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Effects of Argan Cake (*Argania Spinosa* (L.,) Saptaceae) Substitution on the Growth Performance, Nutritional Value, and Economic Efficacy of Broiler Chickens

Miloudi Hilali[1,*], Mustapha Bey[2], Salem Oubarka[2], Khalid Barami[3], Hanae El Monfalouti[1], Larbi El Hammari[4], Badr Eddine Kartah[1], El Housseine Rifi[2] and Ahmed Lebkiri[2]

[1]Laboratory of Plant Chemistry and Organic and Bioorganic Synthesis, Faculty of Science, University Mohammed-V, Av. Ibn Battouta, BP 1014 Agdal-Rabat, Morocco; [2]Laboratory of Organic Synthesis and Extraction Processes, University Ibn Tofail, Faculty of Sciences, Department of Chemistry, PO Box 133 – 14000 - 16 Kenitra, Morocco; [3]Official Laboratory of Chemical Analysis and Research 25, Street Nichakra Rahal, Casablanca, Morocco; [4]Laboratory of Applied Chemistry of Materials, Faculty of Science, University Mohammed-V, Av. Ibn Battouta, BP 1014 Agdal-Rabat, Morocco.
*Corresponding author's e-mail: hilali400@yahoo.com

Argan cake is rarely used in poultry feed. It is proposed that this feedstuff can improve the quality of chicken meat while also lowering the cost of chicken production. The study's objective is to determine the effect of dietary supplemented argan cake on the growth performance and meat/carcass quality of Moroccan broiler chickens. This study included 30 one-week-old chicks. They are divided into three groups of ten subjects each (TA_0, TA_5, and TA_{10}). Each corresponds to three types of experimental feed containing 0 percsent, 5%, and 10% argan cake supplemented/mixed with commercial poultry feed, respectively. The amount of feed consumed was measured on a daily basis, and the birds were weighed once a week. The average weight of broiler chickens in groups TA_5 and TA_{10} that consume argan cake is significantly higher than in group TA_0 at the end of the trial (more than 0.18 kg). According to the chemical analysis, the meat of broiler chickens from groups TA_5 and TA_{10} is higher in protein (19.1 percent and 18.1 percent respectively). TA_0, on the other hand, has a protein percentage of 15.1%. This research also demonstrates that the TA_5 and TA_{10} groups are higher in essential minerals like Ca (19.1mg/kg) and Fe (12.1mg/kg).

Keywords: Argan cake, broiler, performance, growth, meat quality.

INTRODUCTION

The white poultry meat sector is one of Morocco's most dynamic agricultural activities (Ahachad *et al.,* 2008). It enables the creation of over 98,000 direct and 225,000 indirect jobs. It also generates a yearly turnover of 21 billion dirhams for an investment of 8.7 billion dirhams. Morocco produces 490,000 tonnes of white meat per year, as well as 3.9 billion eggs (Abdelmajid *et al.,* 2021). Poultry products are popular among the general public due to their low cost in comparison to other animal products, and they are a good source of protein (Marangoni *et al.,* 2015).

The Argan forest in Morocco covers approximately 800,000 ha and contains over 20 million trees (Sinsin *et al.,* 2020). This Sapotaceae tree is particularly tolerant of the dry and arid conditions of southwestern Morocco. It can withstand temperatures ranging from 3°C to 50°C and is content with very little rainfall.

The Argan tree grows wild and abundant in the arid and semi-arid regions of southwestern Morocco, where it plays an indispensable role in ecological balance and biodiversity preservation (Nassif *et al.,* 2017). It helps maintain the soil and fights water and wind erosion, which threatens much of the region with desertification, thanks to its powerful root system (Buernor *et al.,* 2021).

Because it is a multipurpose tree, the argan tree has a high economic value (Sinsin *et al.,* 2020). Each part of the tree can be used to generate income or food for the user: the wood is used as fuel, the leaves and fruits are fodder for goats and camels, and the oil extracted from the almond is used in human food and traditional medicine (Hilali *et al.,* 2020a; 2020b). As a result, the argan grove plays a significant socioeconomic and environmental role in these geographical areas. Currently, the residue from the extraction of argan oil or cake from the Argan tree is used as feed for fattening cattle. It is high in carbohydrates and proteins (46.6 to 49%) and

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contains an important pharmacodynamic group made up of saponins (Kamal *et al.,* 2021).

There have been some attempts in the literature and published studies to use argan three products and argan by-products in livestock (Bas *et al.,* 2005; Mercha *et al.,* 2021; Moutik *et al.,* 2021). Found that goat meat raised in the Argan tree forest has a lower fat content and a better fatty acid profile than other goat meats, particularly in terms of polyunsaturated fatty acids (PUFA). Furthermore, Moutik *et al.,* (2021) found that supplementing lambs with argan by-products (oil cake and pulp) resulted in higher average daily gain, meat chemical quality, crude protein, ash, and higher C18:0 fatty acid than the control group lambs, despite the fact that the control group had a higher feed conversion ratio in their study. Using argan by-products also improves the fatty acid profile in milk, increasing the levels of monounsaturated fatty acids and PUFA (Mercha *et al.,* 2021).

There was no research work related to the inclusion of argan by-products in poultry diets in the published study. As a result, it's critical to understand how adding this special feedstuff will affect poultry diets. The goal of this work is to investigate the effect of substituting argan tree cake (Argania spinosa (L.,) sapotaceae) on the zootechnico-economic performances of chickens. With this in mind, the current study was designed to assess the effect of argan cake on the Zootechnico-economic performance of broilers. Its specific goal is to determine the effect of including Argan cake in the ration on growth performance, carcass characteristics, and economic results in Moroccan broilers.

MATERIALS AND METHODS

Ingredients and formulation of experimental rations *r*aw materials and ingredients used

The argan (Argania spinosa (L.,) sapotaceae) cake used in the current study was procured from the South Akkain Cooperation, Morocco. Commercial feed, Alf Issen Company, Morocco, for rearing of birds were procured from. Nutrient intakes for broilers during the Starter and Grow-Finish stages is grouped in Table 1.

Table 1. Nutrient intakes for broilers during the Starter and Grow-Finish stages.

Chicken Age	Startup	Crowth–finish
	1-4 weeks	5-8 weeks
Metabolizable energy (in Kcal EMA)	2750-2850	2800-2900
Crude protein (%)	21	19
Digestible lysine (%)	0.90	0.74
Digestible methionine (%)	0.35	0.30
Methionine + digestible cystine (%)	0.68	0.56
Fat (%)	2 - 5	2 - 7
Calcium (%)	1.1	1
Available phosphorus (%)	0.42	0.35
sodium (%)	0.15	0.15

***Experimental Ration*:** Experimental were reared in one place for first three weeks of life and before the start of experimental ration. After three weeks, total of 30 chicks were selected and divided into three groups TA_0, TA_5 and TA_{10} in such a way that each group contained 10 chicks. TA_0 group served as control group 0% argan caked was supplemented in the diet, while TA_5 and TA_{10} groups were supplemented with 5% and 10% of argan cake in the commercial diet. Argan cake were mixed in the commercial feed manually, unless a homogeneous feed mixture was obtained.

***Bird management and data collection Experimental location and management*:** The trial took place in Abdlatif farm in Sale city during the period between May-June 2021.

Two weeks before the arrival of the chicks, the broiler house was emptied, cleaned with soapy water and disinfected with bleach (250ml / 10 liters of water). All utensils and equipment were also cleaned in the same way. The broiler house was heated with butane gas (25°C to 35°C) before the arrival of the chicks.

***Receiving of chicks*:** On arrival, the Cobb 500 chicks were routine checked (number, condition of legs, navel and liveliness etc.) and placed in brooder area. All birds were reared together for three weeks then were randomly assigned into three groups as explained in experimental treatments. During experimental feeding, all birds were reared individually

***Periods of growth*:** Three commercial diets, starter (0-3 weeks), grower (3-5 weeks) and finisher (5-8 weeks) were fed to the birds. All the chicks in the starter were fed with the starter feed (commercial feed, Alf Issen Company, Morocco, which does not contain argan cake), in the grower and finisher diet - the chicks were reared on the feed supplemented with 0% (TA_0), 5% (TA_5 group) and 10% (TA_{10} group) of the argan cake.

***Data collection*:** Feed consumption

Feed consumption per week was obtained by subtracting the weight of feed offered and refused.

***The weight gain*:** At the end of the third week of age (21 days), the chicks were weighed early in the morning after overnight feed withdrawal. The weight gains of the chicks were calculated on weekly basis using electronic balance (± 10 g) Milliot QHW.

Calculation of growth performance parameters

***Feed conversion ratio*:** Feed conversion ratio was calculated by using the formula

$$FCR = \frac{\text{feed consumed}}{\text{weight gain}}$$

Average Daily weight Gain (ADG)

Average daily weight gain was determined by using following formula

$$ADG = \frac{\text{Weight gain during a period (g)}}{\text{Duration of period (day)}}$$

Feed Consumption index

Feed consumption index (CI) was determined by using following formula

$$CI = \frac{\text{Average quantity of feed consumed during a period (g)}}{\text{Average weight gain during the same period (g)}}$$

Mortality rate (MR)

Mortality rate (MR) was determined by using following formula

$$MR\ (\%) = \frac{\text{Number of deaths during a period x100}}{\text{Workforce at the start of this period}}$$

***Protein analysis by the Kjeldahl method (kjeldahl method, 2017*)**: Organic compounds containing nitrogen (proteins and nucleic acids in certain matrices) are decomposed when hot, under the action of sulfuric acid and a catalyst. This catalyst contains potassium sulfate (K_2SO_4), which increases the boiling temperature of sulfuric acid, and copper sulfate ($CuSO_4$) which acts as a catalyst for the reaction. Nitrogen will quantitatively give ammonium sulfate: this is the mineralization step.

The ammonia is then displaced from its salt by soda, distilled by steam distillation and collected in a known amount of excess hydrochloric acid. This is the distillation step.

The amount of unreacted hydrochloric acid is measured back with sodium hydroxide. This is the dosing step.

$$\text{N organic} \xrightarrow[K_2SO_4\ CUSO_4/\ 350°C]{\text{mineralization}} (NH_4)_2\ SO_4$$

$$NH_4^+ + OH^- \xrightarrow{\text{distillation}} NH_3 + H_2O$$

$$NH_3 + HCL \longrightarrow NH_4^+ + Cl^-$$

$$HCl + NaOH \xrightarrow{\text{dosing}} H_20 + NaCl$$

Calculate the protein content in a bioproduct.

Two samples were prepared:

- A sample containing the bioproduct, liquid or previously ground
- A sample not containing the bioproduct, this was the control

The following calculation was then applied, considering a conversion factor of 6.25 (16% nitrogen on average in proteins):

For a given mass of bioproduct

$$m_P = m_N \times 6.25$$

$$m_N = n_N \times M_N$$

$$N_n = n_{NH4^+} = N_{NH3} = n_{HCl}\ \text{reacted}$$

$$n_{HCl}\ \text{reacted} = n_{HCl\ total} - n_{HCl}\ \text{excess}$$

***Analysis of essential minerals (Ward, 2010*)**: Digestion and preparation of sample solutions taking the quantity of 0.4g of ground sample and weighed in a porcelain crucible then placed in the oven (Prolabo) at 650°C for 5 hours. After cooling, 5ml (of 1 mol) nitric acid was added to the ash obtained and then brought to total evaporation on a sand bath. To the residue were added 5 ml (of 0.1 mol) hydrochloric acid. It was then returned to the oven at 400°C for 30 minutes. The final residue was recovered with 10 ml (of 1 mol) hydrochloric acid then poured into a 50 ml flask. The crucible was rinsed twice with 10 ml of hydrochloric acid. The flask was filled to 50 ml with hydrochloric acid. Under the same conditions, a blank test was carried out.

The wavelengths of the elements to be analyzed were first defined on the device (424.7 nm for calcium, 324.8 nm for copper, 248.3 nm for iron and 213.9 nm for zinc). Then, the different readings of the calibration ranges made it possible to establish the calibration curve reflecting the absorbance as a function of the concentration. Finally, the solutions containing the ash were presented to the apparatus in order to determine the absorbance. Note that it was mandatory to pass the white between the passages of two different solutions.

RESULTS AND DISCUSSION

***Ambience settings*:** The average weekly temperatures recorded in the broiler house varied between 25°C and 33°C. The test took place between March and June corresponding to a period relatively cool and transient to that of the heat in Morocco.

Effects of the incorporation of argan cake in the feed ration on the health status and growth performance of chickens

***Effects on the health status and mortality of chickens*:** During the three week test, the incorporation of argan cake into the chicken ration did not cause any disease or mortality in the birds. No mortality was recorded in the chicks.

Table 2. Effect of the incorporation of argan cake on the mass of broilers.

Age (week)	Weight gain kg TA_0	Mass gain per week kg TA_0	Weight gain kg TA_5	Mass gain per week kg TA_5	Weight gain kg TA_{10}	Mass gain per week kg TA_{10}
0	0.04	0.00	0.04	0.00	0.04	0.00
1	0.12	0.08	0.12	0.08	0.12	0.08
2	0.32	0.20	0.32	0.20	0.32	0.20
3	0.72	0.40	0.72	0.40	0.72	0.40
4	1.15	0.43	1.17	0.45	1.15	0.43
5	1.57	0.42	1.61	0.44	1.60	0.45
6	2.01	0.44	2.07	0.46	2.03	0.43
7	2.41	0.40	2.52	0.45	2.43	0.40
8	2.70	0.30	2.87	0.35	2.80	0.37
Averages weight gain (week)	1,226 kg		1,271 kg		1,245 kg	

Table 3. Feed consumption index and feed conversion rate.

Age (week)	Consu. Week kg TA_0	Consu. total kg TA_0	Mass gain kg TA_0	FIC TA_0	Consu. Week Kg TA_5	Consu. total kg TA_5	Mass gain week kg TA_5	FIC TA_5	Consu. week KgTA_{10}	Consu. total kg TA_{10}	Mass gain week TA_{10}	FIC TA_{10}
0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.12	0.125	0.085	1.47	0.125	0.125	0.085	1.47	0.125	0.125	0.085	1.47
2	0.30	0.425	0.20	1.50	0.300	0.425	0.20	1.50	0.30	0.425	0.20	1.50
3	0.62	1.045	0.40	1.55	0.620	1.045	0.40	1.55	0.62	1.045	0.40	1.55
4	0.91	1.955	0.43	2.11	0.925	1.970	0.45	2.05	0.92	1.965	0.43	2.13
5	1.10	3.055	0.42	2.61	1.130	3.100	0.44	2.54	1.14	3.105	0.45	2.53
6	1.20	4.255	0.44	2.72	1.300	4.400	0.46	2.68	1.30	4.405	0.43	2.61
7	1.30	5.555	0.40	2.75	1.400	5.800	0.45	2.70	1.40	5.805	0.40	2.68
8	1.40	6.955	0.38	2.76	1.550	7.350	0.35	2.72	1.50	7.305	0.37	2.70
Averages cons. (week)	0,773Kg				0,817kg				0,812kg			

***Effects on the weight gain of chickens*:** The change in the weight gain of the chickens by feeding treatment over time during the test is shown in Table 2.

From this result, the weight gains of the birds of the TA_5 and TA_{10} groups were found to be slightly higher than those of the TA_0 group (control chickens). On the other hand, the average mass of the chickens of the TA_5 group at the end of the experiment is more than 0.17 Kg than the average mass of the TA_0 group. The result of this work shows that the average mass of the TA_{10} group is higher than the mass of the chickens of the TA_0 group (more than 0.10 Kg). With regard to the average weight gain, the result shows that the weight gain per week of group TA_5 and TA_{10} (50 g/day) is higher than the average weight gain of group TA_0 (42,85 g/day). The result of this work clearly shows that the cake of the argan tree in the feed of broilers can increase the chicken mass and these results are consistent with those reported by Benahmed *et al.*, (2020)

***Feed consumption*:** The result of the feed consumption index (in Kg) per chicken is grouped in Table 3. The effects of the different feed treatments on the feed efficiency of the chickens during the trial period are shown in Table 3. The results of this work show that the total feed consumption during the start-up period varies from 0.125 kg to 1.045 kg, On the other hand, the total food consumption during the growth-finishing period varies from 1.95 kg to 7.30 kg, the birds of TA_5 (7.35 kg) and TA_{10} (7.30 kg).

Fed on the base of the argan tree recorded a greater quantity of consumption compared to the control subjects TA_0 (6.95 kg). This result explains that the chickens which took nutritional feed based on the cake of the argan tree can grow faster than the TA_0 control chicken.

Concerning the indices of consumption of the subjects of the various food treatments from the 4th to the 8th week (the period of growth-finishing) (MacLeod *et al.*, 2013), the result of this work shows that the index of consumption of the birds of TA_5 (2.72) and TA_{10} (2.70) fed with cake from the argan tree recorded a lower consumption index compared to the control subjects TA_0 (2.76) (Peter, 2011). This explains why the TA_5 and TA_{10} chickens can grow faster with a lower price than the TA_0 control chicken. These results are consistent with those reported by the authors Bouras *et al.*, (2020) and Mekki *et al.*, (2020). These results clearly show that the chickens of the groups which are fed on the basis of cake from the argan tree can grow faster and do not cost more to feed.

***Essential minerals*:** The result of the essential minerals is grouped in Table 4 and Fig. 1.

Table 4. The results of essential minerals

Essential minerals	TA_0	TA_5	TA_{10}	Argan cake
Cu (mg/kg)	1.0	0.6	1.9	9.8
Fer (mg/kg)	20.2	10.3	12.1	72.6
Ni (mg/kg)	0.4	0.1	0.1	0.8
Ca (mg/kg)	189.8	139.5	210.7	0.5
Al (mg/kg)	5.2	8.5	6.4	13.5
Pb (mg/kg)	0.100	0.070	0.070	0.100
Cd (mg/kg)	0.015	0.015	0.015	0.015
Hg (mg/kg)	0.015	0.015	0.015	0.015
Tin (mg/kg)	5	5	5	5

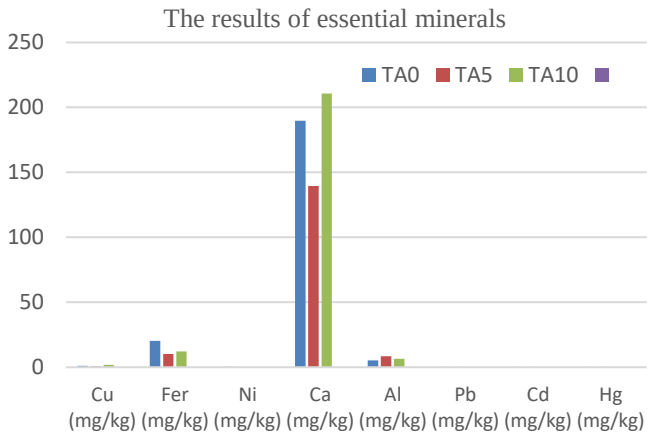

Figure 1. The Results of Essential Minerals of Chicken.

This finding indicates that broiler meat is high in calcium (up to 210 mg/kg TA10), iron (20 mg/kg), and aluminum (8 mg/kg) (Fig. 1). This finding indicates that the TA10 group's meat contains more calcium (210 mg/kg). As a result, it is clear that the argan tree cake can improve the essential minerals in broiler meat (Gnakari *et al.,* 2007). Analyses of argan cake, on the other hand, show that the cake is higher in iron (72.6 mg/kg), copper (9.8 mg/kg), and aluminum (13.5 mg/kg) (Table 4); these essential minerals add value to the argan tree cake, making it a good poultry feed. These minerals are extremely potent antioxidants (Rémi, 2017).

***Protein*:** The protein result is shown in the following Table 5 and Fig. 2. The protein content of broiler meat from groups TA5 and TA10 is higher (19.1 percent and 181 percent, respectively) (Table 5 or Fig. 2). These findings are consistent with those of Gustave *et al.,* (2020) and Hein *et al.,* (2018), who found an increase in the percentage of protein value in lots fed argan cake-containing feed. The current study found that the cake of the argan tree can be used as a feed resource for poultry.

Table 5. The results of chicken protein

Groups	TA_0	TA_5	TA_{10}	Cake of argan
Protein %	15.1	19.1	18.1	24.4

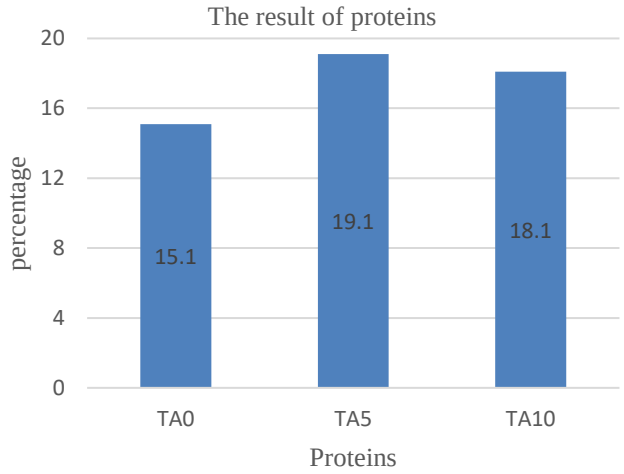

Figure 2. The Results of Chicken Protein

While some studies suggest that detoxification of argan cake can affect ruminal microbiology in ruminants and possibly cause gastrointestinal disorders, it is for the removal of saponin from argan cake (Lakram *et al.,* 2019a, 2019b). As a result, comprehensive studies on the effect of potential anti-nutritional factors in argan tree cakes are required to determine the efficacy of this feedstuff in livestock.

***Conclusion*:** In conclusion, the results of this study show that chickens fed diets supplemented with argan cake at a percentage of 5% and 10%, respectively, performed better. As a result, it is concluded that increasing the concentration of argan cake in broiler feed during the start-up and growth phases improves performance (increase in weight gains). This study also found that increasing the concentration of argan cake in chicken feed boosts the levels of essential minerals like calcium and proteins. As a result, adding argan cake to chicken meat can boost its calcium and protein content. Whereas more analytical research into the potential anti-nutritional factors of argan cake is required.

***Declarations*:** Corresponding author: hilali400@yahoo.com

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***Availability of data*:** The data can be availed to the journal upon request.

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