RESEARCH OPINIONS IN ANIMAL & VETERINARY SCIENCES
PRINT ISSN 2221-1896, ONLINE ISSN 2223-0343
www.roavs.com

Effect of dehydrated *Spirulina platensis* on performances and meat quality of broilers

A. Raach-Moujahed[1], S. Hassani[1], S. Zairi[1], M. Bouallegue[2], C. Darej[3], B. Haddad[3] and C. Damergi[3]

[1]Département des Sciences et Techniques des Productions Animales, Ecole Supérieure d'Agriculture de Mateur, Tunisia; [2] Faculté des Sciences Mathématiques, Physiques et Naturelle de Tunis, Tunisia; [3] Institut National Agronomique de Tunis, Tunisia

Abstract

The present study was carried out to determine the effects of dietary spirulina on performance, meat pH, colour and sensory attributes of growing broiler chickens. Two hundred eight one day-old chicks (Arbor Acres) were fed 4 experimental diets containing Spirulina at rate of 0, 1.0, 2.5 and 5.0% for 38 days. No significant difference among treatments were observed in body weights, daily weight gain and feed intake. However, a significant (P<0.05) decrease was observed in feed conversion ratio in the group fed 2.5% of Spirulina diet. The diet with 2.5% of spirulina gave the highest carcass yield when compared to 1.0 and 5.0% of Spirulina diets. No effect of Spirulina at any rate of incorporation was observed on meat pH values. In skin and meat, the lightness (L*) and the redness (a*) were equivalent in all the treatments. However, a significant difference (P<0.05) in yellowness (b*) was noted in the case of 2.5 and 5.0% spirulina containing diets. The sensory analysis did not show significant differences for tenderness, juiciness, odour, colour and the flavour (P>0.05) between the different diets. It was concluded that Spirulina improved the feed conversion ratio as well as the carcass yield of Arbor Acres broiler at a rate of 2.5% of incorporation and that only the yellowness of meat and skin (b*) were accentuated with 2.5 and 5.0% of Spirulina.

Keywords: *Spirulina platensis*, Broiler, Meat Quality

Introduction

Spirulina platensis is a cyanobacterium which is generally regarded as rich sources of protein, essential amino and fatty acids, vitamins and minerals. It has been traditionally used since hundreds of years by some populations in human nutrition (Giferri and Tiboni, 1985). It was showed that *Spirulina* enhance immune function, reproduction and increase growth and has been used throughout the world as a feed component in quality broiler (Yoshida and Hoshii, 1980) and layer diets to enhance yolk colour and flesh (Blum et Calet, 1975; Blum et al. 1975; Venkataraman et al. 1994; Ross and Dominy, 1990 and Toyomizu et al. 2001).

For few years, Tunisia produced spirulina via a private company located in the area of Mehdia. The production is mostly intended for the cosmetic production and some human feeds. In Tunisian poultry production system conditions spirulina was rarely tested in animal feeding. Therefore, the aim of the current study was to evaluate the effect of national produced spirulina as an alternative agent to improve performances and meat quality in broiler chicken.

Materials and Methods

The experiments were carried out in an experimental unit of the Centre de Formation Professionnelle Agricole en Aviculture (CFPAA) de Sidi Thabet, located 25 km from Tunis city. Arbor Acres chicks (208) were obtained from the hatchery of the CFPAA at 1 day of age. They were divided into 16 groups of 13 birds each and allocated randomly into 16 pens in a temperature-controlled room with continuous light. Chick received experimental concentrates containing spirulina at 0, 1, 2.5 and 5% (one diet for 4 groups of 13). Starter (1-14d) and grower-finisher (15-38d) were used. Concentrates were typical corn and soybean (table1) and were formulated to be iso-energetic and iso-nitrogenous to meat NRC (1994) recommendations for all nutrients. The chicks were given feed and water *ad libitum* throughout the experimental period (0 to 38 days).

Body weight gain was recorded individually and feed intake was recorded on a pen basis weekly. Data were summarized for period from 0 to 38 days. Feed conversion ratio (FCR) was determined as the feed intake divided by the weight gain during the experimental period. At the end of the experimental period (day 38), 3 birds per group (12 birds/ diet) were selected and then slaughtered. The pH was measured in the breast at 2 cm depth at 15 min, 1, 3 and 24 hours after slaughtering using a Hanna digital pH meter equipped with a Hanna electrode calibrated before measurement with pH 4.0 and 7.0. The carcasses were weighted and then conserved at 4°C during 24 hours to individually measure pH and colour of skin breast and breast using a Minolta CR-200 Chromameter (Minolta Camera, Co, Osaka, Japan).

Colour was expressed in the CIELAB dimension of lightness (L*), redness (a*) and yellowness (b*). Before colour evaluation, the breast and thighs were separated and frozen at -18°C for sensory evaluation.

A consumer test was conducted at Institut National Agronomique de Tunis. Breast and thighs were thawed at refrigerated temperature (4°C) and cooked for 50 min in a standard commercial oven at 200°C, such that the final internal temperature of the meat was 65°C. The sensory attributes consisted in 10 untrained consumers who had previously participated in similar sensory evaluations and were chosen from the staff of Institut National Agronomique de Tunis. Panel members were not given any information about the meat or the experimental treatments and procedures. Serving sizes were of a split breast and thigh pieces served without the skin. Panelists were asked to evaluate liking of tenderness, juiciness, colour, odour and flavour of each meat sample individually, on the basis of a scale from1 to 10. Feeds were analysed using AOAC procedures (AOAC, 1990).

Statistical Analysis

Data were analysed using GLM procedure of SAS software (1999), to test the effect of diet (Spirulina rate) on intake, performances, carcass characteristics, pH, colour and sensory attributes, using the following model: $Yik = \mu + Ri + Eik$

μ: average,

Ri: effect of the ith diet (1, 2, 3, 4),

Eij: random residuals

The analysis was completed using Duncan test to compare treatment levels.

Results and Discussion

Chemical compositions of experimental diets and Spirulina are presented in table 2. Diets are approximately iso-energetic and iso-nitrogenous and met the NRC (1994) recommendations (CP and ME contents averaged respectively 20.8 % and 2900 kcal/kg).

Performances, intake and carcass rate of broiler (1 to 38 d) fed diet with different levels of spirulina are summarised in table 3. Increasing Spirulina rate in diets did not significantly affect body weight (table 3) nor daily weight gain or total gain. Our results demonstrated the compatibility of dietary spirulina with conventional feedstuffs of broiler chicken and confirm those of several earlier studies on spirulina effects in broiler. Indeed, Ross and Dominy (1990) found that including spirulina at 50 to 100g/kg resulted in normal growth of poultry and found that growth was depressed only when spirulina rate reached 200g/kg.

In addition, Venkataraman et al. (1994) showed that substitution of growth protein with sun dried and powdered Spirulina up to 170 g/kg did not result in any effect on performances. Toyomizu et al. (2001) confirmed these results when spirulina was introduced at the rates of 40 and 80g/kg in broiler diets.

Total intake was not affected by dietary spirulina (averaged 4075 g). In contrast, feed conversion ratio decreased significantly (P<0.05) from 2.6 in control diet to 2.2 and 2.3 respectively in diet1 and diet 2.5. Similar results were found on feed conversion ratio by Blum and Calet (1975) and recently by Razafindrajaona et al. (2008a). The improvement of the feed conversion ratio, in particular at the rate of 2.5% indicates a better efficiency of metabolic use of the nutrient. For this reason, Razafindrajaona et al. (2008a), Blum and Calet (1975) and Toyomizu et al. (2001), recommend the use of low dose (lower than 5%). Indeed, the energy efficiency thus decreases when the level of incorporation of the spirulina increases.

Spirulina improved the carcass yield of Arbor Acres broiler at a rate of 2.5% of incorporation (75.4%). A similar result was observed by Razafindrajaona et al. (2008a) who found that Spirulina incorporated according to 100 mg/kg body weight, improve the carcass yield, with an additional profit from +7%, when it is used only during the starter phase of growth and +11.4% when added in during the entire period of rearing. According to Razafindrajaona et al. (2008a), the improvement of the carcass yield indicate a better development of the “noble” pieces, in particular the thighs and the breast, indicating that Spirulina improved not only the nutritional value of the diet but also its biological efficiency inducing a rise in the noble pieces of broiler.

No significant differences between diets were observed on breast pH within each measurement time (P>0.05) (table 4). In the poultry meat and particularly the chicken meat, Warris et al. (1988) show that the high values of the ultimate pH are caused by the low concentration of glycogen measured immediately after slaughter. In our study, the relatively low values of the ultimate pH could be allotted to the stress of collecting, transport and slaughter of broiler. This stress ant mortem would generate ultimate pH relatively low in muscle (Gigaud et al., 2006 and Debut et al., 2003).

Table1: Composition of diets (%)

Diet	S0	G0	S1	G1	S2.5	G2.5	S5	G5
Corn (%)	64	69	64	69	64.5	69.5	65	70
Soybean meal (%)	32	27	31	26	29	24	26	21
Spirulina (%)	0	0	1	1	2.5	2.5	5	5
[1]MVP (%)	4	4	4	4	4	4	4	4

*Sn: starter with n% of spirulina given for 14 days, Gn: Grower with n% of spirulina given for 24 days.
[1]MVP: Mineral-Vitamin Premix provided the following per kilogram of diet: vitamin A, 10 000 IU; vitamin D3, 2 500 IU; vitamin E, 20 mg; nicotinic acid, 30 mg; vitamin B12, 0.12 mg; calcium pantothenate, 11 mg; vitamin K3, 2 mg; thiamin, 1 mg; riboflavin, 4.2 mg; vitamin B6, 1.7 mg; folic acid, 0.5 mg; biotin, 0.5 mg; Fe, 172 mg; Cu, 20 mg; Mn, 110mg; Zn, 125 mg; Co, 0.3 mg; I, 2.4 mg; Se, 0.5 mg

Table 2: Chemical composition of diets and *Spirulina platensis* (%)

Diet	Spirulina	S0	G0	S1	G1	S2.5	G2.5	S5	G5
DM (%)	92.6	87.3	86.3	87.3	86.4	87.4	87.3	87.3	86.5
Ash (%)	15.6	7.6	8.4	7.1	6.2	7.9	7.5	7.6	6.7
CP (%)	57	20.3	20.8	20.3	21.1	20.9	21.2	20.7	21
CF (%)	0	2.3	4.7	2.3	5.2	2.3	4.4	1.9	2.3
Fat (%)	3.2	2.5	3.1	2.2	2.6	2.4	2.7	2.3	2.5
ME (Kcal/kg)	2645	2895	2930	2890	2940	2906	2942	2900	2930

*Sn: starter with n% of spirulina given for 14 days, Gn: Grower with n% of spirulina given for 24 days. DM: dry matter, CP: crude protein, CF: crude fiber, ME: metabolisable energy

Table 3: Intake, performances, mortality and carcass rate of broiler (1 to 38 d) fed diet with different rates of spirulina

Item	Diet0	Diet1	Diet2.5	Diet5	SEM
Body weight 38d (g)	1695.5	1725.3	1826.7	1751.8	45.4
Body Weight gain (g) (1-38d)	1650.4	1693.7	1758.1	1706.2	45.20
Daily Weight Gain (g/d)	43.4	44.1	46.3	44.9	1.21
Total feed intake (g) (1-38d)	4331.8	3987.6	3937.3	4042.0	135.8
Feed conversion ratio (g/g)	2.6^{a}	2.3^{bc}	2.2^{c}	2.4^{b}	0.04
Carcass rate (%)	72.6^{b}	71.8^{b}	75.5^{a}	72^{b}	0.72

[a-c] Means within the same line with different letters are statistically different ($P<0.05$)

Table 4: Evolution of pH *post mortem* of broilers fed diets with different spirulina contents

	Diet0	Diet1	Diet2,5	Diet5	SEM
pH 15mn	6.07	5.94	6.09	5.90	0.03
pH 1hour	5.80	5.82	5.80	5.72	0.02
pH 3hours	5.67	5.65	5.73	5.62	0.02
pH 24hours	5.60	5.50	5.62	5.54	0.02

SEM: Standard error of the mean

Results of the colour characteristics (L*-, a* -and b*- values) of breast and skin breast are presented in table 5. Lightness (L*-value) in skin breast and breast was not affected by Spirulina proportion in diet. The same trend was found by Toyomizu et al. (2001) in pectorals muscle (superficialis and profundus) and skin when Spirulina was included at the rates of 40 and 80g/kg of diets in broiler.

The redness (a*- value) was not affected by any rate of incorporation of Spirulina, neither in muscle (breast) nor in skin. Our results were confirmed by Toyomizu et al. (2001). By another hand, the yellowness (b*- value) was affected with increasing diet Spirulina content both in breast and skin. The b*-value increased significantly ($P<0.05$) in breast and skin from the rate of 2.5% of spirulina with a similar effect at the proportion of 5 %.

In this connection, Venkataraman et al. (1994) showed that colour pigmentation of skin, breast and thigh muscles was deeper in broilers by substituting ground nut protein with sun-dried and powdered spirulina up to 170 g/kg or with fish meal spirulina (140 g/kg) on iso-nitrogenous basis. Toyomizu et al. (2001) found that including spirulina in broiler feeds influenced both the yellowness and redness of broiler flesh. They reported that the increase of yellowness

Table 5: Changes in colour characteristics (L*-, a*- and b*- value) of pectoralis and skin of broilers fed diets with different spirulina contents

Diets	Skin breast	Breast
	L*- value	
Diet 0	67.45	53.59
Diet 1	67.75	56.32
Diet 2.5	69.73	57.76
Diet 5	67.35	57,49
SEM	0.86	0.71
	a*- Value	
Diet 0	1.10	1.13
Diet 1	0.73	0.74
Diet 2.5	0.85	1.40
Diet 5	0.56	1.42
SEM	0.23	0.19
	b*- Value	
Diet 0	9.86[b]	5.64[b]
Diet 1	10.16[b]	5.56[b]
Diet 2.5	14.18[a]	9.54[a]
Diet 5	14.11[a]	8.22[a]
SEM	0.69	0.42

ab Means within the same column with different letters were significantly different (P<0.05)

with dietary spirulina content may possibly be reflected in the common yellow pigment related to the accumulation of zeaxanthin within the flesh. The differences of result trends between our results and the other authors could be mainly due to the differences in Spirulina rate and diets composition. Indeed, Diets contained more than 64% of corn (rich in β carotène) probably did not show a difference between the four diets for the redness.

The sensory panel did not showed differences between studied diets for tenderness, juiciness, odour, colour and the flavour (table 6). The incorporation of spirulina at 1, 2.5 & 5% rates did not show modification in organoleptic attribute of meat chicken.

The sensory panel results did not confirm those presented by Razafindrajaona et al. (2008b), which affirmed that incorporation of Spirulina in diets of broilers at the amounts of 50 and 100 mg/kg of body weight provided red, rather tender and salted meat, with more pronounced taste & savour according to Spirulina amount. These differences with the results of the literature would be probably due primarily to the differences of the methods of the evaluation sensory, to the various amounts of spirulina used, diets composition and possibly to the not standardized methods of cooking.

Table 6: Impact of spirulina diets on sensory attributes of chicken thigh and breast meat

Variable	Diet0	Diet1	Diet2.5	Diet5	SEM
Thigh					
Tenderness	7	7.69	6.79	7.35	0.18
Juiciness	5.94	6.21	5.57	5.94	0.17
Colour	5.02	4.94	4.52	5.52	0.23
Odour	5.7	5.98	5.41	6.38	0.28
Flavour	5.55	5.96	5.03	5.64	0.27
Breast					
Tenderness	5.77	6.78	7.05	6.31	0.23
Juiciness	5.07	5.38	5.58	4.86	0.26
Colour	3.58	3.52	3.03	4.14	0.21
Odour	5.05	5.61	4.96	5.09	0.25
Flavour	5.60	5.69	5.27	5.63	0.26

SEM: Standard error of the mean

Conclusions

It was concluded that spirulina improved the feed conversion ratio as well as the carcass yield of Arbor Acres broiler at a rate of 2.5% incorporation and that only the yellowness of meat and skin (b*) were accentuated with 2.5 and 5% of Spirulina. No effects of spirulina were found on organoleptic attributes in Arbor broiler meat.

References

AOAC, 1990. Official's methods of analysis. Assoc. official analytical chemists, Wasghongton, DC.

Blum, J.C. and Calet, C. 1975. Food value of spiruline algae for growth of the broiler-type chicken. *Annales de la Nutrition et de l'Alimentation,* 29: 651-674.

Blum, J.C., Guillaumin, S. and Calet, C. 1975. Food value of spiruline algae for the laying hen. *Annales de la Nutrition et de l'Alimentation*, 29: 675-682.

Ciferri, O. And Tiboni, O. 1985. The biochemistry and industrial potential of Spirulina. *Annual Review of Microbiology*, 39: 503–526.

NRC. 1994. Nutrient Requirement of Poultry. 9th Ed., National Academy Press, Washington, DC, USA.

Debut, M., Berri, C., Baéza, E., Sellier, N., Arnoud, C., Guéméné, D., Bouten, B., Jehl, N., Jégo, Y., Beaumont, C. and Le Bihan-Duval, E. 2003. Variation of Chicken Technological Meat Quality in Relation with Genotype and Stressing Pre-Slaughter Conditions. *Poultry Science*, 82: 1829-1838

Gigaud, V., Geffrard, A., Berri, C., Le Bihan-Duval, E., Travel, A. and Bordeau, T. 2006. Conditions environnementales *ante mortem* (ramassage-transport-abattage) et qualité technologique. *Viandes Produits Carnés*, Vol 26 (1): 17-20.

Razafindrajaona, J.M., Rakotozandriny, J.N., Rakotozandrindrainy, R., Tsivingaina, A., Ramapiherika, K.D. and Randria, J.N. 2008a. Influence de l'incorporation dans les provendes de la spiruline de Madagascar (S*pirulina platensis var. toliarensis)* sur la croissance des poulets de chair. International Symposium on Spirulina–Toliara Sud-Ouest de MADAGASCAR. Avril 2008.

Razafindrajaona, J.M., Rakotozandriny, J.N., Rakotozandrindrainy, R., Tsivingaina, A., Ramapiherika, K.D. and Randria, J.N. 2008b. Influence de l'incorporation dans les provendes de la spiruline de madagascar (*spirulina platensis var. toliarensis)* sur la qualité organoleptique des viandes des poulets de chair. http://www.erails.net/MG/biotec-et-innovation/spiruline-et-viande/Home/(January 2011).

Ross, E. and Dominy, W. 1990. The nutritional value of dehydrated blue-green algae (Spirulina platensis) for poultry. *Poultry Science*, 69: 794-800

SAS 1999. SAS user's guide, Statistics, Version 10th Edn. SAS institute Inc., Cary NC.

Toyomizu, M., Sato, K., Taroda, H., Kato, T. and Akiba, Y. 2001. Effects of dietary *Spirulina* on meat colour in muscle of broiler chickens. *British Poultry Science*, 42: 197–202

Venkataraman, L.V., Somasekaran, T. and Becker, E.W. 1994. Replacement value of blue-green alga (*Spirulina platensis*) for fishmeal and a vitamin-mineral premix for broiler chicks. *British Poultry Science*, 35: 373–381.

Warris, P.D., Kestin, S.C., Brown, S.N. andBevis, E.A. 1988. Depletion of glycogen reserves in fasting broiler chickens. *British Poultry Science,* 29: 149-154.

Yoshida, M. and Hoshii, H. 1980. Nutritive value of spirulina, green algae, for poultry feed. *Japanese Poultry Science*, 17: 27–30.