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NUTRITIVE VALUE OF TWO TYPES OF OLIVE CAKE (*OLEA EUROPAEA* L.) FOR GROWING RABBIT[1]

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Abstract: The nutritive value of 2 types of sun-dried olive cake (OC), extracted traditionally (COC) or with a 3-phase olive cake (TPOC), was studied for the growing rabbit. Four diets containing 10 or 20% of COC (COC10 and COC20) or of TPOC (TPOC10 and TPOC20) in substitution for a basal diet were compared to a control diet without OC (OC0). Five groups of 12 rabbits were fed one of the 5 diets *ad libitum* from weaning (35 d) to 46 d of age. The faecal digestibility was individually measured between 42 and 46 d of age. COC and TPOC are high fibre and lignin sources, with 707 and 787 g/kg dry matter (DM) of neutral detergent fibre, 530 and 554 g/kg DM of acid detergent fibre, 242 and 243 g/kg DM of acid detergent lignin, respectively. Replacing 20% of basal diet by COC sharply reduced (P<0.001) the digestibility of energy and crude protein from 0.67 to 0.54, but that of protein only moderately (from 0.80 to 0.76). The same effect was observed with the incorporation of 20% of TPOC. The digestible energy (DE) content of COC and TPOC were calculated by regression and were 3.24±0.41 and 2.94±0.52 MJ DE/kg DM respectively, corresponding to an apparent faecal digestibility of the gross energy of 0.14 (COC) and 0.13 (TPOC). The apparent faecal digestibility of the crude protein of COC was 7 units higher than TPOC (0.44 *vs*. 0.37) and the digestible protein (DP) content was 20% higher (27.9±4.2 g *vs*.22.4±6 g DP/kg DM). Olive cake could be considered as a high fibre source with a low protein and energy content for the growing rabbit.

Key Words: rabbit, olive cake, digestibility, nutritive value.

INTRODUCTION

The rabbit is a monogastric herbivore able to optimise fibrous raw materials. Moreover, fibre intake is necessary to prevent digestive disorders for the growing rabbit. Acid detergent fibre (ADF) contributions of 18% and contributions in acid detergent lignin (ADL) over 5% are recommended (Gidenne, 2015). In several countries like Algeria, in order to comply with these recommendations, dehydrated alfalfa is often imported to be used as the primary source of fibre in feed formulation for rabbits. This leads to a high cost and reduced sustainability of the feeding system.

Olive cake (*Olea europaea* L.), a solid by-product of olive oil extraction composed of a mixture of skins, pulp, woody endocarps and seeds (Dal Bosco *et al.,* 2007) is locally available in large quantities. The quantity of oil olives produced in the 2014/2015 crop was 420 000 tons, and Dal Bosco *et al.* (2007) reported that olive cake represents 35% of the weight of olives pressed. Thus, olive cake produced during one year was around 147 000 tons. The amounts used as fuel are low and olive cake is usually deposited around the oil mills or thrown into rivers. According to Rupić *et al.* (1999), due to the long period required for its degradation, olive cakes present an environmental pollution source.

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[1] One part of these results was presented during the 11th World Rabbit Congress (Qingdao, China, June 2016).

Olive cake can be used in animal feed (Heuzé *et al.,* 2014). However, it contains high amounts of crude fibre (220 to 350g/kg), which can limit its use in chicken or pork, but may be beneficial in ruminant and rabbits (Rupić *et al.,* 1999). Indeed, several studies (Ben Rayana *et al.,* 1994; Fernández-Carmona *et al.,* 1996; Chaabane *et al.,* 1997; Kadi *et al.,* 2004; Carraro *et al.,* 2005; Dal Bosco *et al.,* 2007) report the use of olive cake in rabbit diets. In those studies, the incorporation of this by-product in rabbit feed did not affect their health or performance. In addition, in several studies conducted locally on rabbit feeding (Kadi *et al.,* 2004, 2011 and 2012) olive cake was used as a source of fibre up to 20% incorporation rate of diet without impact on the health or growth performance and slaughter parameters. Therefore, the olive cake is a useful source of indigestible fibre to prevent digestive problems in growing rabbits, with a high content in lignins and a good balance between the different fibre fractions of the feed (Carraro *et al.,* 2005).

There are 3 different types of olive cake according to the oil extraction method: crude olive cake obtained from traditional oil mills by a hydraulic press system and woven mats; the exhausted olive oil cake obtained by mechanical means and solvent extraction of oil. The latter product contains less residual oil than the former and the olive cake from modern mills using a continuous string extraction process (Chaabane *et al.,* 1997). According to Wiesman (2009), depending on the product obtained, continuous extraction systems can be of 2 types: a 2-phase extraction system (oil and olive cake) or a 3-phase extraction system (oil, olive cake and vegetable water).

Very little is known about the nutritional value of olive cake and application as feed ingredient for the growing rabbit. Our study thus aimed to determine the nutritive value of 2 types of sun-dried olive cake for the growing rabbit: a crude olive cake and olive cake obtained from a continuous string extraction process.

MATERIALS AND METHODS

Experimental design and feeds

Sixty rabbits of Algerian white local population were used to assess the nutritive value of the 2 types of olive cake. The trial was conducted in May 2015 in a private rabbit breeding unit located in Tizi-Ouzou area (Algeria). The crude olive cake (COC) was provided by a traditional oil mill, while the modern olive oil (TPOC) was provided by a plant using a continuous method with 3 phases decantation, located in Tizi-Ouzou area. The 2 OC were then sun dried. A basal mixture that contained dehydrated alfalfa, soya bean meal, wheat bran and barley as main ingredients (Table 1) was formulated to fit the nutritional requirement of the growing rabbit according to the recommendations of Gidenne *et al.* (2015). One control diet without OC (OC0) and 4 experimental pelleted diets containing an increasing incorporation rate of olive cake were prepared by substituting the basal diet without minerals and premix with 10 or 20% of crude olive cake (COC10 and COC20) and with 10 or 20% of continuous method olive cake (TPOC10 and TPOC20). Mineral and premix were added to all diets at a fixed amount of 2%. Dietary ingredients and chemical composition are shown in Table 1.

Animals and measurements

Rabbits were weaned at 35 d of age (mean weight: 702±36 g), allotted into 5 groups (12 per diet) according to weaning weight and litter origin and fed one of the experimental diets *ad libitum*. They were placed in individual wire mesh cages. The cages were equipped with wire net under the flooring to individually collect the hard faeces. After a 7 d adaptation period, faeces were collected from 42 to 46 d of age according to the European reference method (Perez *et al.,* 1995) and stored daily in polyethylene bags at –20°C. At the end of the experimental period, faeces excreted by each rabbit during the 4 d of collect are pooled, dried and stored at –20°C for further chemical analysis.

Chemical analyses

Chemical Analysis were conducted at INRA Occitanie Toulouse (GenPhySe, France). Dry matter, ash, crude protein, gross energy and Van Soest fibre (NDF, ADF and ADL) were measured on diets and on the faeces (7 per group), according to EGRAN harmonised procedures (EGRAN, 2001). For olive cake, in addition to the previous analysis, the ether extract and crude fibre contents were measured, according to EGRAN harmonised procedures (EGRAN, 2001).

Table 1: Ingredients and chemical composition of experimental diets and of sun-dried olive cakes.

	OC0	COC10	COC20	TPOC10	TPOC20	COC[1]	TPOC[2]
Ingredients (% as fed)							
Olive Cake	-	10.0	20.0	10.0	20.0		
Alfalfa dehydrated	37.2	33.4	29.6	33.4	29.6		
Barley	8.8	7.9	7.0	7.9	7.0		
Soybean meal	9.8	8.8	7.8	8.8	7.8		
Wheat bran	42.1	37.8	33.5	37.8	33.5		
Premix[3]	2.0	2.0	2.0	2.0	2.0		
Chemical composition (g/kg DM)							
Dry matter (DM)	883	884	891	890	889	874	870
Crude ash	87	87	82	84	80	26	28
Crude protein	191	182	166	174	166	64	60
Crude fibre	-	-	-	-	-	455	470
Ether extract	-	-	-	-	-	82	74
Neutral detergent fibre	337	373	414	390	416	707	787
Acid detergent fibre	173	202	236	217	241	530	554
Acid detergent lignin	44	60	80	72	78	242	243
Gross energy (Kcal/kg)	4375	4428	4519	4456	4521	5335	5313

[1]COC: crude olive cake from a traditional oil mill.

[2]TPOC: olive cake collected from modern olive oil extraction plant.

[3]Provided by Bouhzila S. A (Sétif, Algeria). Mineral and vitamin composition (g/kg premix): Se: 0.025, Mg: 5, Mn: 7.5, Zn: 7.5, I: 0.12, Fe: 3.6, Cu: 2.25, Co: 0.04, thiamine: 0.1, riboflavin: 0.45, calcium dpantothenate:0.6, pyridoxine: 0.15, biotin: 0.0015, nicotinic acid: 2, choline chloride: 35, folic acid: 0.4, vitamin K 3: 0.2, dl-α-tocopheryl acetate: 1.35, cyanocobalamin: 0.0006, vitamin A: 850000 IU, vitamin D3: 170000 IU.

The first step was to grind the samples using a RetschZM 1 grinder with a 1 mm grind. Dry matter was determined by oven drying at 103°C (±3°C) for 24 h (ISO 6496:1999). Ash was determined by calcinations in a muffle furnace at 250°C for 1 h and then at 550°C for 5 h (ISO 5984:2002). Nitrogen content was determined by the Dumas method (ISO 16634-2:2009). A conversion factor of 6.25 was used to convert nitrogen to crude protein.

NDF, ADF and ADL were determined successively, according to AFNOR (2013), ISO 16472:2006 and ISO 13906:2008 (Fibertec type apparatus). The crude fibre was determined according to the methodology of the AOAC (1978) (method 978.10). The gross energy was determined by combustion in an adiabatic calorimeter IKA C5010 (ISO 9831:1998).

The ether extract was measured with Soxtec® (Tecator) equipment according to the methodology proposed by Alstin and Nilsson (1990) and corresponding to an acid hydrolysis pre-treatment followed by a petroleum ether extraction.

Statistical analyses

Data were analysed as a completely randomised design with type of diet as the main source of variation using the GLM procedure of SAS software (OnlineDoc®, SAS Inst., Cary, NC). Mean comparisons were performed by Scheffe test. In addition, the effect of crude olive cake incorporation was analysed with the REG procedure from SAS. Furthermore, a linearity test was carried out for the increasing rates of incorporation of olive cake and a contrast test between the 2 types of olive cake.

The nutritive value of crude olive cake was calculated according to the regression method described by Villamide *et al.* (2001).

RESULTS AND DISCUSSION

Olive cake composition

Relatively large variations in the composition of the olive cakes can be observed in the literature, depending on the characteristics of the olive, the climate and geographical origin of the olive (Mioč *et al.,* 2007), as well as the manufacturing process (De Blas *et al.,* 2015). According to the chemical composition (Table 1), olive cake can be considered a high fibre source, with a low protein content.

COC contained a low crude protein level (64 g/kg dry matter, DM) compared to values reported by Fernández-Carmona *et al.* (1996) or Chaabane *et al.* (1997), reaching 100 and 87 g/kg DM, respectively. COC contained a large amount of crude fibre 455 g/kg DM, close to that reported by Chaabane *et al.* (1997): 476 g/kg DM, and in the range of the Feedipedia database (Heuzé *et al.,* 2014): 381 g/kg DM but higher than that reported by Fernández-Carmona *et al.* (1996): 258 g/kg DM. The lignin (ADL) content was similar to the average value reported in the Feedipedia database (272 g/kg DM; Heuzé *et al.,* 2014). Moreover, the COC presented a high fat content (82 g/kg DM) close to the values reported previously (Fernández-Carmona *et al.,* 1996; Chaabane *et al.,* 1997; Heuzé *et al.,* 2014). For the ash content, the values of 26 and 28 g/kg DM obtained for COC and TPOC, respectively, were two to three times lower than tabulated values in the Feedipedia database (Heuzé *et al.,* 2014).

As expected, the chemical composition of TPOC differed mainly from COC by a 10% lower fat content. Other nutrients, such fibre or protein, were present at similar levels between the two olive cakes.

Feed intake and growth of rabbits

As our study aimed to determine the nutritional value of olive cake, the duration of the trial was short (11 d) and the number of rabbit low. Therefore, our results on performances were not sufficiently relevant to indicate the good physiological status of the animals. The feed intake, growth, weight gain and feed conversion ranged within the values classically measured for the growing rabbit (Table 2). They did not differ according to the diet for the period between 35 and 42 d and for the period between 42 and 46 d. However, for the total period (35-46 d) we detected a significant increase in feed conversion for the highest incorporation rate of COC.

Table 2: Effect of dietary level of inclusion of olive cake (COC, TPOC) on feed intake and growth of rabbits.

	Experimental diets					standard	
	OC0	COC10	COC20	TPOC10	TPOC20	error	*P*-value
n	7	7	7	7	7		
Period 35-42 d							
Live weight at 35 d, (g)	716	699	690	694	696	3.80	0.780
Live weight at 42 d, (g)	843	803	817	795	775	9.60	0.234
Weight gain, (g/d)	36.1	29.8	36.3	28.8	31.7	1.32	0.158
Daily intake, (g/d)	71.5	71.7	76.2	67.6	73.2	1.63	0.574
Feed conversion, (g/g)	2.02	2.68	2.13	2.40	2.31	0.10	0.202
Period 42-46 d							
Live weight at 46 d	1049	979	1012	971	932	16.69	0.179
Weight gain, (g/d)	40.0	34.8	34.2	37.7	39.1	0.97	0.598
Daily intake, (g/d)	81.1	80.5	89.9	81.6	85.1	1.49	0.682
Feed conversion, (g/g)	2.04	2.41	2.76	2.20	2.36	0.10	0.195
Period 35-46 d							
Weight gain, (g/d)	38.1	32.3	35.3	33.2	33.5	0.87	0.337
Daily intake, (g/d)	76.3	76.12	83.04	74.6	75.0	1.30	0.730
Feed conversion, (g/g)	2.03^{a}	2.54^{ab}	2.45^{b}	2.30^{ab}	2.47^{ab}	0.08	0.043

Nutritive value of olive cake

Digestible energy

The increasing incorporation of COC logically led to a sharp linear decrease in the energy digestibility (*P*<0.001): from 0.67 for OC0 to 0.54 for COC20 (Table 3), sourcing mainly from the high fibre content of COC. Using the calculation procedure proposed by Villamide *et al.* (2001), the digestible energy (DE) of the sun-dried crude olive cake reached a value of 3.24 MJ DE/kg DM; the standard error for the predicted value was 0.41 (14.3%). The equation obtained by regression method to predict the digestible energy was: DE (MJ/kg)=–0.081 COC (%)+10.81; R^2=0.99 and COC=crude olive cake (Figure 1).

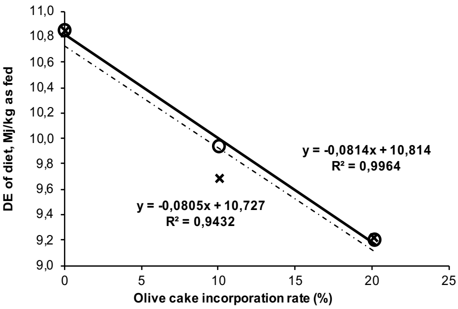

Figure 1: Digestible energy (DE) of the diet for the growing rabbit, according to the incorporation level of 2 olive cakes. — COC: Crude Olive Cake; –•–•TPOC: Three-Phase Olive Cake.

Likewise, the energy digestibility decreased linearly (*P*<0.001) with the TPOC incorporation rate from 0.67 (OC0) to 0.54 (TPOC20) (Table 3). Using the calculation procedure proposed by Villamide *et al.* (2001), the DE of sun-dried olive cake continues method reached a value of 2.94 MJ/kg DM; the standard error for the predicted value was 0.52 (20.2%). The equation obtained by regression method to predict the digestible energy was: DE=–0.080 TPOC+10.72; R^2=0.94 and TPOC=continuous method olive cake (Figure 1).

As fat content was higher in COC than in TPOC (Table 1), the value of DE obtained for COC reached 3.24 MJ/kg DM, whereas it only reached 2.94 MJ/kg DM in TPOC.

Our values for the concentration in digestible energy (3.24 and 2.94 MJ DE/kg DM for COC and TPOC respectively) were roughly half of the value of 7.1 proposed by Fernández-Carmona *et al.* (1996). This difference can be related to the higher fibre content of our olive cakes (NDF: 707 g/kg DM for COC and 787 for TPOC *vs.* 640 g/kg DM). In addition, Fernández-Carmona *et al.* (1996) used adult rabbits and the direct method to determine the nutritive value of olive cake (as the sole ingredient corrected by mineral-vitamin mixes), leading to a very low feed intake (48 g DM/kg$^{0.75}$ d) resulting in abnormal growth in both digestive retention time and digestibility.

Table 3: Effect of dietary level of inclusion of COC and TPOC on faecal digestibility coefficients and nutritive value of experimental diets in growing rabbits between 42 and 46 d of age.

	Experimental diets									
	OC0	COC10	COC20	TPOC10	TPOC20	standard error	*P*	L1	L2	*P**
Digestibility coefficients										
Dry matter	0.684^{c}	0.627^{b}	0.573^{a}	0.604^{b}	0.567^{a}	0.56	<0.0001	<0.0001	<0.0001	0.018
Organic matter	0.678^{c}	0.614^{b}	0.556^{a}	0.591^{b}	0.553^{a}	0.60	<0.0001	<0.0001	<0.0001	0.033
Energy$^{\mu}$	0.666^{c}	0.601^{b}	0.543^{a}	0.579^{b}	0.542^{a}	0.64	<0.0001	<0.0001	<0.0001	0.076
Crude protein$^{\mu}$	0.803^{b}	0.782^{ab}	0.764^{a}	0.778^{ab}	0.758^{a}	0.76	<0.002	<0.001	<0.004	0.50
Neutral detergent fibre$^{\mu}$	0.315^{b}	0.242^{a}	0.199^{a}	0.215^{a}	0.184^{a}	1.47	<0.0001	<0.0001	<0.0001	0.17
Acid detergent fibre$^{\mu}$	0.224^{b}	0.130^{a}	0.102^{a}	0.125^{a}	0.104^{a}	1.51	<0.0001	<0.0001	<0.0001	0.90
Dietary nutritive value										
DP (g/kg)	136^{c}	126^{b}	113^{a}	121^{b}	112^{a}	1.17	<0.0001	<0.0001	<0.0001	0.022
DE$^{\mu}$ (MJ/kg)	10.77^{d}	9.85^{c}	9.15^{ab}	9.61^{bc}	9.11^{a}	0.11	<0.0001	<0.0001	<0.0001	0.20

n=7, DP: digestible crude protein, DE: digestible energy, $^{\mu}$: significant global linear effect (*P*<0.05) , Mean values in the same raw with different superscript differ at *P*<0.05. L1: linear effect of crude olive cake, L2: linear effect of olive cake continues method. *P**: *P*-value of contrast COC *vs.* TPOC.

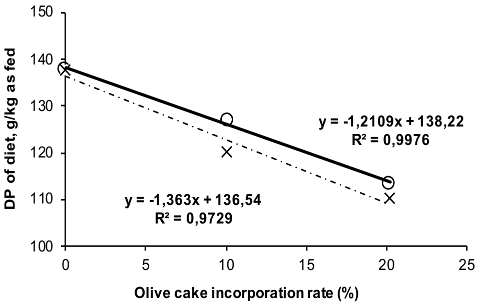

Figure 2: Digestible protein (DP) content of the diet for the growing rabbit, according to the incorporation level of 2 olive cakes. ━ COC: Crude Olive Cake; ‒•‒•TPOC: Three-Phase Olive Cake.

Digestible protein

The digestibility coefficient for crude protein of crude olive cake decreased from 0.80 (OC0) to 0.76 (COC20) (Table 3). The equation obtained by regression method to predict the digestible protein is DP (g/kg)=–1.210 COC (%)+138.2; R^2=0.99 (Figure 2). The predicted digestible protein concentration was 27.9 g DP/kg DM, which corresponded to a crude protein digestibility of 0.44; the standard error for the predicted value was 4.2 g (14.3%).

The increasing level of TPOC led to a decrease in the digestibility coefficient of crude protein from 0.80 (OC0) to 0.76 (TPOC20) (Table 3). The equation obtained by regression method to predict the digestible protein is DP (g/kg)=–1.363 TPOC (%)+136.5; R^2=0.97 (Fig. 2). The predicted digestible protein concentration was 22.4 g DP/kg DM, which corresponded to a crude protein digestibility of 0.37; the standard error for the predicted value was 6 g (31%).

The nutritive value of the olive cake continues method were close to the value obtained for “traditional” crude olive cake and much higher than the 9.7±4.3 g DP/kg DM obtained by Fernández-Carmona *et al.* (1996) with direct method, which did not specify the origin (modern or traditional oil mill). Moreover, crude protein digestibility coefficient obtained in our essay were close to the value of 0.49 reported by De Blas *et al.* (2015) for partially destoned olive cake provided from a 2 phase centrifugation process, and using the *in-vitro* method. This variability in nutritive value may also be related to the methodology of measurements used, as mentioned by Perez *et al.* (1995).

CONCLUSION

Olive cake could be considered as a high fibre source, but a moderate source of nutrients for growing rabbit. When extracted traditionally, the olive cake contained about 10% more lipids, leading to a 10% higher energetic value for the rabbit. Further experiments are needed to determine the optimum inclusion rate of crude olive cake in growing rabbit diets without impairing their growth or health status.

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