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Research Article

Date Scraps and Rumen Content Extract in Broiler Feed: Effects on Growth Performances, Carcass Yields, Meat Quality and Economic Efficiency

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Abstract
The aim of this study was to determine the effect on the production performances and carcass characteristics of local broiler chickens of replacing corn with cull dates from agri-food industries in oasis zones and of complementing this with rumen content extract from sheep abattoirs in the chickens' feed rations. A total of 200 male and female day-old chicks of local stock, with an average weight of 25±2g, were divided randomly into 4 groups of 50 individuals, each group distinguished by the respective rate of substitution of corn by cull dates (0%, 20%, 30% and 40%) for a period of 48 days. Each group was divided into ten (10) cages of 5 subjects. The live weights after 48 days improved for all experimental groups, recording an increase of +162g (20%); +82g (30%) and +31g (40%). All of the characteristics remained unchanged for all groups with the exception of liver weight, which was lower in the experimental groups. Substituting until 40% of the corn by culls dates while adding 250 ml rumen content extract per kilogram of broiler feed increased the live weight and average daily gain compared to the control.

Keywords: broiler, productivity performance**,** cull dates, rumen content extract, feed.

Introduction
Poultry farms provide white meat more quickly than those supplying red meat. They provide the most disadvantaged people with cheaper animal proteins than those derived from red meat. Nevertheless, in most emerging countries, livestock production is dependent on imports of raw materials used in the preparation of feed for these monogastric animals, as is the case in Algeria. In this type of production, food accounts for 60% to 70% of farming expenditure [1] and to ensure a reduced impact on the kilogram of meat produced, it makes sense to reduce the cost of feed formulae by using unconventional foodstuffs and in particular agro-industrial by-products such as cull dates from oasis regions. Taken from the date packaging and processing industries, they are available in large quantities [2] and their chemical composition and nutritional value have been determined [3, 4]. Several studies have focused on the incorporation of the by-products of dates [5] and the improvements made to them through chemical treatment [3, 6, 7]. A number of production performance

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improvement tests were examined, which used growth enhancers [8], probiotics, with or without minerals, and vitamins [9-11], exogenous enzymes, essential amino acids [12, 13] and rumen juice [14]. Rumen juice was tested in monogastric animals, and in particular broiler, as a growth enhancer [15].
The aim of our study was to determine the influence of replacing corn with cull dates and injecting 250 ml sheep rumen content extract per kilogram of food into the different substitution plans with a view to offsetting the impact of the protein deficit of cull dates on the productivity performances and the quality of broiler carcasses.

Material and Methods

Animals, diet and experimental protocol
The test was conducted at the El Kala poultry facility (El-Tarf wilaya) in a closed, statically ventilated building reserved for experiments on broiler chickens. A total of 200 male and female day-old chicks of local stock, with an average weight of 25±2g, were divided randomly into 4 groups of 50 individuals allocated a surface area of 5 m^2 per group with litter made from crushed durum wheat straw. Each batch was divided into ten (10) pens of 5 subjects, banded and numbered.
The cull dates (CD) of Deglet Nour variety were provided by packaging plants in south-eastern Algeria (Biskra). They were first dried in the sun then crushed using a hammer mill with a 1-mm grate. The chemical composition is presented in Table 1.

Table 1.
Chemical composition of cull dates (Arbouche *et al.,* [4])

Organic matter (% of DM)	97.1
Total nitrogenous matter (% of DM)	4.2
Crude fibre (% of DM)	9.4
Fat (% of DM)	8.2
Mineral matter (% of DM)	2.9
Total sugars (% of DM)	62.3
Nitrogen-free extract (% of DM)	66.1
Crude energy (kcal/kg of DM)	4,235
Metabolisable energy (kcal/kg of DM)	3,683
Lysine (g/100g of proteins)	3.2
Methionine (g/100g of proteins)	1.5
Cystine (g/100g of proteins)	1.7

DM: dry matter
Metabolisable energy: estimated using the formula developed by Carpenter and Clegg [16] with ME (kcal/kg of DM) = 35.3 x CP (%) + 79,5 x EE (%) + 40.6 x NFE (%) + 199 (EM: metabolisable energy, PB: crude protein, EE: ether extract, NFE: nitrogen-free extract)

The rumen content was recovered from abattoirs immediately after the sheep were eviscerated. It was treated with a 1% solution of hydrochloric acid, in order to prevent flies from laying any eggs, then spread on plastic film. During the sun-drying process, the dates were turned several times. The rumen content (RC) was soaked in water heated to 80°C at a rate of one kilogram per liter (1 kg/l) and mixed every six hours for 24 hours. After filtering, the extract (RCE) was refrigerated at a temperature of 4°C [17]. The total nitrogenous matter (TNM) and amino acid (AA) content is presented in Table 2.

Table 2.
Content of TNM (% of DM) and AA (as % of TNM) in ovine rumen content extract (RCEo)

RCE_o	TNM	AA								
		Cystine	Methionine	Threonine	Lysine	Glutamic acid	Aspartic acid	Arginine	Leucine	Isoleucine
	8.32	0.89	1.10	2.14	2.56	10.21	6.24	2.85	4.36	1.81

TNM : total nitrogenous matter ; AA : amino acid

Using the WUFFDA software for the broiler chicken feed formulae, four rations were prepared with 0% (control feed), 20%; 30% and 40% rate of substitution of corn by cull dates and 250 ml rumen content extract for the different rearing phases (Table 3).
A temperature varying between 36 and 38°C was maintained over the first ten days thanks to gas incubators and lighting operated 24 hours a day before being reduced to 18 hours a day with 6 hours of night. The water and feed were distributed ad libitum. The chickens were vaccinated against Newcastle disease and infectious bronchitis on the 7 and 21 rearing day as well as against Gumboro disease at 14 days of age (no booster required). Furthermore, an anti-coccidian was administered in the drinking water at 17 and 34 days of age for two consecutive days.

Table 3.

Formulae (kg/100 kg of feed) for starter feed (1 to 20 days), grower feed (21 to 33 days) and finisher feed (34 to 48 days) distributed to the chickens according to the substitution rate of corn by cull dates soaked in rumen juice

Type of food	Starter				Grower				Finisher			
Rate of substitution	0	20	30	40	0	20	30	40	0	20	30	40
Ingredients												
Corn	61	48.8	42.7	36.6	64	51.2	44.8	38.4	70	56	49	42
Cull dates	0	12.2	18.3	24.4	0	12.8	19.2	25.6	0	14	21	28
Soya cake	30	30	30	30	27	27	27	27	21	21	21	21
by-products of milling	6	6	6	6	6	6	6	6	6	6	6	6
Bi-calcium phosphate	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
MVS	1.25	1.25	1.25	1.5	1	1	1	1	1	1	1	1
L-Lysine	0 .15	0 .15	0 .15	0 .15	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
DL-Methionine	0.4	0.4	0.4	0.15	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Nutrient content as % of DM												
Metabolisable energy (Kcal/Kg)	2,890	2,912	2,923	3,119	2,840	2,920	3,015	3,242	2,990	3,351	3,610	3,873
Crude protein (%)	21	20.18	20.02	19.51	20.33	19.21	19.02	18.85	18	17.8	17.1	16.75
Fat (%)	2.8	2.33	3.3	1.87	2.88	2.4	2.15	1.91	3.05	2.52	2.25	1.99
Mineral matter (%)	3	3	3.2	3.3	2.7	2.7	2.8	3	2.9	3	3	3.1
Crude fibre (%)	2.96	2.69	2.62	2.43	2.91	2.63	2.49	2.51	2.81	2.5	2.35	2.19
Lysine (%)	1.20	1.17	1.15	1.14	1.38	1.35	1.33	1.31	1.22	1.18	1.16	1.14
Methionine (%)	0.72	0.69	0.68	0.67	0.6	0.58	0.57	0.56	0.57	0.55	0.54	0.52

MVS (mineral-vitamin supplement) composed of: 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, B1: 100 mg/kg, B2: 300 mg/kg, calcium pantothenate: 570 mg/kg, niacin: 1,750 mg/kg, B6: 99 mg/kg, 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 (sulphate): 970 mg/kg, zinc (sulphate): 6,080 mg/kg, manganese (oxide): 7,500 mg/kg, iodine (iodate): 120 mg/kg, selenium (selenite): 25 mg/kg and other additives; DL-methionine: 180 g/kg, antioxidant, citric acid, orthophosphoric acid.

The animals were weighed individually at 10, 20, 33, 42 and 48 days of age. During the rearing cycle, the feed was distributed freely after having been sprayed with 250 ml rumen content extract per kg of feed, and uneaten feed was weighed every day. The mortality rate was recorded every day throughout the entire duration of the experiment. On the 49 day, 25 chickens picked at random from each group were killed. The live weight, eviscerated carcass weight and weight of the feet, head, feathers, gizzard, guts and liver were determined.

Statistical analysis

The descriptive statistic and the single-factor variance analysis (ANOVA) were conducted using the SPSS software (version 21, 2012) to analyze the live weight (LW), the average daily gain (ADG), the quantity of food ingested and the feed conversion ratio (FCR). Using the post-hoc test by applying the Dunnett bilateral test made it possible to estimate the significance or homogeneity between the different sub-groups (comparison test between averages). The differences are deemed to be significant with an error risk of 5%.

Economic efficiency

The choice of the complete cost method was necessary to analyze the composition of the costs incurred in obtaining by-products. The main aim of this method is to calculate the most complete production costs possible, taking account of all expenses incurred during the production and processing of a finished by-product intended for poultry feed. This production cost does not include marketing costs, abnormal costs or storage costs not linked directly to production.

Results and Discussion

Results

Throughout the entire duration of the experiment, we recorded no deaths. The weights at 10 days of age were significantly identical ($p<0.05$) for the groups with 0% (control), 20% and 30% corn substitution by cull dates, while the 40% group displayed the lowest weight (176 g) (Table 4).

Table 4.
Change in weight increase during starter, grower and finisher phases according to the rate of substitution

Starter phase	0	20	30	40	ESM	p
Initial weight (g)	25	25	25	25		
Weight at 10 d (g)	185^{a}	180^{a}	182^{a}	176^{b}	2.60	0.03
ADG1-10 (g/d/animal)	16^{a}	15^{b}	16^{a}	15^{b}	0.28	0.03
Weight at 20 d (g)	552^{a}	525^{b}	556^{a}	552^{a}	8.15	0.04
ADG11-20 (g/d/animal)	37^{a}	34^{b}	37^{a}	38^{a}	0.80	0.02
ADG1-20 (g/d/animal)	26	25	27	26	0.42	0.566
Grower phase						
Weight at 33 d (g)	$1{,}480^{a}$	$1{,}520^{b}$	$1{,}537^{b}$	$1{,}542^{b}$	19.83	0.03
ADG21-33 (g/d/animal)	71^{a}	76^{b}	75^{b}	76^{b}	1.48	0.04
Finisher phase						
Weight at 48 d (g)	$2{,}607^{a}$	$2{,}769^{b}$	$2{,}689^{ab}$	$2{,}638^{ab}$	23.62	0.02
ADG34-48 (g/d/animal)	75^{b}	83^{a}	77^{b}	73^{b}	1.95	0.001
ADG 1-48 (g/d/animal)	55	58	57	56	0.50	0.500

This group was characterized by an average daily gain (ADG) of 15 g, the same value as that recorded for the 20% group. The 0% and 30% groups had identical ADGs (16g). After 20 days, the trend appeared to reverse, with a significantly similar weight for the groups with 0%, 30% and 40% incorporation of cull dates whereas the 20% group displayed a fall in weight (525g) reflected by a low ADG (34g) compared to the other groups, in which the ADGs were significantly comparable. Between the 1st and 20th day, the ADG was nevertheless similar for all groups ($p > 0.05$). With a weight of 1,480g at 33 days of age, during the growth phase, the control group was the least representative group compared to the other groups, all of which displayed significantly greater weights proportional to the rates of cull date incorporation. The same observation could be made with regard to the ADGs over this period. During the final phase, the rate of substitution of corn by cull dates generated significantly greater weights for the experimental groups in relation to the control group ($p < 0.05$), the 20% group being the heaviest with an ADG of 83g, significantly higher than that of the other groups. The ADG across the entire rearing period (day 1 to 48) was significantly identical for all groups. The quantity of food ingested was significantly similar for the 0% (control), 20% and 40% groups across the entire process, with the 30% group consuming a larger quantity (6,495g) (Table 5).

Feed conversion ratio for the 0% and 30% groups remained the same while the 20% group displayed the lowest FCR at 2.26; the 40% group recorded an intermediate value of 2.38.

During the starter phase, the quantity of food ingested displayed a saw-tooth pattern in relation to the rates of cull date incorporation in the chickens' diet, with the 40% group recording a significantly lower quantity ingested (731g). The same observation applied to the FCR. During the grower phase, the 0%, 20% and 30% groups were characterized by an identical quantity of food ingested, which was nevertheless below that of the 40% group (1,928g), although the FCR I for the 0% group remained similar to that of the 40% group. During the final phase, the 30% group maintained the highest level (3,699g) and the 0%, 20% and 30% groups recorded significantly similar quantities ingested.

Table 5.

Change in quantity of food ingested and the feed conversion ratio according to the rate of substitution

	0	20	30	40	ESM	p
Food ingested (g)						
From 1 to 10 days	162[a]	159[b]	164[a]	146[c]	1.52	0.01
From 11 to 20 days	766[a]	779[b]	802[c]	731[d]	6.82	0.001
From 21 to 33 days	1,850[a]	1,811[a]	1,830[a]	1,928[b]	10.24	0.03
From 34 to 48 days	3,497[a]	3,468[a]	3,699[b]	3,433[a]	19.56	0.01
From 1 to 48 days	6,275[a]	6,217[a]	6,495[b]	6,238[a]	53.8	0.02
Feed conversion ratio g/g)						
From 1 to 10 days	1.01[a]	1.02[a]	1.04[a]	0.96[b]	0.035	0.04
From 11 to 20 days	2.08[a]	2.26[b]	2.14[c]	1.94[d]	0.566	0.007
From 21 to 33 days	1.99[a]	1.81[b]	1.86[b]	1.94[a]	0.992	0.03
From 34 to 48 days	3.09[a]	2.7[b]	3.21[c]	3.13[c]	0.127	0.04
From 1 to 48 days	2.41[a]	2.24[b]	2.41[a]	2.36[ab]	0.32	0.01

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

The slaughter parameters remain similar regardless of the rate of cull date incorporation in the chickens' diet, with the exception of the live weight, which remained lower (< 50g) in the experimental groups and significantly different from that of the control group (65g) (Table 6).

Table 6.

Change in slaughter parameters according to the rate of substitution

	0	20	30	40	ESM	p
Parameters						
Live weight (g)	2,793	2,836	2,921	2,761	93.9	0.631
Weight evisc. carcass (g)	1,979	2,077	2,130	1,974	80.17	0.522
Weight of feet (g)	105	105	107	108	5.54	0.989
Weight of head (g)	70	63	72	74	4.91	0.402
Weight of feathers (g)	112	99	100	100	10.1	0.608
Weight of gizzard (g)	64	72	77	70	3.92	0.093
Weight of guts (g)	431	386	408	401	17.51	0.299
Weight of liver (g)	65.0[a]	46.2[b]	50.8[b]	48.2[b]	3.30	0.00

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

Economic efficiency

Our calculations concerning the price of feed distributed in each rearing phase are based on the average price of corn, currently at DZD 27/kg. For the processed rumen content (RC), the complete cost was DZD 12.514/kg (covering the labor costs for recovering the rumen and treating it with HCl, including the cost of the acid). The experimental ration modified by the rumen content was processed when the ration was served. The weight of the liquid used is not considered as part of the weight of this feed. However, this treatment was proportional to the weight of the ration, i.e. quarter of a liter per kilo of feed, thereby allowing the additional cost of the treatment to be evaluated at DZD 261.98

per kilo of feed, with the exception of the control group (Table 7).
The cost of the cull dates (CD), including labor and amortization of the equipment used to recover and crush the dates, was evaluated at DZD 12.572/kg.
The prices of the concentrates of the control groups (starter = DZD 51.68/kg, grower = DZD 49.25/kg, finisher I DZD 47.04/kg) are those provided by the national office for livestock feed [18]. The prices of the experimental concentrates were calculated according to the prices of the raw materials, constituents and substitution ingredients (Table 3 and Table 7).

Table 7.

Costs of different concentrates according to the rate of substitution.

Starter feed	0%	20%	30%	40%
Cost of corn + CD (DZD/Qx)	1,647	1,470.9	1,382.9	1,294.9
Cost of full concentrate (DZD/Qx) *	5,168	4,991.95	4,903.93	4,815.9
Cost of rumen content	0	261.98	261.98	261.98
Total cost of concentrate	5,168	5,273.93	5,165.91	5,077.88
Grower feed				
Cost of corn + CD (DZD/Qx)	1,728	1,543.29	1,450.94	1,358.59
Cost of full concentrate (DZD/Qx) *	4,925	4,740.29	4,647.94	4,555.59
Cost of treatment by Hcl1n	0	261.98	261.98	261.98
Total cost of concentrate	4,925	5,002.27	4,909.92	4,817.57
Finisher feed				
Cost of corn + CD (DZD/Qx)	1,890	1,687.98	1,586.97	1,485.96
Cost of full concentrate (DZD/q) *	4,704	4,501.98	4,400.97	4 299.96
Cost of treatment by Hcl1n	0	261.98	261.98	261.98
Total cost of concentrate	4,704	4,763.96	4,662.95	4,561.94

* Cost of full concentrate = cost of control concentrate – cost of quantity of corn removed + cost of quantity of cull dates added = cost of control concentrate – quantity substituted × difference in price between the two materials

Discussion

Through this study, it is interesting to note that while the initial weight was low (25g), explained by the use of a hardy, local breed that is widespread within the region [19], the weight at 10 days of age and the ADG (16g) remain comparable to those of the Isa Vedette breed and that partial substitution of corn by cull dates of up to 40% generates a positive effect on live weight and ADG, the best results provided by a substitution rate of 20% (2,769g) while the 40% group (2,638g) also displayed a higher weight than the control group (2,607g), i.e. +6% and +1.2% respectively. These results were obtained with the addition of 250 ml of rumen content extract (RCE) per kg of feed.
In the case of broiler, several authors have reported the regressive effect of a cull date incorporation rate in feed greater than 20%, causing a reduction in both live weight and ADG [6, 20, 21]. The addition of the probiotic (rumen content extract) promoted an increase in live weight and average daily gain up to an incorporation rate of 40%, as reported by Kuçukersan *and al* [15]. Generally speaking, the different incorporation rates of cull dates in animals' diets (0 to 40%) do not cause any variation in the quantity of feed ingested [21], although they do result in a significant reduction in the FCR of the 40% group in relation to the control group, an observation which is inconsistent with that of these same authors and El- Deek *and al* [22]. The variations in carcass characteristics are not significant, as observed by Al-Homeidan [23], although Al-Bowait and Al Sultan [24] and Masoudi *and al* [21] indicate a decline in these parameters as the incorporation rates of cull dates in feed increases.
The experimental diets have a positive influence on feed by improving growth performances (final live weight) (Table 8).

Table 8.

Economic indicators according to the rate of substitution

	0			20			30			40		
Period period	UP	QI	PQFI	UP	QI	PQFI	U P	QI	PQFI	UP	QI	PQFI
1-20 d	51.68	928	47.95	53.04	938	49.75	52.16	966	50.38	51.28	877	44.97
21-33 d	49.25	1,850	91.11	50.52	1,811	91.49	49.60	1830	90.76	48.67	1,928	93.83
34-48 d	47.04	3,497	164.49	48.14	3,468	166.56	47.13	3699	174.33	46.12	3,433	158.32
TCF	303.57			307.8			315.47			297.12		
Final LW (g)	2,607			2,769			2,689			2,638		
CA/ kg of LW	116.44 DZD		(€ 0.862)	111.15 DZD		(€ 0.823)	117.31 DZD		(€ 0.868)	112.63 DZD		(€ 0.834)
TPC/kg of LW	194.06 DZD		(€ 1.437)	185.25 DZD		(€ 1.372)	195.51 DZD		(€ 1.448)	187.71 DZD		(€ 1.39)
CSE				322.43			313.11			307.18		
WD (DZD)				+ 18.86			+ 9.54			+ 3.60		
FD (DZD)				+13.80			-2.25			+9.95		
Difference (%)				-4.54%			+0.74			-3,27		

UP = Pi: unit price of 1 kg of feed (DZD); QI: quantity ingested (g) ; PQFI = Pi × Qi: price of quantity of feed ingested (DZD) TCF: total cost of feed; LW: live weight; TPC: total production cost; CSE: TCF that the farmer must spend on control feed t obtain experimental outputs; WD: difference in cost resulting from increased weight (DZD); FD: difference in cost resultin from reduced cost of feed (DZD)

Our economic results are similar to those obtained by Mourad [25] and Kaci [26]; € 0.862/kg compared to € 0.875/kg and €0.852/kg respectively for animals fed on 100 % corn. For the experimental groups (20% and 40%), our feed costs are more advantageous than those obtained by these same authors: € 0.823/kg and € 0.834/kg compared to € 0.875/kg and €0.852/kg, respectively.

Production costs are higher than those recorded by Mourad [25]: (€ 1.32/kg) and the ITAVI [27] (€ 0.962/kg) and similar to those obtained by Kaci [26] : (€ 1.42/kg) and the OFAAL [28] : (€ 1.37/kg).

For substitution to be rational, the production/cost ratio after substitution is equal to that before substitution, all other things being equal [29] :

$CP / Y = CP_1 / Y_1$

$(PX) / Y = [(P_1 X_1 + P (X - X_1)] / Y_1$

$(PX)Y_1 / Y = [(P_1 X_1 + P (X - X_1)]$

$(PX)Y_1 / Y - P(X-X_1) = P_1 X_1 = (P X) [Y_1 / Y - 1] + P X_1$ $P_1 = (P X) [Y_1 / Y - 1] / X_1 + P$

$P_1 = P [(Y_1 / Y - 1) X / X_1 + 1]$, where

P1: Price of interest of the rejects of dates; P: price of foodstuff to be substituted (corn); Y1 / Y: production after substitution / production before substitution; X/X1: rate of substitution of production factors (corn / CD).

P =DZD 27/kg; X = 61% and Y = 2,607 g of meat

Table 9 shows that the price of cull dates used as a substitute for corn must not exceed DZD 27.80/kg. In our experimentation, the cost of CDs is DZD 12.572/kg.

Table 9. Interest price of cull date according to the substitution rate

	20%	**30%**	**40%**
X1	12.2	18.3	24.4
Y1 (g)	2,769	2,689	2,638
P1 (DZD/Qx)	3,538.89	2,982.8	2,780.26

P1: Price of interest of the rejects of dates ;
Y1 : production after substitution ;
X1 : rate of substitution of production factors

Conclusions

Incorporating cull dates until a 40 % substitution rate instead of corn, with the addition of 250 ml of sheep rumen content extract per kilogram of feed, improves live weight and average daily gain with a reduced quantity of food ingested and a lower FCR. The characteristics of the carcasses remain unchanged. The diet with a 20% substitution rate proved to be more profitable than the 30% and 40% diets from a technical and economic standpoint (LW = 2,769 g and PC = € 1.37/kg), although the latter remain competitive compared to the control group.

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