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Effects of *Opuntia ficus-indica* on Growth Performance and Serum Parameters of Broiler Chicken in Algeria

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Résumé :

Effets d'*Opuntia ficus-indica* sur les performances de croissance et les paramètres sériques du poulet de chair en Algérie

Grâce à la grande diversité des sols et du climat, l'Algérie dispose d'un nombre important de plantes pouvant être utilisées dans l'alimentation animale. Ce travail fait partie de la valorisation des raquettes du figuier barbare (*Opuntia ficus-indica*-OFI), largement présent dans le paysage rural algérien, en tant que complément alimentaire pour poulets de chair. Les objectifs de cette étude sont de mesurer les effets de la poudre d'OFI sur les performances de croissance, les paramètres sériques et les caractéristiques de la carcasse. L'expérience a été réalisée dans un élevage privé, situé dans la région de Chemini. Dans cette étude, 120 poussins mâles Ross-308 d'un jour ont été suivis. Ils ont été répartis en trois groupes en fonction du régime alimentaire (4 x 10 poussins par groupe). Le groupe 1 a reçu un aliment commercial, tandis que les groupes

2 et 3 ont reçu la même alimentation contenant respectivement 5% et 10% d'OFI. L'OFI n'a montré aucun effet négatif sur le poids corporel, le gain quotidien moyen et les caractéristiques de la carcasse. En revanche, il a diminué ($p < 0,05$) certains paramètres biochimiques dans le sang (glucose plasmatique, urémie, cholestérol et triglycérides). En conclusion, l'OFI peut être utilisée comme additif potentiel dans l'alimentation commerciale des poulets de chair, ce qui pourrait réduire efficacement leurs coûts de vente sur le marché algérien.

Abstract :

Thanks to the wide diversity of soil and climate, Algeria has a substantial number of plants which can be used in animal feed. This work is a part of the barbaric fig cladodes evaluation, widely present in the Algerian rural landscape, as a broiler chicken feed supplement. The aims of this study are to measure the effects of *Opuntia ficus-indica* (OFI) powder on the growth performances, serum parameters and carcass characteristics of broiler chickens. The experiments were performed in a private poultry farm, located in the Chemini region. In this study, 120-Ross-308 days-old male chicks were monitored. They were divided into three groups according to the specific diet consumed (4 x 10 chicks by group). The group 1 was offered a commercial feed, while groups 2 and 3 received the same feed containing: 5% and 10% of OFI powder respectively. The OFI powder did not show any negative effect on the final body-weight, average daily gain and carcass characteristics. In contrast, it decreased ($p < 0.05$) some biochemical parameters in blood, like plasma glucose; uremia; cholesterol; and triglycerides. In conclusion, the OFI powder can be used as a potential additive in the commercial feed of broiler chickens which could efficiently reduce their cost sales in the Algerian market.

Keywords : Algeria, broiler, cactus, feed, growth performances, serum parameters

Introduction

In Algeria, ingredients used in animal feed are mainly essentially imported from abroad, which affects negatively affects the production cost of the chicken meat and its sale price in the market at the national level.

Opuntia ficus indica is part of the Cactaceae family. Species of *Opuntia* are of a particular interest, especially in arid and semi-arid regions, where they serve as food and water sources, for humans and animals (24). They have been successfully used to control land erosion, to rehabilitate arid environments (11), and to reduce lead contamination in water (15). Furthermore, *Opuntia* spp are mainly used as a fruit for human consumption (26), and as a promising ingredient in food technology (5, 17). Finally, the importance of *Opuntia* members in medicine can be noted with their diverse bioactive properties, reported such as diuretic, astringent, tonic properties (23), protective effect against liver damages caused by organophosphorus pesticides in mice (18), anti-inflammatory (14), cicatrizant (6), antimicrobial properties (28), and inhibition of tumor cell growth (30). *Cactus* fruit extracts have also been used to control diabetes (1), cholesterolaemia and oxidative stresses (28). Cactus pears contain few dry matter, crude protein, and structural carbohydrates, but is rich in highly digestible non-structural carbohydrates and calcium (7). The calcium contained in the cactus is bio-available and has the potential to improve bone mineral density (10).

Incorporation of *Opuntia* spp in livestock diet has already been evaluated in sheep (16, 20), cattle and rabbit (29). However, this work is the first to study the feed potential evaluation of barbaric fig cladodes, widely present in the Algerian rural landscape, in broiler chickens livestock.

Materials and methods

Ethics statement

Due to the lack of animal ethics commission in Algeria, the authors followed the regulations applied in the Liege University (Belgium). In order to limit the stress of the chicks, the light intensity was reduced during all manipulations. The chickens were killed after stunning by an electric shock (110 mA). The heads were cut and the chickens were bled.

Preparation of the *Opuntia ficus-indica* powder and analytical composition of the cactus

Opuntia ficus indica used in this study was obtained from the region of Ath-Waghlis (Chemini, Bejaia). The cladodes were pre-dried by sun exposure (T > 30 °C), during 7 days. Then, they were dried at 50 °C, for about 2 days, before being crushed and ground. Finally, the powder obtained was dried for the last time in an oven at 105 °C for 3h (AOAC, 2000). Chemical analyses were carried according to the procedures of AOAC (2000). Crude Protein (CP) was determined by the Kjeldahl method; ether extract (EE) by the Soxhelt method (method no. 920.39); and crude fiber (CF) by the method of Weende (method no. 978.10). Finally, atomic absorption spectrometry was used to assay minerals.

Animals, rearing and slaughtering, and blood analysis

This study was performed in a private poultry farm in the Chemini region (Wilaya de Bejaia). A total of 120 Ross-308 one day-old male chicks, obtained from a commercial hatchery, were monitored. They were randomly divided into 3 groups (Group 1, 2 and 3), according to a specific diet consumed. In each group, chicks were distributed in 4 replicates (10 chicks per replicate). The replicates were bedded with fresh wood shaving. Chickens were monitored twice a day, in the morning and in the evening, during feed distribution. Daily visits allowed assessing the clinical condition of animals (general conditions, behavior and lesions if present). The experimental diets were mainly based on commercial feed (Table 1). The group 1 (Control group, CG) received the commercial feed while groups 2 and 3 consumed the same feed whose 5% and 10% of its weight were replaced by the *Opuntia ficus-indica* powder; giving *Opuntia ficus* 5% (OFI5) and *Opuntia ficus* 10% (OF I10), respectively (Table 1). All birds were fed on a starter diet from day 1 (d 1) to day 14 (d 14), and a grower diet from day 15 (d 15) to day 42 (d 42). The ambient temperature was thermostatically set at 33 °C on the first day of the experiment and decreased by 1°C every three days thereafter, a course of the duration of the experimental period. Feed and water were offered ad libitum, and lighting was provided for 24 h for the first 48 h post hatching, then for 16 h per day until the end of the experiment. The relative humidity was around 50 to 70%. Individual body weight of each bird and feed intake per replicate were recorded. Average daily gain (ADG) and feed conversion ratio (FCR) were calculated over the period of 42 days and were corrected for the body weight at hatching and mortality during the study. The bird's mortality was evaluated during all the growing period. Pre-slaughter blood samples were taken from wing vein on 12 chickens (3 per replicate) from each experimental group and sent to a private analytical laboratory located in the wilaya of Bejaia (Lab-Bio Bejaia). Feed was withdrawn approximately 12 h before slaughter. After electrical stunning (110 mA), necks were cut and birds were bled. Carcasses were scalded in a 65 °C water bath for 20 s and defeathered in a rotary drum picker. Heads and necks as well as legs and shanks

were removed. However, carcasses, gizzard and abdominal fat were sampled and weighed.

Table 1. Composition and main characteristics of diets.

Composition (g/kg)						
Starter	Corn	Soybean	Wheat bran	Ca(H2PO4)2	Premix	Opuntia ficus-indica
CG	62	30	5	2	11	0
OFI5	62	30	0	2	11	5
OFI10	60	27	0	2	11	10
Growth						
CG	64	28	5	2	12	0
OFI5	64	28	0	2	12	5
OFI10	60	27	0	2	12	10

Analytical composition of Control group feed

	Metabolizable energy (MJ/kg)	Crude protein (%)
Starter	2818.59	20.30
Growth	2779.99	19.60

[1]Premix added to the starter provided the following per kilogram of diet: vitamin A, 15,500 IU; vitamin D3, 5,000 IU; vitamin E (DL-α-tocopheryl acetate), 70 mg; Mn, 80 mg; Fe, 60 mg; Zn, 50 mg; Cu, 17 mg; I,1.01 mg; Se, 0.44 mg; Co, 0.38 mg; 3-phytase, 600 FTU; endo-1,4-β-Xylanase, 12 IU; Nasarin (coccidiostat), 48 mg; Nicarbazin, 48 mg (coccidiostat).

[2]Premix added to the grower provided the following per kilogram of diet: vitamin A, 12,000 IU; vitamin D3, 3,000 IU; vitamin E, 40 mg; 5 vitamin K, 3 mg; thiamine, 3 mg; riboflavin, 6 mg; cobalamin, 30 µg; niacin, 50 mg; pantothenic acid, 12 mg; folic acid, 1,000 µg; biotin, 100 µg; Mn, 108 mg; Fe, 80 mg; Zn, 72 mg; Cu, 14 mg; I, 1.44 mg; Se, 0.45 mg.

Statistical analyses

The SAS software (SAS Institute 2000) was used for statistical analyses. Feed and age effects, on each parameter were assessed by a general linear model (GLM). Least square means (LSM) and standard errors were calculated. All statements of significance were based on the probability of $p < 0.05$.

Results

Opuntia ficus-indica powder composition

Table 2 presents the analytical composition of *Opuntia ficus-indica* powder. This powder is composed of 93.20% of dry matter (DM), 21.40% of ash, 6.40% of crude protein (CP), 19.7% of crude fiber (CF) and 1.54% of ether extract (EE).

Table 2. Analytical composition of Opuntia ficus indica cladodes pow

Chemical composition	Mean
DM (%)	93.20
Ash(% DM)	21.40
CP(%DM)	6.40
EE (%DM)	1.54
Crude fibre (%DM)	19.70
Calcium (g/kg DM)	4.61
Phosphorus (g/kg DM)	0.13
Potassium (g/kg DM)	3.08
Sodium (g/kg DM)	0.01
Magnesium(g/kg DM)	1.45
Copper (mg/kg DM)	8.40
Manganese (mg/kg DM)	477.30
Zinc (mg/kg DM)	55.00
Iron (mg/kg DM)	106.60

Growth performance and carcass characteristics

The monitoring of chickens lesions and behavior did not show any critical observation, in all the period of the experiment. The average body weight of broilers body weight (BW) at d0 was 44.7 ± 0.57 g, 43.0 ± 0.57 g and 43.6 ± 0.58 g, respectively, in the case of OFI10, OFI5 and CG, as shown in table 3; when chickens reached the age of d 42, respective average BW were 1877 ± 44.4 g, 1972 ± 43.1 g and 1949 ± 43.2 g ($p > 0.05$). Same results were obtained for ADG, FCR, and Mortality parameters; in fact, no significant difference ($p > 0.05$) was estimated (Table 3). Mortality yields during d 42 were 12.50%, 10.00% and 10.00%, respectively, for OF I10, OF I5 and CG.

Carcass characteristics are presented in Table 4. No significant differences were found between groups in carcass weight (mean values comprised between 1,426 g and 1,485 g, $p > 0.05$). However, a significant effect of diet was observed in the case of a gizzard weight ($p < 0.001$), liver weight ($p < 0.01$) and abdominal fat weight ($p < 0.001$). In fact, gizzard and liver weight were significantly higher in OFI10 (48.17 ± 0.79 and 58.42 ± 1.22 respectively), while abdominal fat was significantly lower (22.58 ± 0.78).

Table 3. Growth performances and feed conversion index of the different groups.

Parameters	OFI10	OFI5	CG	Effects			R2
				Feed (F)	Block (B)	F*B	
Body Weight (g)							
Day 0	44.67±0.57a	42.97±0.57b	43.64±0.58ab	Ns	***	**	0.52
Day 7	129.95±3.58	168.87±3.54	149.45±3.60	***	***	Ns	0.50
Day 14	308.68±11.49a	389.88±11.49b	349.09±11.51c	***	**	Ns	0.34
Day 21	726.44±24.12	792.28±24.12	785.08±21.12	Ns	Ns	Ns	0.09
Day 28	1059.95±28.73a	1151.68±28.73b	1141.70±28.80b	Ns	*	Ns	0.18
Day 35	1662.35±52.97	1790.90±52.97	1709.71±53.10	Ns	Ns	Ns	0.06
Day 42	1877.02±44.41	1972.30±43.05	1949.28±43.19	Ns	Ns	Ns	0.06
ADG (g)							
ADG 0-14 days	18.90±0.83a	24.68±0.83b	21.92±0.83c	***	***	Ns	0.35
ADG 15-42 days	56.17±1.70	56.44±1.64	57.19±1.65	Ns	Ns	Ns	0.05
ADG 0-42 days	43.63±1.05	45.93±1.02	45.37±1.02	Ns	Ns	Ns	0.06
FCR 0-42days	2.05	1.97	1.95	-	-	-	-

*FCR : Food conversion ratio; *ADG : Average daily gain;

On a same row, values bearing a same letter a statistically not different (P< 0.05); ***: P < 0.001 ; ** : P < 0.01; *: P < 0.05; Ns: P ≥ 0.05.

OFI10: *Opuntia ficus-indica* 10%, OFI: *Opuntia ficus-indica* 5%, CG: Control group.

Table 4. Carcass yield of the different groups.

Parameters	OFI10	OFI5	CG	Feed effect	R^2
Carcass weight (g)	1426.08±45.50	1485.20±45.50	1438.75±45.54	Ns	0.03
Carcass yield (%)	69.83±0.54	70.71±0.55	70.21±0.54	Ns	0.04
Gizzard weight (g)	$48.17±0.79^a$	$43.06±0.79^b$	$39.88±0.79^c$	***	0.63
Liver weight (g)	$58.42±1.22^a$	$52.42±1.22^b$	$54.11±1.22^b$	**	0.28
Abdominal fat weight (g)	$22.58±0.78^a$	$28.11±0.78^b$	$32.58±0.78^c$	***	0.71

On a same row, values bearing a same letter a statistically not different (P < 0.05); ***: P < 0.001 ; ** : P < 0.01 ; *: P < 0.05 ; Ns: P ≥ 0.05.

OFI10: *Opuntia ficus-indica* 10%, OFI: *Opuntia ficus-indica* 5%, CG: Control group.

Blood and biochemical parameters

Table 5 summarizes the changes in broiler chickens blood parameters, depending on the diet. Globally, most of biochemical parameters (triglycerides; glucose; uremia and cholesterol) were influenced by diet. In fact, glucose and triglycerides concentrations; and cholesterol were significantly lower in blood of chickens fed with OF I10, comparing to CG. In other side, the dose of uremia was significantly higher in OF I5 group, when compared to CG. However, no significant effect was observed on the dose of total proteins (Table 5).

Table 5. Biochemical parameters of the different group

Parameters	OFI10	OFI5	CG	Feed effect	R^2
Triglycerides (g/l)	0.50 ± 0.02^{a}	0.55 ± 0.02^{ab}	0.58 ± 0.02^{b}	*	0.23
Glucose (g/l)	1.83 ± 0.05^{a}	2.01 ± 0.05^{b}	2.09 ± 0.05^{b}	***	0.35
Uremia (g/l)	0.020 ± 0.001^{a}	0.023 ± 0.001^{b}	0.019 ± 0.001^{a}	**	0.27
Total protein (g/l)	25.17±0.58	26.07±0.58	26.03±0.58	Ns	0.04
Cholesterol(g/l)	0.80 ± 0.06^{a}	1.10 ± 0.03^{b}	1.20 ± 0.06^{c}	***	0.36

On a same row, values bearing a same letter a statistically not different (P< 0.05); ***: P < 0.001 ; ** : P < 0.01 ; *: P < 0.05 ; Ns: P ≥ 0.05.OFI10: *Opuntia ficus-indica* 10%, OFI: *Opuntia ficus-indica* 5%, CG: Control group.

Discussion

Opuntia ficus-indica powder composition

The variations in the nutritional quality of cactus cladodes were widely reported (8). Indeed, it is considerably influenced by plant age, harvest season, variety, climate conditions, soil fertility and storage. Previous studies reported the composition of fresh stems of OFI, as shown in table 6. The crude protein value of the OFI in this study (6.40%) was similar to those reported by Ayadi *et al.*, (2) in Tunisia. This could be explained by the similarity in the pedo-climatic conditions of Algeria and Tunisia. However, lower crude proteins proportion was observed in India by Misra *et al.* (16).

Table 6. Composition of fresh cactus stems according to some authors

DM	218g/kg	Misra *et al.* (16)
CP	12.6%3.3 to 8.8 g/100g DM	Misra *et al.* (16)Ayadi e*t al.* (2)
Dietary fiber	41.83% of total carbohydrates (30.36 insoluble and 8.48% soluble)	Ayadi *et al.* (2)
Starch	13.9 g/100 g DM	Ayadi *et al. (*2)
Soluble sugar	6.1g/100 g DM	Ayadi *et al.* (2)
Mucilage	50% of pectin	Bayar, Kriaa and Kammoun (4)
Fat content	7.2 g/100 g DM	Malainine *et al.* (13)
Ash	23.3g/100 g DM	Ayadi *et al.* (2)

Animal growth performance

In the present work, overall broiler chickens mortality, close to 10%, was higher than that observed for standard chicken (5.1%) (21), which remains unexplained after the macroscopic analysis carried out on cadavers. The FCR presented by the broiler chickens at d 42 of breeding was high (1.95 to 2.05) compared to recommendations for standard chickens (1.90) (21). This difference could be explained by the difference of stocking density in intensive broilers farming compared to the present study, as described by Sekeroglu *et al.* (22) which indicated that density influences the FCR in the Ross chicken strain. The ADG was significantly different in the first 2 weeks, in favor to

OF I5. However, no statistical difference ($p > 0.05$) was observed for the other breeding periods. Moreover, no difference (p $p > 0.05$) was observed in the ADGs of the three groups at the end of the growing period. Despite the absence of a significant difference $p > 0.05$), OFI5 had an ADG better (+ 0.6 g/day) than the CG and the OFI10 (+ 2.3 g/day).

Body weight about 1900 g obtained at d 42 was usual for Algerian breeding conditions of industrial broiler strains. The differences observed between groups are not significant (p > 0.05). At the end of the finishing phase, the highest body weight was observed in OF I5 (1,972.30 g) with 23.02 g more than the broilers of CG and 95.28 g more than the broilers of OF I10. Positive results were found an increase when adding *Opuntia* spp in other livestock species, such as lamb and lactating goats diet (12), allowing enhanced dry matter intake and a similar weight gain when compared to a commercial diet. However, Pinos-Rodriguez *et al.* (20) found opposite results in finishing lambs with negative effects on dry matter intake and balance of energy reported in finishing lambs. In cattle, cactus incorporation at 400 g per kg in the diet was accompanied by an acceptable growth performance, while higher levels were associated with reduced nutrient digestibility. When used in sheep diet, *Opuntia* spp reduced nitrogen intake, ruminal N-Balance, acetate and butyrate concentrations, indicating richness in readily available carbohydrates, and low N available (16). To counterbalance the lack of protein in the *Opuntia*, adjunction of oil by-products, such as cotton seed cake or peanut cake, successfully enhanced weight gain and feed conversion efficiency in sheep.

Carcass characteristics

The carcass weight and its characteristics were not different ($p > 0.05$) among feeds groups. However, abdominal fat was lower ($p < 0.01$) in carcasses of broilers fed diets containing cactus powder (OF I10: 22.58 g, OF I5: 28.11 g) than those fed the CG diet (32.58 g). Alcaron-Aguilar *et al.* (1), reported that incorporation of fresh or dehydrated spineless cactus into the lamb's diet reduced back fat carcasses. Similarly, lambs fed *Opuntia* spp had less fat in *Longissimus dorsi*, leaner meat and carcass, high content of conjugated linoleic acid and C22:5n3 (12). According to Basurto *et al.* (3), these differences can be explained by the main components of spineless cactus (pectin's, gum rubber, and mucilage), because it has been reported that these encapsulate greases and drag them to the posterior tract, and thus eliminate them. There were significant differences regarding gizzard weight between the three groups. Supplying a diet with insoluble fibers was previously shown to increase development of gizzard with no negative effect on performances as long as the upper limit for inclusion is not reached (see extensive review by Svihus, 25).

Blood and biochemical parameters

A significant ($p < 0.05$) decrease of glucose, triglyceride, cholesterol, and total proteins concentrations were recorded in OFI10 group compared to CG. When compared to CG, OFI 10 and OF I5 groups had respectively 33% and 8% less cholesterol, 12% and 4% less glucose, 5% and 14% less triglycerides. It had been shown that cactus can reduce blood glucose levels up to 21.2% in rabbits (9). The hypoglycaemic effect of cactus may be due to its richness in dietary fibre, particularly pectin, which causes a decrease in absorption of carbohydrates by formation of a pectin gel (27). Moreover, Onakpoya *et al.* (19) explain this hypoglycemic effect by the fact that cactus is very rich in dietary fibre which increases some microbial enzymatic activity, which causes the inhibition of hydrolysis. A significant reduction in plasma cholesterol (60.57%) and triglycerides (1.55%) was also observed in rabbit (9).

Conclusion

The *Opuntia ficus-indica* powder did not show any negative effect on the final body-weight, average daily gain and carcass characteristics. In contrast, it decreased ($p<0.05$) some blood biochemical parameters such as plasma glucose, uremia, cholesterol, and triglycerides. The *Opuntia ficus-indica* powder can be used as a potential additive in the commercial feed of broiler chickens which could efficiently reduce their cost sales in the Algerian market.

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