

Effect of spirulina platensis as a dietary supplement on broiler performance in comparison with prebiotics

Hussein A. Kaoud

Department of Veterinary Hygiene and Environmental Pollution, Faculty of Veterinary Medicine, Cairo University, Egypt

Corresponding author email: ka-oud@link.net

ABSTRACT: A trial was conducted to investigate the effects of dietary supplementations of prebiotic (Lactose and Myco) and Spirulina platensis on broiler performance, carcass yield, and organs weights. Six hundred 1-d-old broiler chicks were randomly assigned to 1 of 4 dietary treatments for 6 wk. The dietary treatments were 1) control, 2) basal diets supplemented with prebiotic (lactose) (1 kg per ton of feed), 3) basal diets supplemented with prebiotic (Myco) (1 kg per ton of feed), 4) basal diets supplemented with dry powder Spirulina platensis (1 kg per ton of feed). The body weights, average daily weight gain, carcass yield percentage, and feed conversion rate were significantly ($P < 0.05$) increased by the dietary inclusion of the prebiotic and Spirulina platensis as compared the control fed broilers. In conclusion, the prebiotic and Spirulina platensis supplementation significantly increased BW and decreased feed gain ratios and decreased the mortality. The Spirulina platensis offers a good alternative to improve poultry production.

Key words: prebiotic· Spirulina platensis · performance· broilers

Introduction

Antibiotics are used in the poultry industry to prevent disease so as to improve meat and egg production. However, the use of antibiotics in feed resulted in development of drug-resistant bacteria (Sorum and Sunde, 2001), drug residues in the body of the birds (Burgat, 1999) and imbalance of normal micro flora (Andreumont, 2000). In addition, the banded use of dietary antibiotics had driven the worldwide implantation of alternative strategies to prevent proliferation of pathogenic bacteria. As a consequence, it has become necessary to develop alternatives using either beneficial microorganisms or non-digestible ingredients that enhance microbial growth. A probiotic is a viable microbial dietary supplement that beneficially affects the host, either animal or man, through its effects in the intestinal tract (Fuller, 1989). The bacterial genera most often used as probiotics are lactobacilli and bifidobacteria although other groups are also represented (Patterson and Burkholder, 2003). The health-promoting effect of lactobacilli and bifidobacteria in the colon has been mainly associated with their capacity to stimulate the immune response and to inhibit the growth of pathogenic bacteria.

Prebiotics – are indigestible carbohydrates, which pass through small intestines and are broken down in the colon. Oligofructans and inulin are considered as the standard prebiotics. They are not digested in the human or animal small intestines, but are selectively fermented in the colon by bifidobacteria to short-chain fatty acids, which in turn reduce pH in the colon, create unfavorable conditions for development of pathogenic bacteria and facilitate resorption of minerals. Avian species cannot digest lactose because they lack of endogenous lactase, hence lactose present in the feed is being digested by intestine bacteria (Siddons and ECoates, 1972) In the course of these microbial processes more volatile fatty acids and lactic acid are released and more microbial proteins are produced (Hinton et al, 1990). Many studies have shown that, in contrast to other carbohydrates, lactose changes micro biota of large intestines by creating an acidic environment. Lower pH reduced the number of pathogenic bacteria, more ammonia is used for biosynthesis of microbial proteins and less gets into the blood (Chambers et al, 1997; Simoyi et al, 2006). It has been noticed that when lactose is used as prebiotic, the number of Lactobacillus reuteri bacteria increases and the number of Salmonella

bacteria in digestive tract of birds decreases (Corrier et al,1997). The most relevant health benefits attributed to the consumption of prebiotics are: immune stimulation, enhancement of the resistance to infectious diseases, alleviation of lactose intolerance, and improvement of serum lipids in hyperlipidemia, reduction of cholesterol and blood pressure, production of B-vitamins, and an increase in calcium and magnesium absorption. As a dietary supplement the fructans help prevent constipation and regulate passage time, thereby reducing the risk of colonic cancer.

Spirulina is a cyanobacterium that has been commercially cultivated for more than 10 years due to its high nutritional content: e.g. protein, amino acid, vitamin, minerals, essential fatty acid and b- carotene (Vonshak, 1997). Spirulina can be considered a nutritional supplement that has various health benefits for humans, and a feed supplement for animals having economic benefits. To date, there is a limited amount of data that could be used to improve the growth of the broiler performance. It has also been reported that Spirulina has health benefits in conditions such as diabetes mellitus and arthritis (Parikh,et al, 2001; Rasool et al,2006).

Bifidobacteria are characterized by antimicrobial, ant carcinogenic, ant allergic, and immune-stimulating effect. They also improve absorption of minerals, protect from diarrhea, and optimize nutrient digestion processes (Gružauskas et al, 2004).

Materials And Methods

Birds

Five hundred, one d-old male Hubbard broiler chicks were obtained from a local commercial hatchery. Chicks were vaccinated for Newcastle, infectious bronchitis, and Marek's disease at the hatchery as well as Avian Flu (H₅N₂) at age 9 days. Chicks were randomly allocated to 4 experimental treatments for 6 wk. Each treatment had 4 replicates of 30 broilers. Each replicate was assigned to a clean floor pen (2 x 2 m), and birds were raised on a wood shaving.

Dietary treatment

The 1st group was served as the control group and the 2nd, 3rd and 4th groups were experimental groups.

Prebiotic Bactocell[®] (obtained from Lallemand SAS in France) was added to combined feed of the 2nd group of chicks at a rate of 1 Kg product/ton of starter (1-14 day) and grower (15-42) feeds

Birds of the 3rd group were supplemented by the prebiotic Myco[®] at a rate of 1 Kg product/ton of starter (1-14 day) and grower (15-42) feeds.

Myco is a prebiotic composed of mannose oligosaccharides derived from the cell wall of the yeast *Saccharomyces cerevisia*. The preparation had been manufactured by Probyn international, USA.

Birds of the 4th group had *Spirulina platensis*, preserved added to their feed at a rate of 1 Kg /ton of starter(1-14 day) and grower(15-42) feeds *Microalgae Spirulina platensis*, preserved in a laboratory at Faculty of Agricultural and Life Sciences, Cairo University of Egypt, was used in this study. It was grown at 25 ± 20 °C in Zarrouk liquid medium (Parada et al., 1998), for 8-10 days under white fluorescent light (90 mmol photon m⁻²s⁻¹) with 14 h illumination. At the exponential growth phase, culture was filtered through filters 47 mm (diameter) (Whatman GF/C). The filter was put in a glass Petri dish in the oven at 35 °C for 3 days (Boussiba and Richmond, 1976).

Growth Performance Traits

All birds were weighed individually after their arrival from the hatchery to the experimental farm (initial weight) and on day 42. Daily weight gain for each dietary treatment was calculated. Feed consumption was recorded in the course of the whole experiment for each treatment, and the feed conversion rates were calculated subsequently

Organ Weights and Carcass Yield Percentages

At the end of experiment, after weighing, 10 birds per treatment were randomly selected and slaughtered. The proventriculus, gizzard, liver, thymus, cecum, and colon were excised and weighed. The gastrointestinal tract was weighed after removal of the content. Afterward, the birds were scalded, de-feathered, and carcasses were eviscerated. The head, neck, and feet were removed, and the carcass weight

was then determined, and the carcass yield percentage was calculated by dividing the carcass weight by the live BW of birds multiplied by 100.

Statistical analyses

Statistical analyses were conducted using analysis of variance on the SAS 6.0. Significance of differences between groups was determined using the Duncan test for post-hoc comparisons. Differences were considered significant if $P \leq 0.05$.

Results

Growth Performance

The initial BW of chicks did not differ between the dietary treatments (Table 1). At the end of the experiment (d 42), birds supplemented with *Spirulina platensis* had a greater body weight (2.279 ± 1.82) as compared with controls (2.322 ± 1.65 kg). Moreover, prebiotic (Lactose) and prebiotic (Myco) -supplemented birds had a greater body weight (2.279 ± 1.82 and 2.275 ± 2.16 respectively) than the control birds (Table 1).

Daily weight gain

The average daily weight gain (from d 1 to 42) increased for birds supplemented with *Spirulina platensis* (51.42 ± 0.49) compared with control birds (49.32 ± 0.52) and birds supplemented with prebiotic 1 (50.49 ± 0.41) and prebiotic 2 (50.65 ± 0.48). Furthermore, prebiotic 1 and prebiotic 2-supplemented birds had a slight greater daily weight gain than control birds (Table 1).

Effect of Feed Conversion Rate Mortality and carcass Percentage

Feed conversion rate (FCR) was lower for birds supplemented with *Spirulina platensis* (1.78) than control birds (1.88) and birds supplemented with prebiotic 1 (1.86) and prebiotic 2 (1.85). In addition, prebiotic, and prebiotic 2 -supplemented birds had a lower FCR than control birds (Table 2). The mortality rate was lower for the *Spirulina platensis* -supplemented group (2.5%) than both the prebiotic 1 and prebiotic 2-supplemented group (3.5% and 3%, respectively) compared to control group (4%).

The means of the carcass weight percentage relative to the BW for control group, prebiotic 1 and 2 as well as *Spirulina platensis* supplemented groups are recorded in Table 2.

The *Spirulina platensis* -supplemented group had a greater ($P < 0.05$) carcass percentage (64.87 ± 1.12 %) compared with the control group (61.10 ± 1.37 %) and prebiotic 1 and 2-supplemented group (61.40 ± 1.62 and 64.87 ± 1.12 , respectively), Table 2.

Effect of feed supplementations on absolute weights of organs

The means of the absolute weights of organs for dietary treatments are recorded in Table 3. The weight of proventriculus decreased for prebiotic 2 (8.1 ± 0.33) compared with the control group (8.4 ± 0.37 g) and other supplemented group (Table 4). The weight of caecum and colon were decreased for all supplemented groups compared with the control group. *Spirulina platensis* -supplemented group showed a decrease in liver weight (38.4 ± 1.4 g) compared with either the control group (44.3 ± 3.22 g) or other -supplemented groups (Table 4).

The weight of bursa was significantly higher in *Spirulina platensis* -supplemented group (4.9 ± 0.29 g) than in control group and the other-supplemented groups.

In addition, the weight of thymus was increased for all supplemented groups compared with the control group.

Discussion

The primary role of feed is not only to provide enough nutrients to fulfill metabolic requirements of the body but also to modulate various functions of the body. Probiotic and prebiotic are either beneficial microorganisms or substrates that facilitate the growth of these microorganisms, which can be suitably harnessed by the food manufacturers and hold considerable promise for the health care industry.

Various authors have noted that probiotics improve birds' growth parameters (Kralik et al, 2004; Torres-Rodriguez et al, 2007). Probiotic and prebiotic stimulate the immune system of an organism, increasing its protective capacity against pathogenic bacteria, as well as stimulating production of certain digestion

enzymes, vitamins and other biologically active substances, all of which affect organism's health via its digestive tract (Grajek et al, 2005).

Improvement in growth performance and feed efficiency of broiler chickens fed prebiotic (Cavazzoni et al, 1998 ; Jin et al,1998; Samli et al,2007) may be attributed to the total effects of their action including the maintenance of beneficial microbial population (Fuller, 1989), improving feed intake and digestion (Nahanshon, Nakaue et al,1992), and altering bacterial metabolism (Cole et al, 1987; LZ et al,1997). Avian species cannot digest lactose because they lack of endogenous lactase, hence lactose present in the feed is being digested by intestinal bacteria (Siddons and Ecoates, 1972). In the course of these microbial processes, more volatile fatty acids and lactic acid are released and more microbial proteins are produced (Hinton et al,1990). Many studies have shown that, in contrast to other carbohydrates, lactose changes micro biota of large intestines by creating an acidic environment. Lower pH reduced the number of pathogenic bacteria, more ammonia is used for biosynthesis of microbial proteins and less gets into the blood (Chambers et al, 1997; Simoyi et al, 2006). It has been noticed that when lactose is used as prebiotic, the number of *Lactobacillus reuteri* bacteria in increases and the number of *Salmonella* bacteria in digestive tract of birds decreases (Corrier et al, 1997).

Prebiotics play an important role in formation of stable intestine micro flora and affect both health and development of the intestine. Intestine micro flora plays an important role in feed digestion and conversion. Use of prebiotics in poorer industrial bird production conditions or for weaker bird groups may produce higher productivity effect (Torres-Rodriguez et al, 2007). In the present study, the beneficial effects of two prebiotics (Myco and lactose) preparations on broiler performance parameters including average daily BW gain, FCR, and BW are in agreement with previous studies (Cavazzoni et al,1998; Jin et al,1998; Zulkifli et al,2000; Kabir, et al,2004; Mountzouris et al,2007; Samli et al,2007) However, *Spirulina platensis* dried-supplement displayed a greater growth-promoting effect and increased the carcass yield percentage. In addition, there was a highly significant difference in the carcass yield (3.77 %) compared to control group.

S. platensis dried-supplement has an excellent nutritional profile (high carotenoids, high protein with includes all of the essential amino acids and rich in minerals and vitamins (Bourges et al,1971; Anusuya et al,1981; Brune,1982; Ross and Dominy ,1985 ; Ross and Dominy 1990). *Spirulina* has been shown to enhance immune function, reproduction and growth, as reported by (Qureshi et al, 1994) and (Khan et al,2005) Feeding *Spirulina* containing diets may increase the *Lactobacillus* population and enhance the absorbability of dietary vitamins (Tokai et al,1987; Mariey et al,2012).

Table 1. Effect of feed supplementations on BW (g) and daily weight gain (g), of the experimental birds¹

Parameter	Dietary treatment				
	Control		Prebiotic Lactose (1)	Prebiotic Myco(2)	S. platensis
Initial B WT(g)	42.6± 1.1		42.7± 0.76	42.9± 1.74	42.2± 0.97
Weight at d 42 (kg)	2.19 ± 1.65 ^e		2.279± 1.82 ^d	2.275± 2.16 ^d	2.322±1.82 ^b
Daily weight gain (g)	49.32± 0.52		50.49± 0.41	50.65± 0.48	51.42± 0.49

^{a,b} Means with different superscripts within the same row differ significantly ($P \leq 0.05$).

Table 2. Effect of feed supplementations on FCR and mortality and carcass percentage of the experimental birds

Parameter	Dietary treatment				
	Control		Prebiotic (Lactose)	Prebiotic (Myco)	S. platensis
FCR	1.88		1.86	1.85	1.78
Mortality %	4.5		3.5	3	25
Carcass percentage	61.10 ±1.37 ^c		61.40± 1.62 ^c	61.9± 0.77 ^c	64.87± 1.12 ^b

^{a,b} Means with different superscripts within the same row differ significantly ($P \leq 0.05$).

Table 3 . Effect of feed supplementations on absolute organ weights (g) of broiler chickens (n=10) Dietary treatment

Organ	Control	Prebiotic Lactose (1)	Prebiotic Myco (2)	S. platensis
Proventriculus	8.4 ± 0.37 c	8.2 ± 0.33 c	8.1 ± 0.33 b	8.3 ± 0.32 c
Gizzard	44 ± 3.43 c	42.9 ± 4.2 c	42.5 ± 3.47 b	41.8 ± 2 b
Liver	44.3 ± 3.22 c	44.1 ± 2.47 c	43.7 ± 3.24 c	38.4 ± 1.4 b
Cecum and Colon	10.8 ± 0.27 b	10.8 ± 0.52 b	10.9 ± 0.49 b	11.1 ± 0.62 b
Bursa	4.6 ± 0.48 ^{ab}	4.8 ± 0.62 ^b	4.8 ± 0.69 ^b	4.9 ± 0.29 ^a
Thymus	9.6 ± 0.6 ^{ab}	11.4 ± 0.43 ^a	11.4 ± 0.43 ^a	11.4 ± 0.43 ^a

^{a,b} Means with different superscripts within the same row differ significantly ($P \leq 0.05$).

Conclusion

Under the influence of the prebiotic lactose broilers body weight was higher by 3.80% percent period and the FCR was improved by 1.1%.

Under the influence of the prebiotic MYCO broilers body weight was higher by 3.6% percent and the FCR was improved by 1.6 %.

Under the influence of *Spirulina platensis* -supplemented body weight was higher by 6% percent and the FCR was improved by 6.3 %.

In conclusion, *Spirulina platensis* may be used as a supplement at 1kg\tone feed for broiler chicks.

References

- Andreumont A. 2000. Consequences of antibiotic therapy to the intestinal ecosystem. *Ann. Fr. Anesth. Reanim.* 19: pp.395–402.
- Anusuya DM, Subbulakshimi G, Madhavi Devi K, Venkataram LV. 1981. Studies on the proteins of mass-cultivated, blue-green alga (*Spirulina platensis*). *J. Agric. Food Chem.*, 29: pp.522-525.
- Bourges H, Sotomayor A, Mendoza E, Chavez A. 1971. Utilization of the algae *Spirulina* as a protein source. *Nutr. Rep. Int.*, 4: pp.31-43.
- Boussiba and Richmond. 1976. cited in *The growth and functioning of leaves* Edited by J.E.Dale and F.L.Milthorpe. 1st ed. 1983. Cambridge University Press.
- Brune H. 1982. Zur verträglichkeit der einzelleralgen *Spirulina maxima* und *Scenedesmus acutus* als alleinige eiweissquelle für broiler. *Z. Tierphysiol. Tierernähr. Futtermittelkd.* 48: pp.143-154 (Abstract.).
- Burgat V. 1999. Residues of drugs of veterinary use in food. *Rev. Prat.* 41: pp.985–990.
- Cavazzoni V, A Adami, C Cstrivilli. 1998. Performance of broiler chickens supplemented with *Bacillus coagulans* as probiotic. *Br. Poult. Sci.* 39: pp.526–529.
- Chambers JR, JL Spencer, HW Modler. 1997. The Influence of complex carbohydrates on *Salmonella typhimurium* colonization, pH and density of broiler ceca. *Poultry Science.* Vol 76. pp. 445-451.
- Cole C B, R, Fuller, M J, Newport. 1987. The effect of diluted yogurt on the gut microbiology and growth of piglets. *Food Microbiol.* 4: pp.83–85.
- Corrier DE, DJ Nisbet, MB Hargis, PS Holt, JD DeLoach. 1997. Provision of lactose to molting hens enhances resistance to *Salmonella enteritidis* colonization. *Journal of Food Protection.* Vol. 60. pp. 10-15.
- Fuller R. 1989. Probiotic in man and animal *J. Appl Bacteriol.* 66: pp.365–378.
- Grajek W, A Olejnik, A Sip. 2005. Probiotics, prebiotics and antioxidants as functional foods// *Acta Biochimica Polonica* . Vol. 52. pp. 665-677.
- Gružauskas R, R Lekavičius, A Racevičiūtė-Stupelienė, V Šašytė, V Tėvelis, GJ Švirmickas. 2004. Viščiukų broilerių virškinimo procesų optimizavimas simbiotiniais preparatais. *Veterinarija ir zootechnika* . T. 28(50). pp. 51-56.
- Hinton A J, DE Corrier, GE Spates, J O Norman, R L Ziprin, RC Beir, JR DeLoach. .1990. Biological control of *Salmonella typhimurium* in young chickens. *Avian Diseases* Vol. 34. pp. 626-633.
- Jin L Z, Y W Ho, N Abdullah, S Jalaludin. 1998. Growth performance, intestinal microbial populations and serum cholesterol of broilers fed diets containing *Lactobacillus* cultures. *Poult. Sci.* 77: pp.1259–1265.
- Kabir S M L, MM Rahman, MB Rahman, SU Ahmed. 2004. The dynamics of probiotics on growth performance and immune response in broilers. *Int. J. Poult. Sci.* 3: pp.361–364.
- Khan M, Shobha JC, Mohan IK, Naidu MUR, Sundaram C, Singh PK, Kutala VK. 2005. "Protective effect of *Spirulina* against doxorubicin-induced cardiotoxicity" *Phytotherapy Research.* 19(12): pp.1030-7.
- Kralik G, S Milakovic, S Ivakovic. 2004. Effect of probiotic supplementation on the performance and the composition of the intestinal microflora in broilers // *Acta Agraria Kaposvaiensis* . Vol. 8. pp. 23-31.
- LZ Y, W Ho, N Abdullah, S Jalaludin. 1997. Probiotics in poultry: Modes of action. *World's Poult. Sci. J.* 53: pp.422–368.
- Mariey YA, HR Samak, MA Ibrahim. 2012. Effect of using *Spirulina platensis* algae as a feed additive for poultry diets: 1- productive and reproductive performances of local laying hens. *Egypt. Poult. Sci.* Vol (32) (D): pp. 201-215.
- Mountzouris K C, P Tsistsikos, E Kalamara, S Nitsh, G Schatzmayr, K Fegeros. 2007. Evaluation of the efficacy of a probiotic containing *Lactobacillus*, *Bifidobacterium*, *Enterococcus*, and *Pediococcus* strains in promoting broiler performance and modulating cecal microflora composition and metabolic activities. *Poult. Sci.* 86: pp.309–317.
- Nahanshon S N, HS Nakaue, L W Mirosh. 1992. Effects of direct fed microbials on nutrient retention and parameters of laying pullets. *Poult. Sci.* 71(Suppl. 1):111. (Abstract.)

- Parikh P, Mani, Iyer U.2001. Role of spirulina in the control of glycaemia and lipidaemia in type 1 diabetes mellitus. J. Med. Food, 4: pp.193-199.
- Patterson , J A and K M Burkholder. 2003. Application of prebiotics and probiotics in poultry production. Poult. Sci. 82: pp.627–63
- Qureshi MA, Garlich D,Kidd MT, Ali RA.1994. Immune enhancement potential of Spirulina platensis in chickens. Poultry Science, pp. 73: 46.
- Rasool M, Sabina EP, Lavanya B.2006. Anti-inflammatory effect of Spirulina fusiformis on adjuvant-induced arthritis in mice. Biol. Pharm. Bull., 29: pp.2483-2487.
- Ross E, Dominy W.1985. The effect of dehydrated Spirulina platensis on poultry. Poultry Sci., 64(S.1): pp.173.
- Ross E , Dominy W.1990. The nutritional value of dehydrated, blue-green algae (Spirulina platensis) for poultry. Poultry Science, 69: pp.794-800.
- Rutter WJ, P Krocjevsky , HM Scott, RG Hansen.1953.The metabolism of lactose and galactose in the chick. Poultry Science. Vol. 32. pp. 706-715
- Samli H E, N Senkoylu, F Koc, M Kanter, A Agma.2007. Effects of Enterococcus faecium and dried whey on broiler performance, gut histomorphology and microbiota. Arch. Anim. Nutr. 61: pp.42–49.
- Siddons R C, M,Ecoates. 1972.The influence of intestinal microflora on dissacharidase activities in the chick. British Journal of Nutrition. Vol 27. pp. 101-112.
- Simoyi MF, M Milimu, R W Russell, R A Paterson, PB Kenney. 2006. Effect of dietary lactose on the productive performance of young broiler. Poultry Science Association The Journal of Applied Poultry Research. pp. 20-27
- Sorum H and M, Sunde . 2001. Resistance to antibiotics in the normal flora of animals. Vet. Res. 32: pp.227–241.
- Tokai Y, et al.1987. Effects of spirulina on caecum content in rats. Chiba Hygiene College Bulletin, 5 (2). Japan.
- Torres-Rodriguez A, AM Donoghue ,DJ Donoghue, JT Barton, G Tellez, BM Hargis. 2007 Performance and condemnation rate analysis of commercial turkey flocks treated with a Lactobacillus spp.-based probiotic. Poultry Science.. Vol. 86 (3). pp. 444-446.
- Vonshak A.1997. Appendics: Spirulina platensis (Arthrospira): Physiology cell-biology and biotechnology. Taylor and Francis Ltd., London, pp. 214.
- Zulkifli I, N Abdullah ,NM Azrin, YW Ho. 2000. Growth performance and immune response of two commercial broiler strains fed diets containing Lactobacillus cultures and oxytetracycline under heat stress conditions. Br. Poult. Sci. 41: pp.593–597.