Vol. 75 | No. 9/1 | Sep 2019
DOI: 10.21506/j.ponte.2019.9.4
PONTE Florence, Italy
International Journal of Sciences and Research

Effects of Incorporating Cull Dates and Apricot Kernel Cake on Fattening Performances and Carcass Characteristics of Local Rabbits

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ABSTRACT
The aim of this study is to determine the effects of incorporating the complex apricot kernel cake and cull dates on the fattening performances of a "white population" breed of rabbits. In total, 288 young rabbits of both sexes (1:1) aged 35 days were divided into 4 equal groups of 72 individuals, with 6 rabbits per cage, according to the rage of replacing corn by cull dates and soya cake by apricot kernel cake (0%, 10%, 20% and 30%). The change in weight between day 35 and day 77 was not significantly different between the different rates of substitution. The average daily gain (ADG $_{(35 \text{ to } 77 \text{ d})}$) displayed a significant difference for 20% and 30% groups (+6%), an increase in meat proteins for the 10% group (+8.8%) and 30% group (+5.6 %) and a reduction in lipids for the 20% group (-19%). The financial gain was €17.3 per hundredweight of food produced for the incorporation of 30% of the complex of dates rebus and apricot kernel meal in substitution for the maize complex and soybean meal.

Keywords: by-products; carcass characteristics; chemical composition of the meat; food; rabbit farming; fattening performances

INTRODUCTION
The most common breed of rabbits in Algeria is a local breed called "white population". In breeding cycles, spending on feed accounts for 60% to 70% of production costs (Nworgu and al,1999), including for rabbits (60%) (Guermah and al 2016). The use of unconventional feed is one alternative capable of reducing production costs Berchiche and al 2000, Guemour and

al 2010, Kadi and al 2010, Lounaouci-ouyed and al 2012, Lounaouci-ouyed and al 2011, Lui and al 2004, Oseni, and Lukefahr 2014). In economic terms, it provides the poorest segments of society with access to cheap animal protein.

Feed rations for rabbits for fattening essentially consist of soya cake and corn, raw materials which are imported in their entirety by Algeria. The proportion of these foodstuffs in the feed ration can be reduced by using cull dates instead of corn and apricot kernel cake instead of soya cake.

Rabbit feed comprises a single pelleted ration and the impact of substituting cull dates for corn can be seen more clearly by a high rate of crude fibre (24%). This is essential to a rabbit's digestive transit (Gidenne 1996, Gidenne and al 2001, Gidenne and al 2004,) and helps avoid the appearance of cases of enteritis, which are often lethal (Abad and al 2012).

The by-products of the date palm contain little protein (5.2% of the total nitrogenous matter), which is concentrated in the stones of the fruit (El-Gasim and al 1989, Chehma and al 2002). The chemical composition of this by-product varies according to the region, the type of cultivar (*Degletnor*, *Mechdeglat*, *Litima*) (Bousdira 2006) and the proportion of stones in the mixture (Garreau 2013). On average, it account for 25% of annual date production (M.A 2007).

The use of apricot kernel cake (AKC) as a source of protein in animal feed has only been studied for broiler chickens (Arbouche and al 2012) and for sheep fattening Arbouche and al 2014) and is therefore not widespread. Several studies have nevertheless examined the level of hydrogen cyanide contained in apricot kernels (Suchars and al 1998, Alpaslan and Hayta 2006, Nwokoro and al 2010, Arbouche 2012). This level depends on the varieties of apricots grown (sweet or bitter) (Arbouche 2007) and the percentage of each variety in the global quota processed by the agri-food industries. The increase in land devoted to apricot trees in Algeria resulting from successive national agricultural development plans (NADPs), in particular in the Hodna region, has resulted in an accumulation of by-products from the agri-food industry with the new production of young orchards covering an average of 31,000 ha (M.A 2007), planted extensively with a density of 300 trees per hectare.

The aim of this study is to determine the effects of incorporating both cull dates and apricot kernel cake when fattening young rabbits, weaned at 35 days, of the local "white population" breed.

MATERIALS AND METHODS

Animals, diets and experimental protocol

The test was conducted during the period running from 12/03/2015 to 23/05/2015 in hutches belonging to a professional breeder in the Rasfa municipality of the Setif wilaya in north-eastern Algeria. Measuring 80 m², the building was fitted with thermal insulation comprising polystyrene panels. Fans and pad-cooling humidifier maintained the correct atmospheric conditions. Two hundred and eighty eight (288) young rabbits of both sexes (50%) of the local "white population" breed, weaned at the aged of 35 days, were divided randomly into 4 groups of 72 individuals. The rabbits in each batch were housed in metal cages, with 6 rabbits per cage. The cull dates came from the date processing and packaging unit located in Tolga, Biskra wilaya, and contained a high proportion of stones (45%) and date pulp (55 %). The mixture was dried in the sun then mashed. The apricot kernels (mixture of sweet and bitter) came from the apricot processing unit located in N'Gaous, Batna wilaya. They were pitted and the shell was separated from the seed manually. After being dried in the sun, the kernel was processed using a hydraulic press following the principle recommended by Ferradji et al. [26] and detoxified by means of a 1% solution of bicarbonate of soda [25] to obtain a cake.

The chemical composition of the cull dates and apricot kernel cake (Table 1) was determined according to the methods of the AOAC (1990) with a triple repetition. The analyses examined dry matter, total nitrogenous matter, crude fibre, fat, mineral matter and hydrogen cyanide. The gross energy was determined by means of adiabatic calorimetry.

Table 1. Chemical composition (% of DM) of cull dates and apricot kernel cake.

	Cull dates	**Apricot kernel cake**
Organic matter	94	96.70
Total nitrogenous matter (TNM)	5	42.30
Crude fibre	24	7.7
Fat	7	10.4
Mineral matter	6	3.3
Non-nitrogenous extractive	58	36.7
Sugar rate	62.27	0
HCN (mg/100g MS)	0	102
NDF	40.2	18.4
ADF	32.3	10.7
ADL	4.6	7.4
Hemicellulose	13.6	7.7
Gross energy (GE) (kcal/kg DM)	4,235	5,180
Digestible energy, rabbit (DER) (kcal/kg DM)*	3,152	3,984
Digestible protein, rabbit (DPR) (g/kg DM)#	9.1	336
Lysine (g/100g proteins)	3.2	1.8
Methionine (g/100g proteins)	1.5	1.2
Cystine (g/100g proteins)	1.7	1.3

DM: dry matter; NDF: neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin. * Estimated using the equation of Maertens et al. [28]: DER (Kcal/kg MS) = 0.8 – 0.230 ADF (%DM) + 0.80 EB (Kcal/kg MS); # estimated using the equation of Villamide and Fraga (1998): DPR (g/kg) = - 34.67 + 0.876 x TNM (g/kg).

Using the WUFFDA (2002) software, four equal-protein rations were prepared, with 0% (control feed), 10%, 20% and 30% rates of substitution of almond kernel cake for soya cake and cull dates for corn during the fattening period (table 2). The feed was distributed in pellet form *ad libitum* every day at 9 a.m. and 4 p.m.

Table 2. Formula (kg/100 kg feed) for feed distributed to the rabbits according to the substitution rates of apricot kernel cake for soya cake and cull dates for corn.

% of substitution	**0%**	**10%**	**20%**	**30%**
Ingredients				
Corn	20	18	16	14
Cull dates	0	2	4	6
Soya cake	12.7	11.43	10.16	8.89
Apricot kernel cake	0	1.27	2.54	3.81
What bran	32	32	32	32
Wheat straw	4.7	4.7	4.7	4.7
Dehydrated alfalfa	29	29	29	29
Salt (NaCl)	0.5	0.5	0.5	0.5
Sel (Nacl)	0,5	0.5	0,5	0,5
Rabbit premix (CMV)	0.5	0.5	0.5	0.5
Calcium carbonate	0.5	0.5	0.5	0.5
L- lysine	0.081	0.085	0.085	0.085
DL-methionine	0.015	0.015	0.015	0.015
Calculated nutrient content				
Crude fibre %	15.20	15.36	15.52	15.67

NDF%	33.71	34.07	34.44	34.80
ADF%	18.72	18.96	19.20	19.44
ADL%	4.24	4.40	4.57	4.73
Hemicellulose %	14.99	15.11	15.23	15.36
Lysine %	0.82	0.85	0.89	0.92
Methionine %	0.24	0.28	0.31	0.34
Total sulphur amino acids %	0.50	0.52	0.55	0.57
Digestible proteins %	11.16	11.05	10.93	10.82
Digestible energy, rabbit Kcal/kg	2,483	2,473	2,463	2,453
Metabolisable energy, rabbit Kcal/kg	2,373	2,369	2,365	2,361
Cellulose VS ADF-ADL%	14.48	14.56	14.63	14.71
DP/DE calculated g/1000kcal	44.95	44.67	44.39	44.11

Premix (Rabbit CMV at 1%) provided per kg diet: Se, 0.08; Mg, 2.6; Mn, 2.0; Zn, 6.0; I, 0.08; Fe, 4.0; Cu, 1.10; S, 6.8; Co,0.04; thiamin, 0.20; riboflavin, 0.20; calcium d-pantothenate, 0.8; pyridoxine, 0.10; biotin, 0.004; nicotinic acid, 2; choline chloride, 12; folic acid, 0.20; vitamin K3, 0.1; dl-α-tocopheryl acetate, 2.0; biotin, 0.004; folic acid, 0.2; cyanocobalamin,0.002; vitamin A, 950000 IU; vitamin D3, 120000 IU.

The animals were weighed individually at intervals of 15 days on days 35, 49, 63 and 77. Feed consumption in each cage was checked every day at a specific time throughout the entire duration of the experiment. The slaughter parameters and carcass characteristics were determined for each batch using 36 individuals chosen at random using the methods recommended by Blasco and Ouhayoun (1996) and Ouhayoun and Dalle Zotte (1996). The pH of the *Longissimus lumborum* muscle was measured directly in the meat 1hour post-mortem using a pH meter. The chemical composition of the meat was determined according to the AOAC's methods (1990) with triple repetition of the sampling. The analyses examined water content, fat content and ash content.

Statistical analysis

The different results were processed using the Microsoft Excel spreadsheet. The statistical analysis and comparison of averages between the different feed types (control group and those using apricot kernel cake and cull dates) were performed by means of a one-factor analysis of variance test (ANOVA) using the Statistical Package for the Social Science software (SPSS version 21), before being completed by the SNK test (Student-Newman-Keules) and Duncan's test if the ANOVA test indicated a significant difference at an error risk of 5% ($p < 0.05$).

Economic analysis

The choice of the full-cost method was necessary when analysing the composition of the costs of obtaining by-products. The main aim of this method is to calculate the production costs as fully as possible, taking account of all costs incurred during the production and processing of a finished by-product intended for rabbit feed. This production cost does not include marketing costs, abnormal costs or storage costs not directly linked to production.

$$\text{Production cost} = CVD + CVI + CFD + CFI$$

where CVD = direct variable costs; CVI = indirect variable costs; CFD = direct fixed costs; CFI = indirect fixed costs.

RESULTS

Growth, consumption index, food ingested and average gain

For the local "white population" breed, the change in weight at days 49, 63 and 77 remained constant, regardless of the diet in question (Figure 1).

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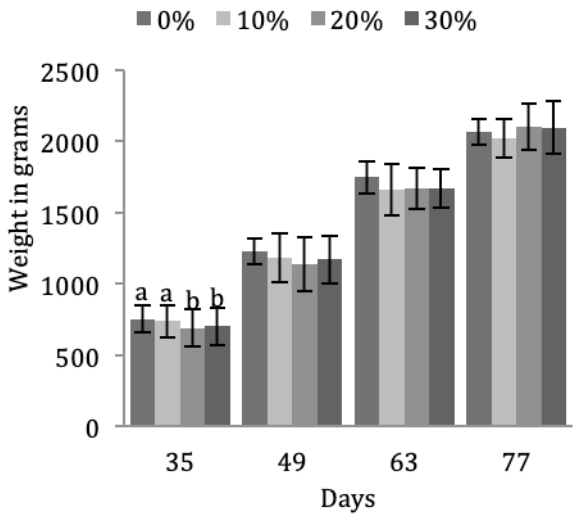

Figure 1. Effects of substitution rates of apricot kernel cake for soya cake and cull dates for corn on growth of the local breed. Exponents a and b indicate significant differences ($p < 0.05$).

None of the diets influenced the consumption index (CI) between days 35 and 63 ($p > 0.05$), but during the period from day 63 to day 77, it changed ($p < 0.014$) in proportion to the rates of incorporation of the cull dates and apricot kernel cake (figure 2).

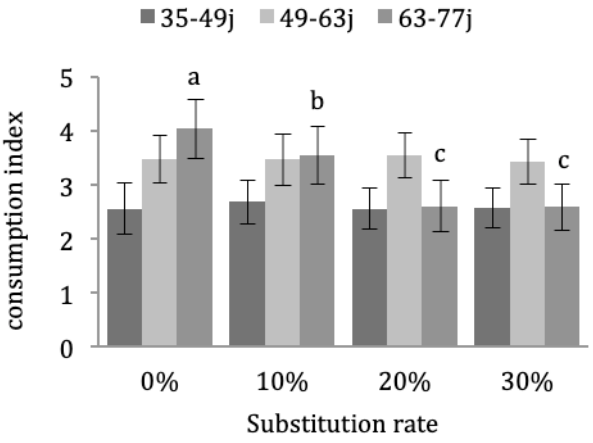

Figure 2. Effect of substitution rates of apricot kernel cake for soya cake and cull dates for corn on the consumption index of the local breed. The different exponents indicate significant differences ($p < 0.05$).

The average daily amount of food ingested (ADDI) during the breeding periods is significantly different between the groups, with -9%, -28% and -13% compared to the control group (Figure 3).

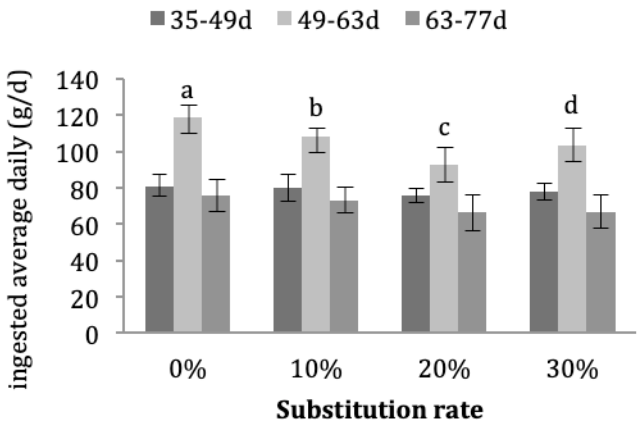

Figure 3. Effects of substitutions of apricot kernel cake for soya cake and cull dates for corn on average daily quantity of food ingested by the local breed. The different exponents indicate significant differences ($p < 0.05$).

Replacing corn by cull dates and soya cake by apricot kernel cake did not change the average daily gain (ADG) between days 35 and 63 ($p > 0.05$), although it fluctuated very significantly in the experimental groups between days 63 and 77 (+9.6%, +33% and +34% respectively) (figure 4).

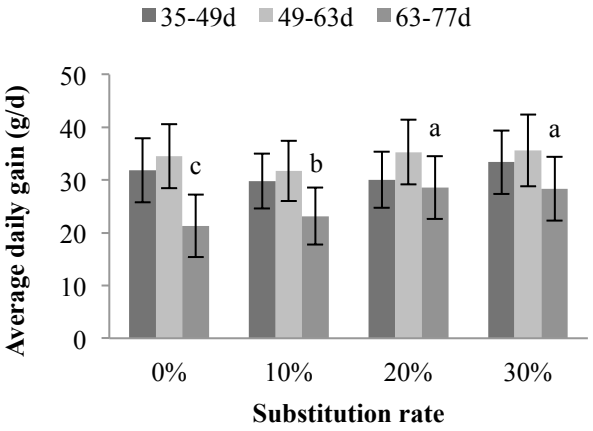

Figure 4. Effects of substitution rates of apricot kernel cake for soya cake and cull dates for corn on the average daily gain of the local breed. The different exponents indicate significant differences ($p < 0.05$).

During the entire breeding phase, the ADQI and the CI fell significantly among the experimental groups by -7%, -26% and -25% ($p < 0.016$) (figure 5) and -12%, -36% and -36% ($p < 0.001$) (figure 6) respectively.

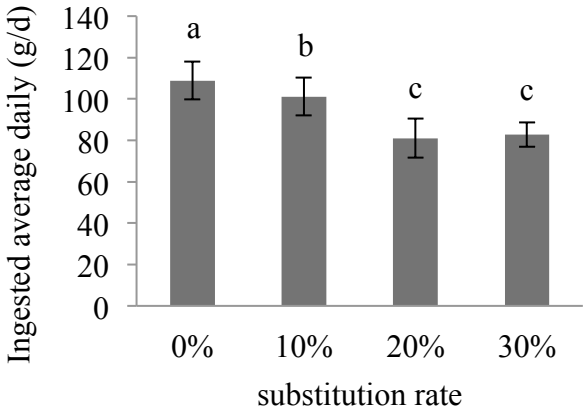

Figure 5. Effects of substitutions of apricot kernel cake for soya cake and cull dates for corn on the average daily quantity of food ingested by the local breeding throughout the entire breed phase (35 to 77 days). The different exponents indicate significant differences ($p < 0.05$).

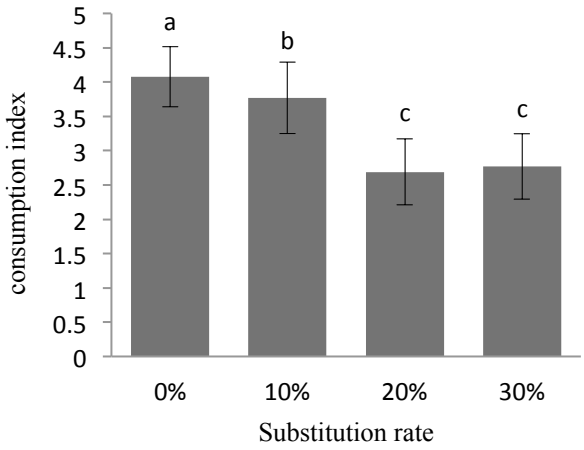

Figure 6. Effects of substitutions of apricot kernel cake for soya cake and cull dates for corn on the consumption index of the local breed throughout the entire breeding phase (35 to 77 days). The different exponents indicate significant differences ($p < 0.05$).

The ADGs displayed a highly significant difference, in particular in the diets with 20% and 30% rates of incorporation (+6%) (Figure 7).

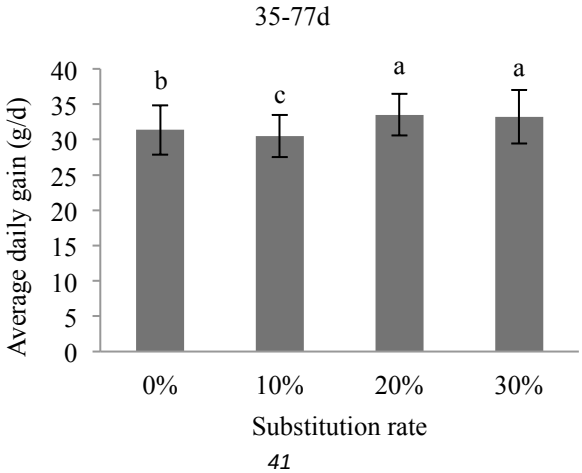

Figure 7. Change in average daily gain of the local breed throughout the entire breed phase per substitution rate. The different exponents indicate significant differences ($p < 0.05$).

Slaughter parameters, carcass characteristics and chemical composition of the meat

The slaughter parameters and the carcass characteristics were not significantly different ($p > 0.05$) (table 3). The water content in the experimental groups was significantly greater than that in the control group (+1.1%, +5.4% and +3.8% respectively). The rates of incorporation of the by-products in the diets resulted in an increase in proteins in the meat, in particular in the 10% group (+8.8%) and 30% group (+5.6%) as well as a marked reduction in the level of lipids in all experimental groups compared to the control group, in particular in the 20% group (-19%). The ash content of the 30% group (-18%) suggested a regressive action of the level of incorporation of the by-products used.

Table 3. Change in slaughter parameters, carcass characteristics and chemical composition of meat from the local bred of rabbits for fattening according to the substitution rate of apricot kernel cake for soya cake and cull dates for corn.

Slaughter parameters	**0%**	**10%**	**20%**	**30%**	**SEM**	**P**
Live weight at slaughter (lws) (g)	1,994	1,957	1,992	2,088	18.72	**NS**
Hot carcass weight (hcw)(g)	1,414	1,473	1,469	1,488	15.89	**NS**
Cold carcass weight (ccw)(g)	1,266	1,242	1,255	1,347	19.71	**NS**
Reference carcass weight (rcw)(g)	985	951	967	1,039	16.89	**NS**
Yield hcw/lws (%)	70.9	75.3	73.8	71.3	0.87	**NS**
Yield ccw/lws (%)	63.5	63.4	62.9	64.5	0.54	**NS**
Muscle/bone ratio	8.04	8.09	8.71	9.37	0.34	**NS**
Carcass characteristics						
Liver weight (lw)(g)	55.3	54.6	60.6	62.6	1.79	**NS**
Liver/lws ratio (%)	2.77	2.79	3.04	3.00	0.08	**NS**
Peri-renal fat weight (prfw)(g)	20.0	29.3	22.0	28.0	2.2	**NS**
Peri-renal fat/live weight ratio (prfw/lws (%)	1.00	1.49	1.10	1.33	0.11	**NS**
Peri-renal fat/hot carcass ratio (%) (prfw/hcw)	1.56	2.32	1.75	2.07	0.15	**NS**
Weight of skin (g)	199	190	181	197	6.06	**NS**
Proportion of skin/lws (%)	9.9	9.7	9.1	9.40	0.28	**NS**
Weight of full digestive tube(g)	331	320	326	317	9.89	**NS**
Full digestive tube /lws ratio (%)	16.6	16.4	16.4	15.2	0.54	**NS**
Weight front section (g)	345	346	351	382	9.23	**NS**
Weight hind section (g)	384	380	373	410	7.21	**NS**
Weight intermediate section, “saddle” (g)	256	224	242	246	2.84	**NS**
Front section/hot carcass ratio (%)	17.3	17.6	17.6	18.3	0.37	**NS**
Hind section/hot carcass ratio (%)	19.2	19.4	18.7	19.6	0.24	**NS**
Saddle/hot carcass ratio (%)	12.8	11.5	12.2	11.8	0.21	**NS**
Chemical composition of the meat						
pH #	6.40^{a}	6.47^{b}	6.53^{c}	6.60^{d}	0.05	***
Water content (%)	65.34^{a}	66.04^{b}	68.88^{c}	67.84^{d}	0.42	***
Proteins (%)	19.31^{b}	21.00^{d}	18.87^{a}	20.39^{c}	0.25	***
Fat (%)	12.95^{d}	11.11^{c}	10.52^{a}	10.87^{b}	0.28	***
Mineral matter (%)	1.10^{c}	1.05^{b}	1.10^{c}	0.90^{a}	0.02	***

SEM: standard error of mean, NS: non-significant, *** highly significant. #pH one hour after slaughter.

Economic analysis

The production costs of the two by-products were calculated according to the fixed and variable costs. The apricot kernel cake was obtained after several stages of processing the apricot kernels: drying, shelling, sorting, oil extraction and detoxification. The two

marketable raw materials obtained were the cake itself and kernel oil. In light of the high level of oil valorisation and taking all costs and sales of the oil in account, it was estimated that the price per kilogramme of kernel cake produced was DZD 00. The cull dates were provided by the processing and packaging units at a price of DZD, 10 per kilogramme.
Given that this incorporation-substitution operation was implemented at the same operational cost (no including the cost of the materials) as that involving corn and soya cake, this value covered the cost of the activities linked to the use of these by-products. Only the direct variable costs were thus taken into consideration.

DISCUSSION

While the weight at weaning (35 days) was not different between the 0%, 10%, 20% and 30% groups, incorporating apricot kernel cake and cull dates in the geed rations did not result in a significant change in weight in the local breed at days 49, 63 or 77 due to the low correlation between weight at weaning and speed of growth (Garreau and al 2013) and would appear to be linked to the threshold rate of sulphur amino acids in the different diets, as highlighted by Colin (1978) (0.63%), Cheeke (1971) (0.45%) and Berchiche and Lebas (1994) (0.62%), which are better assimilated as age increases.
The local breed digests the crude fibre of the cull dates and apricot kernel cake well in the experimental groups due to the fact that the digestibility of fibre increases between weaning and slaughter age (Gidenne and Perez 1993a) while also depending on the source of the fibre (Candau and al 1978a, De blas and Carabano 1996) and the nature of the parietal constituents (Falcao and Cunha 1998, Gidenne 2003), which play an essential role in rabbit feed.
These effects resulted from the polysaccharides contained in the cull dates (Genin and al 2004) and the interaction between all the kernel fibre, the AKC, the easily digested sugars in the cull date pulp and the corn starch, causing an increase in fermentation activity in the hind gut as stated by De Blas and Carabano (1996) for a range of agro-industrial by-products used in rabbit feed.
Replacing corn and soya cake had no influence on the yield at slaughter (ccw/lws) in the local breed (64.50%) and remained in the ranged proposed by Bouguerra, (2012) (64.25% to 69.87%), lower than that of the imported New Zealand breed (between 58% and 60%) (Gidenne and Perez 1993a).
Using the peri-renal weight data recorded for the same breed by Moulla, (2006) (20.06%) and Bouguerra, (2012) (18.64%), incorporating cull dates at a rate of 30% increased the aptitude of the local breed for fattening.
The pH change in proportion to the rates of incorporation of the date and apricot kernel by-products and remain high (6.60), as the measurements were taken one hour post-mortem leaving insufficient time for the different glycolytic activities to begin in the muscles, as indicated by Lambertini and al (1996). These activities only end with *rigor mortis* (24 hours post mortem), thereby lowering the pH to values ranging from 5.6 and 6.4. For higher values, Gill and Newton (1981) record a positive effect on the water retention capacity but a negative effect for refrigeration, encouraging the development of bad smells by proteolytic microorganisms.
The pH of the meat remains different from those recorded by other authors (Blasco and Piles 1990, Parigi Bini and al 1992, Xiccato and al 1990). The results put forward by Mennani and al. (2017) for the New Zealand breed with diets identical to ours (0%, 10%, 20% and 30% substitution of cull dates and apricot kernel cake for corn and soya cake) are nevertheless similar to ours (6.41 vs 6.40, 6.45 vs 6.47, 6.52 vs 6.53 and 6.58 vs 6.60 respectively)

Due to its hardy nature, the local breed capitalises more on the sources of protein in the experimental diets by increasing the protein rates in the meat (table 3) and remains within the norms suggested by Ouhayoun, (1992) (20% to 23%).
The lipid contents in the meat were inversely proportional to the rates of incorporation of the cull dates and apricot kernel cake due to the sugar content of these by-products. However, according to Dalle Zotte (2002), they also depend on the age, sex, genotype and breeding method. They remain in the range indicated by Salvini et al. (1998) (between 0.6 - 14.4%).
The calculation performed involved evaluating the savings made by replacing corn and soya in the ration. In our case, we implemented two substitutions and assumed that the price of cull dates is fixed. The opportunity cost of the apricot kernel cake is thus the unit price enabling the total cost of the ration to remain unchanged. As the weight gain is almost the same in all four groups, we can calculate the opportunity cost of this cake by applying the quantity used at the unit price. In our case, this is DZD 55/kg.
Using the 10% ration as an example:

- Price of corn DZD 27/kg
- Price of cull dates DZD 10/kg
- Quantity of corn saved 2 kg
- Quantity of dates used 2 kg
- Savings on corn DZD 54
- Cost of cull dates DZD 20
- Corn-dates savings DZD 34
- Price of soya DZD 55/kg
- Quantity of soya saved 1.27 kg
- Savings on soya DZD 70
- Total savings with the new ration DZD 70 + DZD 34 = DZD 104
- Opportunity cost of apricot kernel cake = 70 / 1.27 = DZD 55

In light of the proportionality of the results, the opportunity cost is the same for the other rations. This price can represent or cover (1) the cost of extracting and processing the apricot kernels, (2) the specific processing of the by-product, extraction of the kernel and cake processing, possibly in a specific unit. The intermediate prices of the apricots in bags allow the expenses and incomes of each operator in the value chain to be determined. The level of valorisation of other by-products, such as apricot kernel oil destined for the pharmaceutical and cosmetics industries also play a role in distributing this value throughout the value chain.
Taking the four feed formulae used in our study and the prices on the national market into account, the financial opportunity of incorporating the by-products is -9% for the price per hundredweight of feed produced at an incorporation rate of 30% (table 4).

Table 4. Price of rabbit concentrate according to the substitution rate of apricot kernel cake and cull dates.

	Control (0%)	Substitution rate (%)		
		10	20	30
Price of rabbit concentrate (DZD/q)	**3,370**	**3,266**	**3,162**	**3,058**
Difference (DZD/q)		**-3%**	**-6%**	**-9%**

CONCLUSIONS

The cull date/apricot kernel cake combination can be considered a rich source of total nitrogenous matter (47%) and fibre (32%) and can be used as an alternative to the corn soya

cake combination at a substitution rate of 30%, without any harmful effects on zootechnical performances, slaughter parameters and carcass characteristics. It improves the conversion rate of the feed in the local breed, increases the protein content of the meat by reducing the level of fat and reduces the cost price per hundredweight of feed produced. It would be interesting to renew this experiment while increasing the substitution rates in order to determine the optimum thresholds.

ACKNOWLEDGEMENTS

We would like to thank the Joint Evaluation and Prospective Committee, Hubert Curien partnerships (Algerian-French cooperation: Tassili) and the Amar Ben Amar Company (Algeria), for the supply of apricot kernels.

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