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Effect of dietary incorporation of *Spirulina platensis* on the growth performance, carcass characteristics and meat quality in broilers.

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ABSTRACT

This study was conducted to evaluate the effect of *Spirulina platensis* on growth performance, physiochemical properties of meat, carcass characteristics and breast meat quality in broilers. A total of 144-day old commercial broiler chicks were randomly divided into 3 dietary treatments with 4 replicates having 12 birds per replicate and reared for a period of 6 weeks. The dietary treatments were 0 (T_1), 1(T_2) and 2(T_3) % spirulina inclusion in rations. Significantly (P<0.01) higher body weight gain, feed intake and better feed conversion ratio was observed in T_1 and T_2 when compared to T_3. However, no differences (P>0.05) were observed in production parameters between T_1 and T_2. The meat quality parameters *viz.,* crude protein, redness (a*) and yellowness (b*) were significantly (P<0.05) higher in T_2 compared to T_1. However, no significant difference was observed in yellowness of meat between T_2 and T_3 and T_1 and T_3. Microbial analysis of meat indicates that total plate count (TPC), psychrophiles, yeast and moulds in meat was decreased (P<0.05) linearly as the level of spirulina increased from 0 % (T_1) to 2% (T3). Sensory attributes like tenderness, juiciness and overall acceptability were significantly (P<0.05) higher in T_2 and T_3 compared to T_1. Carcass traits revealed that significantly (P<0.05) higher skin weight was observed in T_1 compared to other treatments. However, no significant difference was observed in other parameters like carcass weight, breast weight and carcass percentage among the treatments. The results indicates that supplementation of spirulina in broiler diets up to 1% level improved the growth performance, increased meat colour, quality and overall acceptability. Hence, it can be concluded that spirulina powder can be fed up to 1 per cent level in broiler diets to improve the production and meat quality.

Key words: Spirulina, Body weight gain, Psychrophiles, Crude protein, meat colour

INTRODUCTION

Poultry is an important source of animal protein, as it is considered an essential and effective pillar in filling an important part of the human nutritional needs. As the poultry industry is growing continuously, to improve the performance of poultry and to control the diseases, antibiotics feed additives have been widely used (Gaskin *et al.,* 2002). However, due to ban on antibiotic growth promotors to reduce the antibiotic residues in poultry meat and also consumer preference towards the functional foods, researchers have increased attention for production of meat enriched with functional nutrients and quality meat for better storage stability (El-bhar *et al.,* 2020).

Nutritional quality of the meat depends up on the nutrient composition of feed offered and rearing conditions. Lipid is peroxidation is a primary cause of quality deterioration of meat products, results in undesirable odours and flavours which lowers the sensory attributes and nutritional quality of meat (Sharmin *et al.,* 2022). Hence, there is need to increase the antioxidant capacity of meat by adding feed additives in the diet as these antioxidants have great potential to maintain the meat quality by protecting the cells against the oxidative damage (Descalzo *et al.,* 2008) and also improve the performance (Park *et al.,* 2018).

There are several naturally available phytogenic feed additives are being used in poultry to improve the performance due to their antioxidant, anti-inflammatory and antibacterial activities (Kang *et al.,* 2019). For the past few years, *Spirulina platensis* a marine microalgae have been using as feed additive to improve the performance as it is a good source of high quality proteins (55-65%), rich in vitamins, minerals, pigments (carotene and xanthophylls), essential amino acids, fatty acids and poly unsaturated fatty acids (Juventino *et al.,* 20012; Farag *et al.*, 2016 and Park *et al.,* 2018). Spirulina have potent antioxidant activity, antiviral, antimicrobial, anti-inflammatory and hypolipidemic activity (Moustafa *et al.,* 2021), reduce the heat stress (Mirzaie *et al.,* 2018) and improve the performance (Sugiharto *et al.,* 2018 and Khan *et al.,* 2020) and meat quality (Park *et al.,* 2018). However, very scanty information is available regarding level of inclusion of Spirulina and its effects on meat quality in broilers. Therefore, the present study was designed to evaluate the dietary supplementation of *Spirulina platensis* on growth performance, meat composition, meat quality and carcass characteristics in broilers.

MATERIALS AND METHODS

A total of 144 day old commercial broiler chicks were randomly allocated to 3 dietary treatments with four replicates having 12 birds in each replicate. The birds were fed with basal diet (control – T_1), diet containing 1 (T2) and 2 (T_3) per cent spirulina. All the chicks were reared in a deep litter system with proper floor space and good ventilation system. The experiment was conducted for six weeks and were fed with rations as per ICAR (2013) specifications. *Spirulina platensis* required for the experiment was cultivated in Department of Animal Nutrition, College of Veterinary Science, Tirupati where, algae culture incubated in two ponds with paddle wheels under sun light. The collected Spirulina was dried under sun light and made into powder form for the preparation of experimental diets. Ingredient composition of experimental diets fed to broilers during finisher stage is presented in table 1.

Table 1: Ingredient composition of experimental rations fed to broilers during finisher stage

Ingredient	T_1	T_2	T_3
Maize	58	58.5	59
Soybean meal	33.1	31.6	30.1
Spirulina	0	1	2
Palm oil	5	5	5
DCP	1.6	1.6	1.6
Calcite	1.35	1.35	1.35
DL-Methionine	0.22	0.21	0.21
L-Lysine	0.13	0.14	0.14
Premix	0.1	0.1	0.1
Salt	0.3	0.3	0.3
Liver tonic	0.05	0.05	0.05
Choline chloride	0.1	0.1	0.1
Toxin binder	0.05	0.05	0.05

Growth performance

All the birds were weighed individually on day old and weekly interval during the experimental period (6 weeks). Total feed offered was recorded daily and left over feed was recorded weekly in each replicate to arrive the feed intake in each replicate. Feed conversion ratio (FCR) was calculated based on the feed intake and body weight gain during the experimental period.

Carcass characteristics

At the end of the experimental period, two birds from each replicate total of eight birds were randomly selected, weighed and slaughtered. Individual weights of eviscerated carcass were recorded, the prime cuts, giblets were collected and weighed and carcass per centage was calculated.

The meat samples were analysed for various physico-chemical parameters like Proximate composition (AOAC, 2016), Texture profile analysis (Bourne, 1978). The sensory attributes like appearance, texture, flavour, juiciness and tenderness and overall acceptability were evaluated by using an 8 point hedonic scale (Keeton,1983). For sensory evaluation, breast meat samples were marinated with 1 % salt and 0.1% turmeric powder for 10 min and then pressure cooked in 10 % water for 10 min.

The data was subjected to statistical analysis *i.e* one way ANOVA and means between the treatment groups were compared by using Duncan multiple range test using SPSS version 22. (Snedecor and Cochran, 1995)

RESULTS AND DISCUSSION

Effect of feeding spirulina on growth performance

Effect of dietary supplementation of spirulina on performance of broilers was presented in table 2. Results indicated that body weight gain, feed conversion ratio was significantly (P<0.01) higher in T_1 and T_2 than T_3. However no significant difference was observed between T_1 and T_2. But, numerically higher body weight gain and better feed conversion ratio was observed in T_2. In accordance with present study, Shanmugapriya *et al.* (2015) and Park *et al.* (2018) observed significantly (P<0.01) higher body weight gain in broilers fed with spirulina at graded levels up to 1% and further increase levels of spirulina negative effects were observed. Similarly, spirulina supplementation also improved the performance of heat stressed broilers (Mirzaie *et al.,* 2018 and Moustafa *et al.* 2021). In contrast to present findings, Sugiharto *et al.* (2018) observed no significant difference in body weight gain and feed conversion ratio of broilers fed with 1 % spirulina compared to control.

Increased body weight gain and better feed conversion ratio in T_2 might be due to bio active compounds in spirulina improves the antimicrobial, antioxidant and anti-inflammatory properties (Becker *et al.,* 2007 and Maoka, 2011) and better amino acid composition of spirulina than vegetable proteins (Park *et al.,* 2018). However, as the levels of spirulina increased in T_3 resulted in growth retardation could be due to spirulina cell wall is unable to break completely by endogenous digestive enzymes (Pestana *et al.* 2020) there by most of the proteins present in spirulina is unable to digest completely by digestive enzymes which contributes to lowers the amino acid digestibility, increased gelation of proteins, digesta viscosity (Evans *et al.* 2015) and most of the nutrients are trapped in viscous digesta there by reducing the nutrient absorption.

Table 2. Effect of dietary supplementation of spirulina on growth performance in broilers

Parameter	T_1	T_2	T_3
Initial body weight (g)	44.07 ± 0.41	44.45 ± 0.27	44.51± 0.39
Final body weight** (g)	2367^b± 35.42	2449^b ±16.67	2243^a ± 30.91
Body weight gain** (g)	2322^b± 35.68	2405^b ±16.67	2198^a ± 30.95
ADG** (g/d)	55.31^b ± 0.89	57.26^b ± 0.40	52.35^a ± 0.74
Total feed intake** (g)	4315^b ± 30.41	4372^b ± 25.70	4221^a ± 19.11
Feed conversion ratio**	1.86^a ± 0.02	1.82^a ± 0.01	1.92^b ± 0.02

ADG: Average daily gain, means bearing different superscripts in a same row differ significantly. ** P<0.01

Effect of feeding spirulina on physico-chemical and microbial quality of meat

Feeding of Spirulina in broilers had no significant effect on Proximate composition of breast muscle. However, non-significantly lower fat content and higher (P>0.05) meat protein was observed in spirulina supplemented groups (T_2 and T_3) compared to control (T1). Increased protein content in broiler meat of T_2 and T_3 might be due to better amino acid profile of spirulina compared to other plant feed based protein supplements. The positive impact of spirulina on meat quality could be due to improvement in energy partitioning in favour of muscle development (Moustafa *et al.,* 2021)

Meat colour is one of the important attributes used by consumers to assess the quality of meat. Pigmentation of breast and thigh muscles revealed that, redness (a*) and yellowness (b*) significantly (P<0.05) higher in T2 when compared to other treatments. In accordance with present study, Altmann *et al.* (2020) and Moustafa *et al.* (2021) also observed higher a* and b* values in broilers fed with spirulina than control group. Increase in the yellowness and redness in spirulina supplemented groups could be attributed to its high carotenoid content (Moustafa *et al* 2021., and El-desoky *et al.,* 2013) which is further strengthened by Pestana *et al.,* (2020) who reported higher yellowness, total carotenoid and chlorophyll content in breast and thigh muscles of broilers fed with 15% spirulina in rations.

Microbial evaluation of broiler meat indicates that total plate count (TPC), Psychrophiles and yeast and mould count were decreased linearly (P<0.05) from T_1 to T_3 and was lower values were observed in T_3. Similarly, decrease in coliform count in gut of broilers were observed by Shanmugha Priya *et al.* (2015) and Sugiharto *et al.* (2018) by including Spirulina at 1% levels in diets. Decreased microbial load in T_2 and T_3 could be attributed to antimicrobial compounds present in spirulina *viz.,* c-phacocyanin, gamma linolic acid, lauric acid and palmitoleic acid (El-Sheekh *et al.,* 2014) which decrease the microbial load in body and increases the shelf life of meat.

Table 3: Effect of Spirulina supplementation on physico-chemical and microbial quality of meat

Parameter	T_1	T_2	T_3
Meat composition of breast muscle			
Moisture (%)	73.03 ± 0.81	73.70 ±0.64	74.03 ±0.93
Crude Protein (%)	22.33^{a} ± 0.36	23.61^{b} ± 0.34	23.18^{ab} ± 0.32
Crude Fat (%)	3.97 ± 0.32	3.34 ± 0.30	3.65 ± 0.21
Total ash (%)	1.97 ± 0.07	1.83 ± 0.07	1.91 ± 0.12
Meat colour			
Lightness (L)	56.37 ± 0.35	56.88 ± 0.43	57.01 ± 0.49
Redness* (a)	6.86^{a} ± 0.12	8.95^{c} ± 0.32	7.80^{b} ± 0.15
Yellowness* (b)	16.24^{a} ± 0.30	18.74^{b} ± 0.67	17.47^{ab} ± 0.4
Microbial quality			
TPC*	1.90^{c}±0.009	1.54^{b}±0.01	1.25^{a}±0.01
Psychrophiles*	1.65^{c}±0.01	1.25^{b}±0.008	1.14^{a}±0.007
Yeast and Mould*	1.54^{c}±0.01	1.23^{b}±0.01	1.14^{a}±0.009

means bearing different superscripts in a same row differ significantly. * P<0.05

Effect of feeding spirulina on texture profile and sensory attributes of broiler meat

Texture profile indicates that there was no significant difference in hardness, cohesiveness, springiness, chewiness and gumminess among the treatments. Non significantly (P>0.05) higher hardness was observed in T_2 compared to other groups.

The Sensory evaluation of breast muscles was summarised in table 4. Dietary incorporation of Spirulina had no influence on appearance and flavour, but the meat tenderness, juiciness and overall acceptability were higher (P<0.05) in spirulina supplemented groups (T_2 and T_3) than control group (T_1). These are corroborated with findings of Alfaia *et al.* (2021) who observed increased tenderness in broilers fed with microalgae compared to control. Increased tenderness in spirulina fed group could be attributed to the increased muscle protein and low fat content in meat. However, Abbas *et al.* (2021) observed that feeding of spirulina at 1 to 4 % level in broiler diet did not affect sensory attributes. Absence of off-flavours and increased over all acceptability in meat of birds fed with spirulina indicates that sensory attributes are not affected by addition of spirulina to broiler diets. Hence, spirulina can be safely fed to broilers to increase the functional properties.

Table 4: Effect of Spirulina supplementation on texture profile and sensory attributes of meat

Parameter	T_1	T_2	T_3
Texture profile			
Hardness	756.26±32.91	800.19±39.84	720.66±28.1
Cohesiveness	0.83±0.19	0.62±0.05	0.61±0.08
Springiness	0.99±0.06	1.13±0.14	1.00±0.09
Chewiness	328.21±37.56	329.61±28.98	316.51±26.93
Gumminess	465.59±46.81	467.41±19.98	460.64±19.09
Sensory attributes			
Appearance	6.67±0.211	6.83±0.167	6.83±0.167
Tenderness *	5.83^{a}±0.16	6.67^{b}±0.21	6.83^{b}±0.16
Flavour	6.67±0.21	6.83±0.16	6.50±0.22
Juiciness*	5.67^{a}±0.21	6.83^{b}±0.16	6.50^{b}±0.22
Overall acceptability*	5.67^{a}±0.21	6.83^{b}±0.16	6.5^{b}±0.22

means bearing different superscripts in a same row differ significantly. * P<0.05

Carcass characteristics

Carcass characteristics revelated that spirulina supplementation did not influence the carcass weight, giblets, breast, thigh weight and dressing percentage. Skin yield was significantly (P<0.05) higher in T_1 compared to T_2 and T_3. These results are in agreement with the findings of Sugiharto *et al.* (2018). In contrast to the present study, significant increase in carcass percentage in broilers fed with spirulina was observed by Kaoud (2012) and Mariey *et al,* (2014). Lower skin weight in spirulina supplemented groups could be due to lower subcutaneous fat accumulation as a result of its bioactive compounds.

Table 5: Effect of dietary Spirulina supplementation on carcass characteristics in broilers

	T_1	T_2	T_3
Live body weight (kg)	2.56 ± 0.02	2.67 ± 0.09	2.46 ± 0.08
Weight after defeathering(kg)	2.28 ±0.02	2.37 ± 0.08	2.17 ±0.07
Hot carcass weight (kg)	1.66 ± 0.01	1.78 ± 0.07	1.58 ± 0.06
Giblets weight (g)	130 ± 4.02	132 ± 5.56	122 ± 4.38
Breast weight (g)	595 ± 29.7	640 ± 32.24	551 ±34.96
Thigh weight (g)	475 ±14.3	506 ± 13.3	477 ± 18.2
Skin weight* (g)	176^{b} ± 6.4	155^{a} ± 5.3	150^{a} ± 5.7
Carcass yield (%)	64.85 ± 0.60	66.74 ± 0.96	64.22 ± 0.92

Each value is mean of eight observations means bearing different superscripts in a same row differ significantly. * P<0.05

CONCLUSION

The present study indicates that feeding spirulina up to 1% level in broilers increased the body weight gain, feed intake and feed conversion ratio. As the level of spirulina increased to 2 % decreased the performance of broilers. Meat of broilers indicates higher protein, low fat, better meat colour and lower microbial count compare to non-supplemented group indicating that spirulina addition improved the meat quality due to its functional components. Hence, it can be concluded that spirulina can be fed up to 1 % level in broilers improve the performance and meat quality.

CONFLICT OF INTEREST

The authors do not have any competing interests among themselves or others related to this research work.

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