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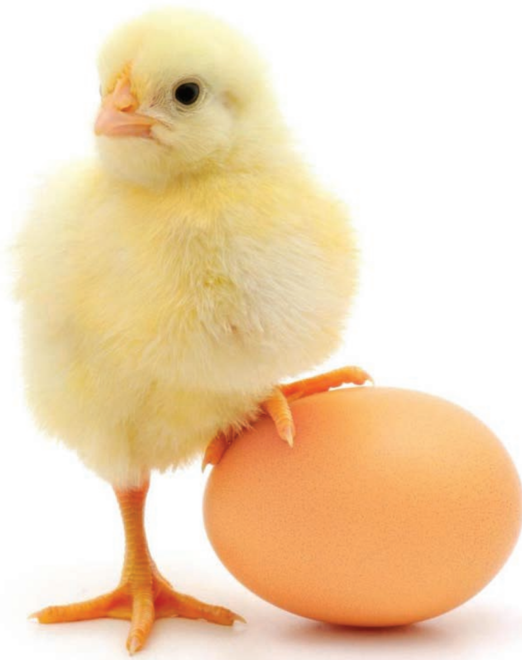

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Research Article
Promoting of Growth in Ross 208 Chicken Broilers Following a Diet Based on *Opuntia ficus-Indica* (Prickly Pear) Fruit

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Abstract
Background and Objective: Growth promoting antibiotics are widely used in modern chicken broiler breeding, however, their use is believed to be associated with many health risks, thus seeking other alternative products became more important. Through this study, we have tried to use the *Oputia ficus indica* (prickly pear) fruit as a phytobiotic in Ross 208 chicken Broilers. **Materials and Methods:** A total of 180 male Ross 208 chicks were divided into two experimental groups of 90 chicks each. An experimental diet supplemented with 10% of the prickly pear's dried fruit was given to experimental group. Surveyed parameters in this study were the body weight evolution, the daily average of body weight gain, the daily average of food consumption and the consumption indices. **Results:** A significant ($p<0.001$) weight gain (9.48%) was recorded in experimental batch when compared to the control group by the end of the experimental period. The average daily body weight gain and the average daily food consumption in experimental batch were higher than the control group, by 10.30 and 17.7% respectively. **Conclusion:** Incorporation of *Opuntia ficus indica* fruit into the broiler chicken diet improved feed intake, weight gain, and zootechnical performance.

Key words: Growth promoting antibiotics, *Opuntia ficus-indica*, phytobiotic, chicken broilers, broiler diet

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Antibiotics are widely exploited in modern broiler breeding to treat certain diseases, for preventive purposes upon exposure to risk factors and to improve growth rates as antimicrobial growth promoter agents (GAPs)[1]. In the 1960s, antibiotics were used in broiler diets as growth promoters. However, given the heightened risk of antibiotic-resistant bacteria, the European Commission decided on January 1, 2006, to eliminate and ultimately ban their use as growth promoters in animal feed (EC Regulation No. 1831/20031)[1]. This prohibition has helped guide the livestock industry towards developing alternatives. In particular, a variety of plant metabolites with antibacterial, anti-inflammatory, and antioxidant activity have been investigated as potential candidates to replace antibiotics.

The prickly pear cactus *Opuntia ficus-indica* (OFI) is a widely used plant in traditional medicine that grows in arid and semi-arid regions and is largely distributed throughout Latin America, South Africa and the Mediterranean[2]. Numerous studies have been carried out on its antioxidant, anti-inflammatory, anti-ulcerogenic[3-6], anti-diabetic[7], anticancer[8] and general nutritional properties[9]. Its fruit has multiple important nutritional and functional properties and can be used to improve the performance of livestock, including broilers[10]. The present study investigated the use of OFI fruit as a phytobiotic growth promoter in the diet of broiler chickens.

MATERIALS AND METHODS

Fruit preparation: Cactus pear (OFI) fruits were collected in August 2016 from the local area of "Sidi Ifni", Morocco. Only fruits without external injuries were selected, thoroughly washed with distilled water and manually peeled. Afterwards, the fruit was dried at 40°C.

Birds, housing and diets

Experimental diets: A basic diet consisting of corn, soybean meal and mineral-vitamin supplements were given to the chickens during this experiment. The composition and raw energies of the experimental diet are shown in Table 1.

Experimental design: Overall, 180 male Ross 208 chicks, at one-day age, were brought from the "Had Soualem" local commercial hatchery in Casablanca region-Morocco and were used in these experimental trials. Accommodation and food as well as temperature and lighting program were implemented according to the guidelines for the Ross 208 breed. Throughout the experiment, feed and water were given to the animals *ad libitum.* In the same breeding conditions, animals were reorganized into two experimental groups of 90 chicks each; The control group (C group) was fed by classical basic diet, while experimental group (E group) was given a supplemented basic diet with 10% of the crushed dried fruit of OFI. Husbandry in this study lasted 48 days (22-days for start-up phase and 26-days for growth phase). During the start-up phase, all groups were fed the same basic diet and during the growth phase, experimental diets based on OFI fruit were given to group F. The starter diets were offered during the start-up phase for all groups as crumbles, and grower-finisher diets were offered during the growth phase as pellets.

Zootechnical parameters: The examined parameters during this study were: the body weight evolution, the daily average of body weight gain, the daily average of food consumption and the consumption Indices.

Body weight evolution and daily weight gain: In this study, experimental chicks were weighed individually every three days, using an electronic balance; 20 birds were randomly chosen from each experimental group, at each weighing.

Table 1: Shape and composition of the feed used during breeding period of broiler

Breeding phase	Shape of feeds	Composition of feeds (%)		Gross energies (kcal EM kg^{-1})
Start-up (day 1-22)	Crumb	Maize	61	2800-2900
		Soyabean meal	32	
		Bran	2.5	
		Vitamin and mineral mix*	1.5	
		$CaCO_3$	1.5	
		Ca_2PO_4	1.5	
Growth (day 22-48)	Granule	Maize	65	2900-3000
		Soyabean meal	28	
		Bran	4	
		Vitamin and mineral mix*	1.5	
		$CaCO^3$	0.5	
		Ca_2PO_4	1	

*Providing the following per kg of diet: of diet 8 000 IU vitamin A, 600 IU Vitamin D_3, 16 mg Vitamin E, 1 mg Thiamine, 3 mg Riboflavin, 1 mg Pyridoxine, 0.01 mg Vitamin B_{12}, 1 mg Vitamin K_3, 16 mg Niacin, 7 mg Pantotenic acid, 70 mg Mn, 50 mg Zn, 30 mg Fe, 4 mg Cu, 1 mg I, 0.2 mg Co, 0.1 mg Se, 240 mg Choline, 300 Units phytase, 110 mg ethoxyquin

Food consumption (FC): The average amount of food consumed was counted every 3 days according to the following equation:

$$\text{Average amount of food consumed} = \frac{\text{The amount of food consumed per batch}}{\text{No. of living subjects}}$$

Consumption Indices (CI): The rate of feed conversion into animal's weight gain was calculated by the consumption indices according to the following formula:

$$\text{CI} = \frac{\text{Amount of food consumed}}{\text{Weight gain per subject}}$$

Statistical analysis: Performance data were evaluated during the growth-feeding period (day 22-48). Body weights were determined individually at days 21, 24, 27, 30, 33, 36, 39, 42, 45 and 48. Weight gain for each experimental group was evaluated at the end of the breeding period by measuring the average weight of the chickens. The weight gain percentage was calculated by the following equation:

$$\text{Weight gain}(\%) = \frac{\text{Final weigt}(g) - \text{intial weigt}(g)^*}{\text{Initial weigt}(g)} \times 100$$

*The initial weight was considered the weight at the beginning of the growth period (day 22).

Data obtained was analyzed using two way analysis of variance (ANOVA); with the help of statistical software program SPSS (SPSS, Inc., IBM, Chicago, Illinois, USA). Results were expressed as Mean±standard deviation (SD) of six animals for each experimental group. Differences of p<0.05 were considered statistically significant.

RESULTS

Body weight evolution and daily weight gain: Table 2 shows the evolution of body weight and daily weight gain throughout the experimental period. A variation in the evolution of average body weight according to diet around the day 27 of the experimental period was obtained. Though growth was gradual throughout the breeding period for all chicks, the speeds differed between experimental and control chicks. The final body weight of experimental chicks (9.84%) was significantly higher than that of the controls. Furthermore, a significant difference in average daily body weight gain was noted in experimental chicks compared to controls beginning at day 30 of the breeding period. Experimental chicks had the highest average daily body weight gain (154.58 g, 10.30%), while the highest of the controls was 140.14 g.

Daily food consumption and consumption indices: Average daily food consumption and consumption indices throughout the experimental period are shown in Table 3.

As with growth, food consumption gradually increased throughout the rearing period. However, a difference in average daily food consumption was noted between the groups from day 27 of the experimental period, with experimental birds having the highest (417.77g). Average daily food consumption remained higher for the experimental group (17.7%) versus the control at the end of the experimental period.

Table 2: Body weight evolution and daily gain throughout the experimental period

	The daily average of body weight (g)		Relative weight gain (g)	
Age (days)	C group	E group	C group	E group
3	63.90±2.23	60.50±2.25	-	-
6	101.50±2.50	95.45±1.86	37.59	34.95
9	170.05±3.06	161.90±2.93	68.55	66.45
12	250.60±6.00	242.15±6.00	80.55	80.25
15	340.40±10.04	335.80±8.63	89.79	93.66
18	450.30±11.13	449.10±10.64	109.89	113.31
21	582.20±15.50	580.80±8.72	131.91	131.70
24	730.70±12.32	742.25±10.8	148.50	161.46
27	890.05±15.33	920.40±13.04	159.36	178.14
30	1064.10±16.80	1120.00±15.39	174.06	199.59
33	1260.35±17.85	1342.35±15.61	196.26	222.36
36	1480.95±18.57	1591.60±16.25	220.59	249.24
39	1720.90±18.21	1866.85±16.82	239.94	275.25
42	1970.60±18.89	2092.80±17.26	249.69	225.96
45	2092.25±21.84	2224.20±24.61	121.65	155.04
48	2166.05±23.44	2379.25±25.14	73.80	131.40
The average value throughout the experimental period	958.43±13.35	1005.69±12.24	140.14	154.58

Table 3: Evolution of the daily average food consumption and consumption indices throughout the experimental period

	Daily average food consumption (g)		Consumption indices	
Age (days)	C group	E group	C group	E group
6	26.13	23.7	0.69	0.68
9	63.09	55.8	0.92	0.84
12	100.05	90.6	1.24	1.13
15	137.04	137.04	1.53	1.46
18	237.63	222.6	2.16	1.96
21	338.22	330.3	2.56	2.51
24	350.64	360.9	2.36	2.24
27	363.09	396.3	2.28	2.22
30	428.49	492.6	2.46	2.47
33	493.89	553.5	2.52	2.49
36	559.29	630.9	2.54	2.53
39	589.74	673.5	2.46	2.45
42	654.69	744.6	2.62	3.30
45	661.86	797.7	5.44	5.14
48	677.73	756.6	9.18	5.76
The average value throughout the experimental period	378.77	417.77	2.73	2.47

Consumption Indices (CI) values showed progression during the growth phase (days 1-22) followed by stability during the promotion phase (days 23-45). After day 39, the CI resumed, especially for control chicks whose CI was strongly stimulated until the end of the experimental period, while only a slight increase in the experimental chicks was observed. The stimulated CI in controls was due to a drop in weight gain and maintenance of consumption rate, while weight gains in experimental chicks continued to gradually decrease at the end of the experimental period, leading to lower CI values.

DISCUSSION

The most commonly recognized mechanisms of GAPs action are related to their antibacterial properties, which can improve livestock performance by preventing growth of excess intestinal microbiota and dysbiosis. A reduction in microbiota, especially pathogenic strains, can improve the availability of certain nutrients to the host. For example, some bacteria reduce the lipid digestion efficiency of the host by deconjugating bile salts, thereby competing directly for certain nutrients[11,12]. GAPs also reduce some energy-intensive immune responses by limiting microbiota development[13]. The action of such GAPs on microbiota may explain why axenic animals grow faster than conventional ones[14].

Numerous studies have shown that dietary supplementation of some GAPs scan modify certain immune parameters in broilers. Birds fed diets supplemented with GAPs have been shown to have high levels of duodenal intraepithelial lymphocytes and low ileal intraepithelial lymphocyte levels compared to untreated control birds[15]. Another study reported an increase in the number of immunoglobulin A+ in ileal cells after oxytetracycline administration, such that their decrease by nosiheptide administration was observed compared to non-GAPs controls[16]. Recently, GAPs treatment has been shown to increase expression of interferon-c in the small intestine of chicken broilers[17].

In chicks, the digestive tract is sterile at hatching and its colonization by microorganisms begins immediately thereafter, depending on their water, environment, and food[18]. A gut microbiota structure change is also caused by the composition of the diet as some bacterial populations disappear or emerge in the gut, while others remain stable throughout the bird's life. Further research has shown that variation of intestinal bacterial strains only partly impacts performance[19]. Other factors that determine performance are related to nutrient digestibility and food consumption, which are directly related to the physicochemical properties of the digestive tract[10]. Specifically, studies have been conducted to determine whether the growth enhancing effects of certain phytobiotics are related to digestive microbiota changes. Although the results largely depend on the phytobiotics considered, form of administration and dose, modification of digestive microbiota can be observed in parallel with an improvement in growth performance[20] without the growth of animals being modified[21].

A beneficial effect on growth can be also observed with inconsequential digestive microbiota[22]. The lack of observed effect on digestive microbiota compared to the *in vitro* effects could be attributed to several factors. These variations could be related to the concentrations and culture media used, as well as the fact that digestive contents' complex biological media are different from those *in vitro*. Thus, antimicrobial compound effectiveness can be reduced by certain food components. For example, diets rich in lipids and/or proteins would protect bacteria from the action of certain active compounds[23]. Studies have suggested greater availability of nutrients in foods compared to *in vitro* as culture media may enable bacteria to promptly repair of damage caused by these active compounds[24].

The present results concerning weight gain corroborate those of other studies[25,26] reporting weight gains around 10% using ground garlic or rosemary essential oil. On the other hand, some phytobiotic additives can negatively impact weight. For example, yarrow essential oil has been shown to cause a 13% decrease in weight[22]. Phytobiotic dietary additives have also been reported to impact food consumption in numerous studies. For example, while dietary use of rosemary essential oil was found to cause a 16% decrease in food consumption[22], thyme essential oil increased consumption by 11%. Numerous studies have also reported various phytobiotic effects on the zootechnical parameters of broilers. Al-Sultan[27] reported a CI of -16% using ground turmeric, whereas Cross *et al.*[22] and Langeroudi *et al.*[28] reported CIs of 7 and 4% using ground thyme and *Zataria multiflora* essential oil, respectively.

Prickly pear fruits are rich in sugars (15%), minerals (calcium and magnesium), vitamins (vitamins C, E, and K and β-carotenes) and amino acids[9,29] as well as antioxidants and other compounds (betalains and taurine)[30]. Furthermore, the prickly pear contains approximately 85% water, 0.3% ash and less than 1% protein[31,32]. Interestingly, despite the traditional use of vegetative parts of *Opuntia* spp. as a source of nutrients for humans, they are rarely used in livestock diets. Nonetheless, the nutritional and chemical properties of OFI fruit make it a potential candidate for improving chicken broilers zootechnical performance by completing their nutritional needs and enhancing yield, while avoiding the undesirable effects of GAPs. OFI fruit consumption has a positive effect on the body's redox balance, improving antioxidant status and decreasing lipid oxidation[33]. One study showed a decrease in total cholesterol and low-density lipoprotein levels after supplementation with prickly pear cactus oil or seed[30]. Moreover, the antioxidant properties of β-carotenes and vitamin E have been shown to ameliorate the stability of fatty oils[34].

The reported efficacy of different phytobiotics often varies from one study to another partly due to different study conditions, such as products and animals tested, administration method, and especially the phytobiotic preparation method[22,26,35-37]. Animal age and genetics are also important. In chicken broilers, studies have shown a greater beneficial effect during the start-up period and others have reported a negative effect on growth when using antimicrobial-active phytobiotics early in the chick rearing period[38].

CONCLUSION

Incorporation of OFI fruit into the chicken broilers diet improved feed intake, weight gain, and zootechnical performance. Further studies are needed to investigate optimal conditions for the application and production of a balanced OFI fruit diet-based formula.

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