aims to consolidate findings from experiments on date fruit by-products, encompassing their chemical composition, nutritional value, impact on growth performance, carcass traits and economic aspects in broilers. Date waste's chemical composition generally aligns with that of corn and barley, with the exception of higher crude fiber values compared to corn and barley [20]. The amino acid content in date seeds is largely comparable to corn [11]. Several studies have explored the incorporation of date wastes as a supplement in poultry diets [12,32,33]. These economical feed additives are promising sources of potential alternatives in poultry nutrition, potentially leading to cost savings in feed formulations. However, it is important to note that the impact of these wasted feed additives on production performance has demonstrated variation across different studies.

From the results of the present study, it was clear the growth performance, carcass characteristics and nutrient digestibility were significant in birds fed $DDM_9$ ration. Significant fluctuations in the market price of maize were observed following its utilization for biofuel production. As a result, there has been a revived interest in harnessing agro-industrial by-products, such as abundant and reasonably priced date waste, to address the scarcity of grains encountered in animal nutrition [17]. Recently, Attia et al. [11] reviewed and concluded that the synthesis of outcomes from various studies suggests that by-products derived from date fruit, specifically date stone meal, can be integrated at levels of up to 10%. This incorporation can effectively substitute maize (10.5 vs. 7.7 CP; 9.43 vs. 3.8 EE; 28.9 vs. 2.3 CF) or barley (9.43 vs. 2.00 EE; 14.2 vs. 5.00 CF) grains to maintain production performance, thereby potentially reducing production costs [20,34]. Nevertheless, the utilization of DSM is commonly disregarded due to its elevated content of crude fiber (14.2%), which restricts its inclusion in the diets of poultry [35]. The chemical composition of date waste typically resembles that of cereals, except for the values related to crude fiber [11]. In studies involving broiler chickens, the inclusion of date waste in their diet up to 200 g/kg led to a decrease in feed intake and an improvement in feed efficiency at a 50 g/kg inclusion level. However, these parameters remained similar to the control group for other levels of date waste supplementation [36]. In a separate study by Kamel [23], diets containing varying proportions of whole Zahidi dates (5, 10, 30 and 47.7%) were fed to broiler chicks and found that 47.7% of whole dates as a complete replacement for corn resulted in a reduced feed conversion ratio (FCR) for the chicks. Most of the studies in the published literature have investigated the effect of DSM on broiler performance [24,28,33]. However, few research articles are available on the effect of date flesh on the broilers' performance and nutrient digestibility. In the present study, the weight gain was significantly higher in $DDM_9$ compared to the control group. It is evident that the weight gain seems to be developed during the finisher phase. The age of the bird typically influences the advantages of incorporating dates into their diets, with mature birds benefiting more from the dietary fiber compared to younger ones. Given the elevated fiber content present in date wastes, their inclusion in finisher diets should involve a higher percentage compared to starter diets [11].

In the present study, the weight of the breast, leg and GIT was significantly higher in $DDM_9$ compared to the control. The weight of the breast and leg could be attributed to the higher body weight in the corresponding groups. Conflicting evidence is available on the use of dates and their by-products on the carcass quality of broilers. Kamel et al. [23] conducted a study involving broiler chicks, where they provided diets containing various proportions of date pits (0%, 5%, 10% and 15%) or whole Zahidi dates (0%, 5%, 10%, 30% and 47.7%). The study revealed notable differences in carcass weight between the 5% group and the control group, while differences between the 5% group and the other groups were not statistically significant. The control group exhibited higher carcass weight percentages compared to the other groups, with the exception of the 10% group. Additionally, giblet weights did not show significant variations across all groups. It was documented that the inclusion of date waste in the diets of broiler chickens at levels ranging from 0 to 200 g/kg had no discernible impact on dressing percentage or the weight (%) of the liver and gizzard [36]. However, it did bring about changes in various other carcass traits, including the weights of the pancreas, heart, intestine and spleen. Similarly, the addition of date waste up to 150 g/kg in the diet of broiler chickens failed to show any influence on dressing percentage. Nevertheless, there were variations in the weight (%) of the pancreas, heart and spleen across the different levels of inclusion [33]. Absolutely, the emphasis on weight differences among various bird parts, particularly in relation to different levels of date waste supplementation, raises an important question about their potential implications on overall health, meat quality and other economically significant factors. Understanding these potential impacts can provide a more comprehensive evaluation of the effectiveness of date waste supplementation in poultry diets. This broader perspective would contribute to a more thorough assessment of its overall benefits and drawbacks in poultry production.

In the present study, the digestibility of DM, CP and EE were significantly higher in $DDM_9$ compared to the control. The improved growth performance could be linked with improved digestibility of nutrients. In comparison, the digestibility values of CP, CF and nitrogen-free extract (NFE) for date waste are typically lower than those observed for barley and corn. However, the digestibility of EE in date waste tends to outperform the corresponding coefficients for barley and corn, as noted by Attia et al. [11]. It was conducted an assessment of the impact of date waste on broiler chickens' diets, replacing wheat bran at levels from 0 to 200 g/kg [36]. These levels were selected to match energy and protein concentrations. The results indicated that nutrient digestibility remained largely unaffected, except for a reduction in CP digestibility observed at the 200 g/kg inclusion level. Similarly, El-Deek et al. [17] found that the inclusion of date waste in broiler chicken diets at various levels (ranging from 0 to 150 g/kg at six different levels) did not bring about any discernible impact on nutrient digestibility. Notably, the results highlight that optimal growth performance and nutrient digestibility were observed at the 9% inclusion level, which also led to lower production costs per bird. To delve deeper, it is crucial to contemplate the potential ramifications of these differing digestibility rates on bird health, overall growth trajectories and the economic aspects of production. This exploration could provide valuable insights into the holistic impact of integrating date waste into poultry diets, encompassing both performance and financial considerations.

In the present study, no significant change in mortality was observed between the control and supplementation of different levels of DDM in broilers. Kamel et al. [23] observed no significant impact of DSM levels on broiler mortality percentage and concluded that there was no discernible connection between chick mortality and date pits in the diets of broilers. Similarly, Al-Homidan [32] noted there was no notable effect on the broiler mortality rate, which remained at 2.2% throughout the entire experimental period of 0 to 7 weeks. This observation held true regardless of the inclusion of whole date waste meal (at levels of 0, 8, 16 and 24%) or DSM (at levels of 5, 10 and 15%) during the starter period, as well as during the finishing period with different inclusion rates. Additionally, substituting wheat bran with date waste at a level of up to 200 g/kg in the diet did not lead to any significant changes in chicken mortality [33].

In this study, it was observed that the inclusion of 9% dried date meal (DDM) led to an increase in the microbial load of Lactobacillus and a decrease in the presence of E. coli. Maintaining a balanced microbial population in the intestinal tract is crucial for promoting growth and ensuring the overall health of the birds [36]. Bacteria in the intestine play a vital role in metabolizing nutrients from the diets, producing essential substances like vitamins, lactic acid and short-chain fatty acids [37]. It is worth noting that the composition of microbial populations in the gut can vary depending on the animal species, their age, the components of their diet and the environment of their gastrointestinal tract [38]. Certain plant-based substitutes and additives can have probiotic and/or prebiotic effects on gut microflora through both direct and indirect mechanisms [38]. In birds, the nutritional benefits derived from microflora are relatively less significant compared to other animal species, as most of this activity occurs in the hindgut [36]. In a study by Alyileili et al. [12], broilers that were fed diets containing 5% and 10% dried date pits (DDP) demonstrated a noteworthy reduction in the total bacterial count in their gut. Specifically, the 10% DDP diet proved to be the most effective when compared to other dietary treatments.

In our current study, it was observed that the inclusion of DDM9 and DDM12 led to significant increases in revenue, profit and cost–benefit ratio in broilers. Specifically, when broilers were fed with varying percentages of date palm kernel (0, 1, 2, 3 and 4%), the net profits per broiler were recorded as 27.01, 32.77, 36.78, 43.47 and 44.51 (in Rs.), respectively. The highest net profit was achieved by birds fed with 4.0% date palm kernel (44.51 per bird), closely followed by those fed with 3.0% date palm kernel (43.47 per bird) [27]. Furthermore, in broilers, the feed cost was significantly lower in birds fed date waste compared to those on the basal diet [39]. Additionally, Al-Homidan [32] reported that incorporating date wastes at levels of 5, 10 and 15% in broiler diets resulted in a reduction in diet costs compared to the control group. This suggests that the inclusion of date waste materials in broiler diets can lead to cost-saving benefits.

## 5. Conclusions

From the results of the present study, it was concluded that growth performance in terms of weight gain (1–35 days), carcass characteristics, nutrients digestibility (dry matter, crude protein and ether extract), fecal microbiota (increased count of *Lactobacillus* and decrease the count of *E. coli*), better economic return (profit and cost–benefit ratio) were significantly improved at the level of 9% inclusion of dried date waste in broilers.

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