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RESEARCH ARTICLE

The Substitution of Maize With Date By-Products in Broiler Chicken Feed

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ABSTRACT

In Algeria, date by-products account for 25% of date palm production, amounting to 200,000 tons annually. Their use in animal feed is both economically and hygienically advantageous. This study aimed to evaluate the effect of substituting maize with Deglet Nour date by-products in broiler chicken diets on growth performance. A total of 250 "ISA f15" broiler chickens were divided into five groups of 50, each receiving one of five dietary regimens with substitution rates of 0%, 10%, 20%, 30%, and 40% over a 48-day period.

The results showed that final weight, average daily gain (ADG), and feed intake significantly decreased in the group with a 10% substitution rate, with a feed conversion ratio ranging from 2.40 to 2.24. However, the 20% substitution group demonstrated the best final weight (2768.75 g), ADG (83.26 g), and feed conversion ratio (2.24) compared to other groups. Incorporating date by-products at substitution rates of 20%, 30%, and 40% did not impair growth performance. At a 30% substitution rate, the feed conversion ratio slightly increased, but the results remained economically viable starting from a 20% substitution rate.

INTRODUCTION

In the context of food security, leveraging and promoting local bio resources and optimizing the use of local products are essential to reducing dependence on imports (Meradi et al., 2016). In this regard, animal production in Algeria represents a significant strategic opportunity, although it heavily relies on the availability and quality of feed rations necessary for its development. The significant growth of the Algerian poultry sector aims to reduce deficits and meet the demand for animal protein, as avian species have relatively short production cycles, which allow for a consistent supply to meet demand and contribute to job creation (Khemiche, 1997). However, over 85% of Algeria's raw material needs for poultry feed production are met through imports (Alloui, 2003).

In Algeria, the poultry feed model is maize-soy based. Maize and soy are considered the primary energy and protein sources in poultry feed rations. While this feed model provides the necessary nutritional balance, it poses economic challenges due to dependency on imports. It is thus imperative to limit imports and develop national potential. For economic reasons, introducing local products or by-products has become a necessity. This strategy reduces feed costs and helps decrease the food import bill paid annually in foreign currency.

Among these local resources, date by-products are available in significant quantities (123,000 tons) and are economically accessible to all categories of farmers at 500 DA/quintal (I.T.D.A.S, 2007). These

by-products represent a substantial energy source that can partially substitute maize. Several studies have examined their incorporation into feed formulas, demonstrating their high energy value and considerable quantity (Sissaoui, 2015 & 2024; Meradi et al., 2016; Arbouche et al., 2008; Bastinnelli et al., 2009; Gigaud et al., 2007). For a long time, they have been used in developing high-energy, nutritionally valuable food products. Quantitatively, they represent a substantial tonnage. According to Chehma et al. (2000), date by-products constitute, on average, 25% of the annual production. Moreover, Gualtieriri and Rappaccini (1994) indicated that date by-products and date seed flour could be incorporated at up to 10% in poultry diets without negatively impacting performance. Zangia badi and Torki (2010) showed that the zoo technical performance of chickens in the control group was almost identical to those fed a diet containing 18% date by-products.

This study specifically aims to evaluate the effect of substituting maize with Deglet-Nour date by-products in feed rations on the growth performance of broiler chickens.

MATERIALS AND METHODS:

Animals, Feed, and Experimental Protocol:

The trial was conducted in the region of Oum Laagareb, Boutheldja municipality, El-Tarf province, during October and November 2016, in a closed building with a static ventilation system. This period was characterized by an external humidity rate of 70% and an average temperature of 21°C.

Two hundred and fifty (250) one-day-old ISA F15 broiler chicks weighing an average of 25 g were obtained from a hatchery in Batna.

The chicks were divided into five homogeneous groups (four experimental groups and one control group) with 50 chicks per group, each housed in a 6.25 m^2 pen (2.5 x 2.5 m). The bedding consisted of wood shavings.

Date by-products were collected from the Biskra province and dried by exposure to air and sunlight (42°C).

In addition to the control diet, four (04) experimental diets were formulated for each group during the starter (1–20 days), growth (21–33 days), and finishing (34–48 days) phases. The maize substitution rates were as follows: control group: 0%, Group 1: 10%, Group 2: 20%, Group 3: 30%, and Group 4: 40% (see Table 2).

The chicks arrived on 17/11/2016. Dead or abnormal chicks were removed, and the remaining chicks were randomly allocated to the groups. Upon arrival, the chicks were first given sugared water for rehydration. Feed was provided 2–3 hours later to allow yolk sac absorption and facilitate digestion of the first meal.

The temperature was maintained between 33°C and 35°C for the first three days, then decreased by 2°C to 3°C weekly. Lighting was continuous for the first 24 hours (3–5 watts/m^2) and later reduced to 18 hours with 6 hours of nighttime illumination.

The chicks were vaccinated against Newcastle disease and infectious bronchitis at 7 and 21 days of age and against Gumboro disease at 14 days of age (no booster). An anti-coccidial was also administered via drinking water at 17 and 34 days of age for two consecutive days.

Feed was provided in mash form and offered ad libitum, along with water. All birds in each group were weighed individually during the three phases:

Starter phase: Days 1, 10, and 20

Growth phase: Day 33

Finishing phase: Day 48

Throughout the rearing period, mortality rates in all groups were zero.

Table 1: Feed formulas (kg/100 kg feed) for the starter (1–20 days), growth (21–33 days), and finishing (34–48 days) phases based on maize substitution rates with date by-products.

Feed Type	**Starter**					**Growth**					**Finishing**				
% Substitution	0	10	20	30	40	0	10	20	30	40	0	10	20	30	40
Ingrédient															
Maize	60	54	48	42	36	64	57.6	51.2	44.8	38.4	69	62.1	55.2	48.3	41.4
Date by-products (S.p. dates)	0	6	12	18	24	0	6.4	12.8	19.2	25.6	0	6.9	13.8	20.7	27.6
Soybean meal	30	30	30	30	30	27	27	27	27	27	21	21	21	21	21
Wheat bran	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Limestone	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Dicalcium phosphate	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Broiler premix (CMV chair)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nutrient Content															
	2877	2865	2845	2834	2855	2975	2964	2953	2932	2942	2975	2965	2950	2936	2945
Metabolizable Energy (kcal/kg)	19.73	19.39	19.07	18.73	18.41	18.79	18.44	18.08	17.73	17.38	16.63	16.25	15.59	15.49	15.12
Crude Protein (%)	2.95	2.81	2.68	2.53	2.40	3.10	2.95	2.80	2.66	2.51	3.27	3.10	2.94	2.79	2.63
Fat content (%)	3.65	3.89	4.14	4.38	4.62	3.54	3.79	4.05	4.15	4.57	3.24	3.51	3.79	4.07	4.35

CMV (Mineral-Vitamin Supplement), composition:

Calcium: 16.8%

Magnesium: 0.1%

Sodium: 12.8%

Chlorine: 20.5%

Vitamin A: 750,000 IU

Vitamin D3: 160,000 IU

Vitamin E: 1,280 mg/kg
Vitamin B1: 100 mg/kg
Vitamin B2: 300 mg/kg
Calcium Pantothenate: 570 mg/kg
Niacin: 1,750 mg/kg
Vitamin B6: 99 mg/kg
Vitamin K3: 190 mg/kg
Folic Acid: 35 mg/kg
Biotin: 1 mg/kg
Choline Chloride: 25,000 mg/kg
Iron Carbonate: 2,500 mg/kg
Copper (sulfate): 970 mg/kg
Zinc (sulfate): 6,080 mg/kg
Manganese (oxide): 7,500 mg/kg
Iodine (iodate): 120 mg/kg
Selenium (selenite): 25 mg/kg
Other additives:
DL-Methionine: 180 g/kg
Antioxidant
Citric Acid
Orthophosphoric Acid

Statistical Analysis:

Descriptive statistics and analysis of variance using the univariate general linear model (ANOVA) were conducted with SPSS software (version 18, 2008) to analyze live weight (LW), daily weight gain (DWG), feed intake, and feed conversion ratio (FCR).

The general linear model was applied to test the effects of factors on variables, and post hoc tests (S.N.K. - Student-Newman-Keuls and Duncan) were used to estimate the significance or homogeneity between different subsets (mean comparison test). Differences were considered significant at a 5% error risk.

RESULTS AND DISCUSSION:

Chemical Composition

Table 2: Chemical composition of Deglet-Nour variety date by-products.

Components	Values
Dry Matter (DM	91%
Organic Matter (OM) (% of DM)	96.3%
Total Nitrogenous Matter (TNM) (% of DM):	4.1%
Crude Fiber (CF) (% of DM)	6.5%
Neutral Detergent Fiber (NDF) (% of DM):	23.5%
Acid Detergent Fiber (ADF) (% of DM)	12%
Acid Detergent Lignin (ADL) (% of DM)	5.6%
Fat Content (FC) (% of DM)	2.1%
Mineral Matter (MM) (% of DM)	3.7%
Nitrogen-Free Extract (NFE)	72.8%
Gross Energy (GE) (kcal/kg DM)	4187
Metabolizable Energy (ME) (kcal/kg DM):	Metabolizable3785
Lysine (Lys) (g/100g of protein)	0.14
Methionine (Met) (g/100g of protein)	0.05
Cystine (Cys) (g/100g of protein)	0.08

MS: Dry Matter

EM: Estimated according to the formula EM (Kcal/kg DM) = 35.3×CP (%) + 79.5×EE (%) + 40.6×NFE (%) + 199 (where EM is metabolizable energy, CP is crude protein, EE is ether extract, and NFE is nitrogen-free extract), according to CARPENTER and CLEGG (1956).

The analyses focused on dry matter, total nitrogenous matter, crude cellulose, fat content, and mineral matter. The gross energy was determined in the laboratory.

The sugar content in our sample was found to be high (73%), which is comparable to values reported by Mercier (1973) (61-68%) and Boudechiche (2009) (65%). The cellulose content of our sample (6.5% of DM) is higher compared to that of corn (2.46% of DM) according to Zitari (2008) and (2.65%). According to Arbouche (2012), the high fiber content in date seeds is likely responsible for this higher crude cellulose content. However, the by-products of dates have moderately low levels of cell wall components (NDF, ADF, and ADL).

Regarding the total nitrogenous matter, our results show a moderately low content (4.1% of DM), compared to corn (9%) according to INRA (1984). Furthermore, several studies analyzing different

varieties of dates have reported a deficiency in proteins, with values ranging from 2-4% according to Chehma (2001), (4.9%) according to Boudechiche et al. (2009), and (4.2%) according to Boukhris et al. (2017).

The metabolizable energy (ME) generated by 1 kg of dry matter from date by-products was 3785 Kcal/kg DM, a value similar to that of corn (3726 Kcal/kg DM) according to INRA (2004). Our results are, however, higher than those reported by Al-Harthi (2006) (3700 kcal/kg DM), El-Deek et al. (2010) (3750 kcal/kg DM), and Boukhris et al. (2017) (3785 kcal/kg DM). The high metabolizable energy content in date by-products could be attributed to their significant content of cytoplasmic carbohydrates, particularly monosaccharides (glucose, fructose), and sucrose (Estanove, 1990).

Furthermore, date by-products have been characterized by a good balance of essential amino acids (lysine, methionine, and cysteine). From a nutritional standpoint, the use of date by-products should therefore preferably be combined with a complementary protein source or synthetic amino acids.

Bodyweight Performance

Table N°3: Evolution of body weight growth during the starter, grower, and finisher phases in broiler chickens based on the percentage of maize substitution with date by-products.

		% of corn substitution with date by-products					
		0	10	20	30	40	GMQ
Starter phase	Initial weight (g)	25					
	Weight at 10 days (g)	184,53^{d}	88.61^{d}	179,90^{b}	181,66^{b}	175.51^{c}	4.58
	Average daily weight gain 1-10 days (g/day/subject)	15,95^{a}	6.36^{d}	15,49^{b}	15,66^{b}	15.05^{c}	0.45
	Weight at 20 days (g)	552,15^{a}	161,13^{c}	524,62^{b}	556.33^{a}	552.06^{a}	16.99
	Average daily weight gain 11-20 days (g/day/subject)	36,76^{a}	7.25^{c}	34,47^{b}	37,46^{a}	37.65^{a}	0.35
	Average daily weight gain 1-20 days (g/day/subject)	26,35^{a}	6.80^{c}	25,03^{b}	26,56^{a}	26.35^{a}	0.40
Growth phase	Weight at 33 days (g)	1479,51^{a}	680,11^{b}	1519,81^{a}	1537.01^{a}	1541.64^{a}	18.67
	Average daily weight gain 21-33 days (g/day/subject)	71,33^{a}	39,92^{b}	45,78^{c}	75,43^{a}	76.12^{a}	0.84
Finishing phase	Weight at 48 days (g)	2607,94^{a}	1783,09^{b}	2768,75^{c}	2688,94^{d}	2638.33^{d}	25.34
	Average daily weight gain 34-48 days (g/day/subject)	75,22^{a}	73,53^{b}	83,26^{c}	76,79^{d}	73.11^{b}	0.69
	Average daily weight gain 1-48 days (g/day/subject)	54,33^{a}	37,14^{b}	57,68^{c}	56,24^{d}	54.96^{d}	0.45

GMQ: Average daily gain (the indices indicate the period in days over which this parameter was calculated). The presence of different letters on the same line indicates a significant difference between the diets ($p < 0.05$). The results are expressed as the mean ± standard error of the mean (SEM).

Body weight performance (BW and GMQ) during the starter phase: The group receiving 30% date by-products showed slightly higher performance compared to the control group (Table 3). However, a growth delay was observed in the 10% group. It can be deduced that the young chicks were less sensitive to the addition of 10% date by-products during the starter phase. During the growth phase, subjects receiving 20%, 30%, and 40% continued their growth in a slightly similar manner, but with an increase compared to the control group. A growth delay was noted in the 10% group (Weight: 680g, GMQ: 39.92 g/day). This is likely attributed to both the palatability of the diet and the nutritional balance of the offered rations. Our results differ from those reported by El-Deek et al. (2010) and Zangiabadi&Torki (2010), who stated that the addition of up to 35% date waste in broiler diets did not negatively affect growth performance. On the other hand, our results align with those reported by Bara et al. (2019) regarding body weight and average daily gain, respectively (1537g, 75g/day) for the 30% group at 33 days of age.

During the finishing phase, the substitution rate of maize by date by-products resulted in significantly higher body weights for the experimental groups (20%, 30%, and 40%) compared to the control group, with the 20% group being the heaviest, showing a GMQ of 83g/day, significantly higher than the other groups. Our results were similar to those of Bara et al. (2019) for body weight and GMQ for the 20%, 30%, and 40% groups, and superior to the results found by Meradi et al. (2016) and Rafik et al. (2017).

Feed intake and consumption index

Table N° 4: Evolution of feed intake and the consumption index during the starter, growth, and finishing phases in broiler chickens based on the percentage of maize substitution with date by-products.

		"% of maize substitution with date by-products					GMQ
		0	10	20	30	40	
Starting Phase (1 to 20 days)	▪ Quantity ingested (g):						
	1 to 10 days	162,17^{a}	128,97^{d}	158,65^{b}	164,41^{a}	145,77^{c}	1.53
	11 to 20 days	765,84^{a}	422,38^{a}	779,33^{b}	802,21^{b}	731.37^{c}	6.83
	1 to 20 days	928,01^{a}	551,35^{b}	937,98^{c}	966,62^{d}	877,14^{d}	35.15
	▪ Feed conversion ratio:						
	1 to 10 days	1.01^{a}	2,02^{c}	1,02^{a}	1,04^{a}	0.96^{b}	1.05
	11 to 20 days	2,08^{a}	5,82^{a}	2,26^{b}	2,14^{c}	1.94^{a}	0.82
	1 to 20 days	1,76^{b}	4,05^{d}	1,87^{c}	1,81^{a}	1,66^{b}	1.02
Growth Phase (21 to 33 days)	▪ Quantity ingested (g):	1849,80^{a}	1226,90^{b}	1811,03^{a}	1829,51^{a}	1928,24^{c}	10.44
	1 to 10 days	1,99^{a}	2,36^{b}	1,81^{c}	1,86^{c}	1,94^{a}	0.95
Finishing Phase (34 to 48 days)	11 to 20 days	3497,25^{a}	2662,5^{b}	3468,36^{a}	3698,65^{c}	3432,89^{a}	55.43
	1 to 20 days	3,09^{a}	2,41^{b}	2,77^{c}	3,21^{d}	3,13^{d}	1.25
Raising Cycle (1 to 48 days)	▪ Feed conversion ratio:	6275,06^{a}	4440,75^{b}	6217,37^{b}	6494,78^{c}	6238,27^{d}	52.8
	1 to 10 days	2,40^{a}	2,49^{b}	2,24^{c}	2,41^{d}	2,36^{b}	0.75

abcd: The presence of different letters on the same line indicates a significant difference between the diets ($p < 0.05$).

During the starter phase, the consumption index for the 0%, 20%, and 30% groups remained the same, while the 10% group recorded a higher value (CI: 2.02). For the same period, the feed intake between days 1 and 20 was significantly lower for the 10%, 20%, and 30% substitution groups compared to the control group, with an increase in the 40% group (1928.24g). During the entire rearing cycle, the best consumption index was observed in the 20% group (CI: 2.24). Our results diverge from those reported by Kamel et al. (1981), Vandepouliere et al. (1995), and Boukhris et al. (2017). Regarding the finishing phase, an improvement in intake was observed in the 0%, 20%, 30%, and 40% groups, with particular emphasis on the 40% group; this could be explained by the

increased dietary, particularly energy, requirements of the chickens in the finishing phase. Consequently, the consumption index for the 40% group during the finishing phase was similar to those of the 0% and 30% groups (with values of 3.13, 3.09, and 3.21, respectively). These results are in agreement with those reported by Hussein et al. (1998), Al-Homidan (2003), Afzal et al. (2006), and Bara et al. (2019), who reported a positive effect of adding date waste in the finishing phase on live weight, GMQ, and feed intake.

CONCLUSION

The incorporation of date by-products at a rate of 20% in the diet, partially replacing maize, is possible without compromising the zootechnical performance of broiler chickens.

The diet with a 20% substitution rate proved to be more cost-effective than the diets with 10%, 30%, and 40% substitution from a technical perspective.

Several perspectives can be considered:

To better valorize our results on this new food resource, it is essential to use well-ground date residues, especially for the pits.

It is necessary to store date waste and recognize that energy sources are of utmost importance to the animal industry and the economy of the country.

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