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RESEARCH ARTICLE

Evaluation of Potential Effects of Locally Isolated *Streptomyces* Species as Growth Promoter in Commercial Broilers

Bakhtawar Maqbool[1*], Muhammad Ashraf[1**], Shazia Khaliq[2], Sajjad-Ur-Rahman[1] and Khurram Ashfaq[3]

[1]Institute of Microbiology, Faculty of Veterinary Science, University of Agriculture, Faisalabad, Pakistan.
[2]Industrial Biotechnology Division, National Institute for Biotechnology and Genetic Engineering (NIBGE), Constituent College of Pakistan Institute of Engineering and Applied Sciences (PIEAS), Faisalabad, Pakistan.
[3]Department of Clinical Medicine and Surgery, Faculty of Veterinary Science, University of Agriculture, Faisalabad, Pakistan.
*Corresponding author: *bakhtawardogar@yahoo.com (BM); **mashraf@uaf.edu.pk (MA)

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A B S T R A C T

In this study, local soil samples were collected for the isolation of *Streptomyces.* Molecular characterization and gene sequencing of 16S rRNA was done for identification of *Streptomyces* species which has been used in this study as a probiotic in feed. To evaluate their potential and efficacy as a probiotic in-Vivo, day old broiler chicks (total 140) were purchased from local hatchery and acclimatized for seven days and then divided in 07 experimental groups having 20 birds in each entitled as Group A, B, C, D, E, F and G, where group A served as control and all other were supplemented with feed having *streptomyces* as a supplement (probiotics). Various species of the streptomyces including *Streptomyces globiosporus*, *Streptomyces toxitricin*, *Streptomyces* WSN2, *Streptomyces rochie* and *Streptomyces fimbritus* to group B, C, D and E, respectively. Group G was treated with commercially available growth promoter (Greig® BS). Parameters including physiological (feed intake, weight gain, organ weight) and immunological parameters (carbon clearance assay, Lymphoproliferative response to avian tuberculin) of the birds were evaluated, thoroughly. The data thus obtained was subjected to the M-stat C software for statistical analysis. Significant additive effect on the broiler's performance in all treatment groups those received probiotic was observed as compared to the control in terms of physiological and immunological parameters. The birds supplemented with *Streptomyces globiosporus* revealed the better growth and improved feed intake as compared to all other tested species. Hence, it has been concluded that these local isolates of the streptomyces have potential to be promoted as the probiotic in the poultry feed which will be more economical and profitable to the farmers.

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INTRODUCTION

Microorganisms are present all around the environment and responsible for many diseases and has been characterized as bacteria, virus, fungi, and some parasites. Mostly microorganisms considered to be the major source of viral and bacterial infections in human as well as in animals, most prominently in poultry birds (Rashad *et al*., 2015). The secondary metabolites produced from different microorganisms exhibiting antibacterial, antiviral, antiprotozoal, antifungal and antitumor activities are called antibiotics. The antibiotics are most interesting and important group of natural products. Antibiotics are defined as secondary metabolites which facilitate regulation of different physiological processes including growth, replications and responding actions in prokaryotic and eukaryotic cells in minimum concentrations (Lee *et al*., 2019). While the living microorganisms including the bacteria and yeast are called probiotics and most commonly used species are *Lactobacillus* and *Bifidobacterium* due to their potential immune-stimulatory and more feed digestibility effects and being used to control diseases in birds and animals (Khater *et al.,* 2020*;* Bhogoju *et al.,* 2021; Coniglio *et al.,* 2023).

In poultry industry, the most important concern is to control the infectious enteric diseases because these diseases result in higher mortality, lower production and posing a serious public health concern due to the

contamination of meat and eggs. To control infectious diseases, different types of antibiotics has been used since long those are responsible for antibiotic resistance in poultry as well as in humans (Trafalska and Grzybowska 2004; Gul and Alsayeqh, 2022; Gul and Alsayeqh, 2023). Another irrational use of antibiotics in poultry industry is as growth promoter alongwith treatment of infectious however, such irrational use of antibiotics has been responsible for the creation of superbugs/antibiotic resistance microbes. Use of antibiotic-growth-promoters in animals affect the human health either directly by antibiotic residues in eggs and meat or indirectly by the spread of antibiotic resistant determinants to human pathogens (Gonzalez and Angeles, 2017; Gul and Alsayeqh, 2022; Coniglio *et al.,* 2023). In addition, consumption of antibiotics as growth promotors also has the bactericidal activity against beneficial bacteria residing in the gut. It has been documented that the frequency of resistant determinants in commensal bacteria is a major cause of development of resistance in pathogenic bacteria (Sarmah *et al*., 2006; Gul and Alsayeqh, 2023; Coniglio *et al.,* 2023).

Streptomyces species including *Streptomyces griseus* and *Streptomyces coelicolor* are being used for the industrial production of antibiotic, however, the most widely used species is *Streptomyces coelicolor* which has been recognized as a workhouse for genetic and a model for antibiotic development and production (Willemse *et al*., 2011). Various methods are being used for the detection and isolation of antibiotics from *Streptomyces* species (Harir *et al*., 2018). These antibiotics have made significant contribution in the preventive and therapeutic options for infectious diseases, enhancement of productivity in animals, improvement of atmosphere and protection of human health (Nikaido, 2009).

Streptomyces species isolated from animal sources can efficiently adapt to the gastric environment of animals. It has been documented that that *Streptomyces* species isolated from chicken faeces have shown resistance at pH 2.3mg/ml pepsin, 1mg/ml pancreatin and 0.3% bile (Latha *et al.* 2015). Due to the spore forming capacity of *Streptomyces* species with high tolerance for bile acids, *streptomyces* are considered promising alternative bacteria for their use as probiotic than non-spore forming bacteria (Das *et al*., 2010). It has been documented in previous researches that probiotic *Streptomyces* are able to regulate the microflora of aquatic environment and also play an important role in reducing ammonia level and increasing the heterotrophic bacteria in aquaculture (Devaraja *et al*., 2002). The increased level of nitrite and ammonia in ponds or lakes causes the accumulation of microbes and decomposition of residual feed that adversely affect the health of aquatic organisms (Das *et al*., 2006, 2010; Aftabuddin *et al*., 2013).

Keeping in view, global trends in terms of antimicrobial resistance (AMR), there is a dire need to explore the alternatives to antibiotics that may assure the safety and economic viability in poultry production not only in developing countries but also in developed world. Hence the present project was designed to evaluate the beneficial effects of *Streptomyces* species, isolated from local soil samples, as a probiotic on growth and immune system of commercial broilers.

MATERIALS AND METHODS

Isolation and identification of streptomyces from soil samples: Soil samples were collected from diverse habitats including rhizosphere of plants and agricultural soil located in Faisalabad, Pakistan. These soil samples were collected from different depths of the earth surface, ranging from layers just below the upper surface to 20cm deep in sterile plastic tubes and were properly labelled. The collected soil samples were dried in oven at 40-50°C for 2 hours, cooled to room temperature and stored at 4°C. After that 1gm of each soil sample was added to a conical flask containing 100 ml of sterile water. All flasks were kept in orbital shaker incubator at 30°C for 1-2 hours. These flasks were kept as source of stock cultures.

Experimental plan: For this project, forty-five days experiment trail was conducted at the experimental sheds of Institute of Microbiology, University of Agriculture Faisalabad, Pakistan. Before the arrival of chicks, shed was thoroughly cleaned, disinfected and fumigated to avoid any contamination from the previous flock.

Day-old commercial broiler chicks were purchased from the local hatchery. Recommended requisites for commercial broiler poultry farming were followed and after acclimatization of 7 days, the birds were divided into 07 groups, 20 birds in each. Different *Streptomyces* species along with a commercially available probiotic were supplemented as treatment to these birds and one group was kept as control, that was given basal feed only. As mentioned in the Table 1. Liquid preparations of *Streptomyces* species (@ 1 x 10^9 cfu/ml/g of feed) were mixed with balanced formulated broiler feed, and was offered to the birds *ad libitum*. During this trial, all the birds were properly vaccinated against different infectious diseases as per standard protocol mentioned for broilers in Pakistan.

Physiological and immunological parameters evaluation: Different physiological parameters were recorded including Morbidity and Mortality, Body weight on weekly basis and feed intake etc. To find out the potential effects of treatments given to these birds on internal organs, 05 birds/group were euthanized humanely, at 15, 30 and 45th days of experiment. The absolute organ weight of Liver, kidney, intestines and heart were recorded.

To find out potential beneficial effects on immune system carbon clearance Assay (Sarker *et al*., 2000), Lymphoproliferative response to avian tuberculin (Akhtar *et al*., 2008) were recorded as per procedures mentioned and the weight of spleen and thymus were also recorded on 15, 30 and 45th days of experiment along with other organs.

Statistical analysis: The data thus obtained was subjected to ANOVA. Duncan multiple range tests were used for comparing means of different groups to determine the significant difference. M-STAT-C software package (Michigan State University, East Lansing, MI 48824, USA) was used and level of significance was kept at $P \leq 0.05$.

RESULTS

The results obtained during this trial has been described below:

Table 1: Experimental plan

Groups	Number of Birds	Treatments
A	20	With no treatment (Control)
B	20	*Streptomyces Globiosporus*
C	20	*Streptomyces Toxytricin*
D	20	*Streptomyces WSN2*
E	20	*Streptomyces rochie*
F	20	*Streptomyces fimbritus*
G	20	Commercially available probiotics

Table 2: Absolute weights of immune organs (thymus and spleen) of birds supplemented with *Streptomyces* species.

Experimental Groups	Experimental Days		
	15th day	30th day	45th day
	Thymus		
A (Control)	0.75 ±0.01^{f}	1.04±0.36^{f}	1.50±0.25^{f}
B	1.24± 0.03^{a}	2.35±0.78^{a}	3.77±0.28^{a}
C	1.13±0.01^{b}	1.76±0.45^{b}	2.20±0.14^{b}
D	1.08±0.02^{ab}	1.37±0.38^{ab}	1.95±0.74^{ab}
E	0.90±0.01^{bc}	1.45±0.28^{bc}	1.84±0.89^{bc}
F	1.04±0.77^{cd}	1.65±0.95^{cd}	1.78±0.54^{cd}
G	0.90±0.03^{de}	1.29±0.27^{de}	1.14±0.54^{de}
	Spleen		
A	0.87± 0.05^{f}	1.13±0.05^{f}	1.75±0.11^{f}
B	1.26 ±0.14^{a}	1.77±0.09^{a}	2.18±0.11^{a}
C	1.17 ±0.01^{b}	1.61±0.03^{b}	2.01±0.09^{b}
D	1.14 ±0.02^{ab}	1.53±0.07^{ab}	1.96±0.05^{ab}
E	1.07 ±0.12^{bc}	1.46±0.06^{bc}	1.85±0.06^{bc}
F	1.04 ±0.07^{cd}	1.28±0.08^{cd}	1.76±0.05^{cd}
G	0.90 ±0.03^{de}	1.15±0.07^{de}	1.69±0.03^{de}

Note: Values (Means ± SD) having similar alphabets in a column are statistically non-significant (p>0.05): A= Control –, B=*Streptomyces globiosporus*, C= *Streptomyces toxitricin*, D= WSN2, E= *Streptomyces rochie*, F= *Streptomyces fambritus*, G = Commercially available probiotics

Morbidity and mortality: During this trail the birds were acclimatized as per standard protocols and divided into treatments groups after 07 days as mentioned in materials and methods section. After first week, birds in all experimental groups remained healthy and no mortality was recorded. As per daily observations, the birds treated with experimental strains of the *Streptomyces* and commercially available probiotics were more active with good body scoring as compared to the control group A.

Weekly body weight and feed intake of broiler birds: In this experimental trail, the body weight of all the groups was not significantly different during the period of acclimatization (1st week). A significant increase in the weight gain was observed in all the groups supplemented with different strains of the *Streptomyces* as a probiotic. Highest body weight was recorded in Group B supplanted with *Streptomyces globiosporus* followed by the other treatment groups. The birds supplemented with commercial probiotics (group G) showed comparatively lower weight gain than the other treated groups. However, all the probiotic treated groups gained more body weight as compared to the control (group A) as shown in Fig. 1.

The feed intake of all birds in the experimental groups was not significantly different during the acclimatization (1st week) period. However, a non-significant increase in the feed intake by the birds was observed in all the groups supplemented with different strains of the *Streptomyces* as a probiotic on 7, 15 and 21st days of experiment as compared to control group A. Feed intake was significantly high in groups supplemented with *Streptomyces* strains at 28, 31 and 38th day of age. Feed intake was high in group G as compared to group A, while feed intake in group B, C, D, E and F was significantly different from control group A as shown in Fig. 2.

Organ weight: absolute weight of liver, kidney, intestine and heart: A significant difference in the absolute weight of the liver was seen in the groups supplemented with the different isolates of *Streptomyces* species on 15th day of the experiment as compared to the control group A. Highest liver weight was recorded in group B supplemented with *Streptomyces globiosporus* followed by other groups. Even groups C, D, E and F have higher liver weight as compared to the group G supplemented with commercial probiotic. The same trend was observed on 30th and 45th day of experiment as shown in Fig. 3.

A significant difference in the absolute weight of the of both the kidneys was seen in the groups supplemented with different isolates of *Streptomyces* species on 15th day of the experiment as compared to the control group A. Highest kidneys weight was recorded in group B supplemented with *Streptomyces globiosporus* followed by other groups. Groups C, D, E and F have higher weight as compared to the group G supplemented with commercial probiotic. The similar weight gain trend of kidneys was observed on 30 and 45th of experiment as shown in Fig. 3.

A significant difference in the absolute weight of the of intestines was recorded in the groups supplemented with the different isolate of *Streptomyces* species on 15th day of the experiment as compared to the control group A. Highest intestinal weight was recorded in group B supplemented with *Streptomyces globiosporus* followed by other groups. Groups B-F have higher intestinal weight as compared to the group G and similar trend was seen on 30th and 45th days of experiment as shown in Fig. 3.

Like all other vital organs mentioned above, a significant difference in the absolute weight of the of heart was recorded in the groups supplemented with the different isolates of *Streptomyces* species on 15th day of the experiment as compared to the control group A. The highest heart weight was recorded in group B supplemented with *Streptomyces globiosporus* followed by other groups. Groups B, C, D, E, F have higher heart weight as compared to the group G and similar trend was seen on 30th and 45th day of experiment as shown in Fig. 3.

Absolute weight of immune organs (Thymus and Spleen): A significant difference in the absolute weight of the of thymus was seen in the groups supplemented with the different isolated *Streptomyces* species on 15th day of the experiment as compared to the control group A. The highest thymus weight was recorded in group B supplemented with *Streptomyces globiosporus* followed by other groups. Groups B, C, D, E and F have higher weight as compared to the group G and similar trend was observed on 30th and 45th days as per experimental data shown in Table 2.

When spleen was observed, a significant difference in the absolute weight was observed in the groups B-E on 15th day of the experiment as compared to group A. Comparatively, higher weight was recorded in group B supplemented with *Streptomyces globiosporus* followed by other groups. All the groups B-F have higher weight of spleen as compared to the group G and the similar trend was recorded on 30 and 45th days of experiment as shown in Table 2.

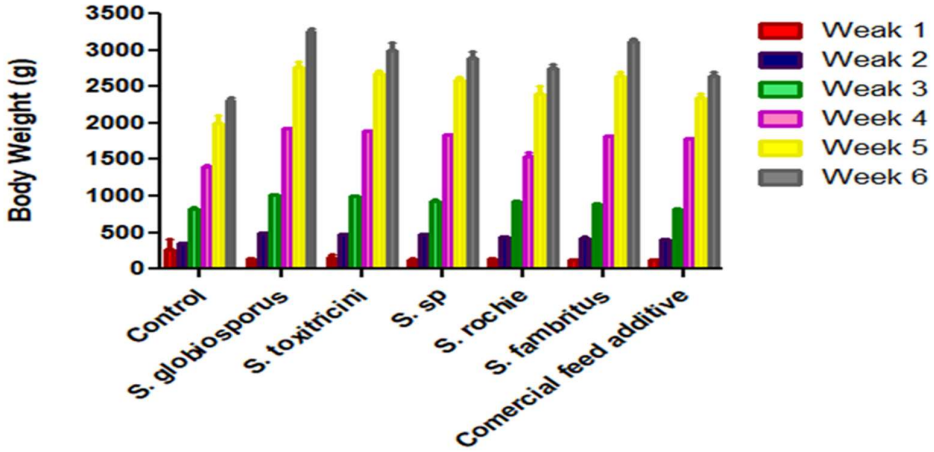

Fig. 1: Body weights of broiler birds with different treatments: (A= Control, B=*Streptomyces globiosporus* , C= *Streptomyces toxitricin*, D= WSN2, E= *Streptomyces rochie,* F= *Streptomyces fambritus*, G = Commercially available probiotic)

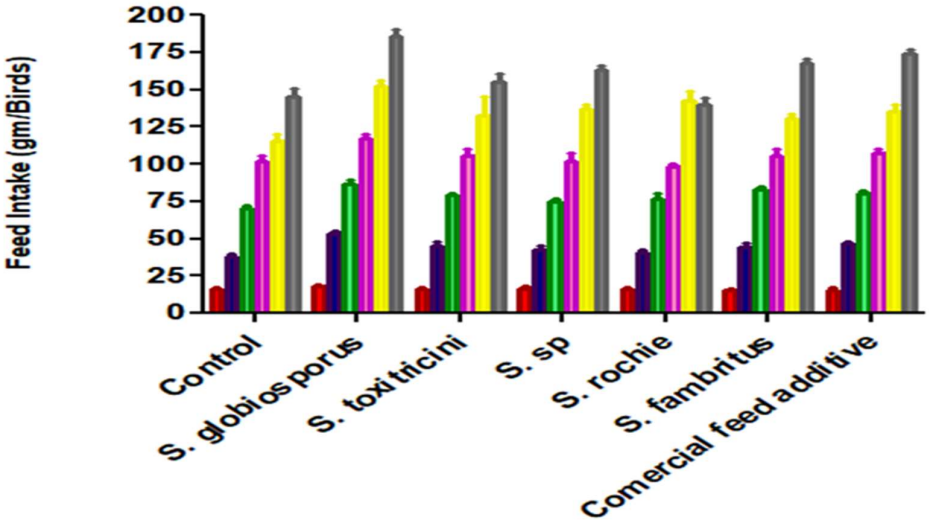

Fig. 2: Feed intakes of broiler birds with different treatments for the six weeks: (A= Control, B=*Streptomyces globiosporus* , C= *Streptomyces toxitricin*, D= WSN2, E= *Streptomyces rochie*, F= *Streptomyces fambritus*, G = Commercially available probiotic)

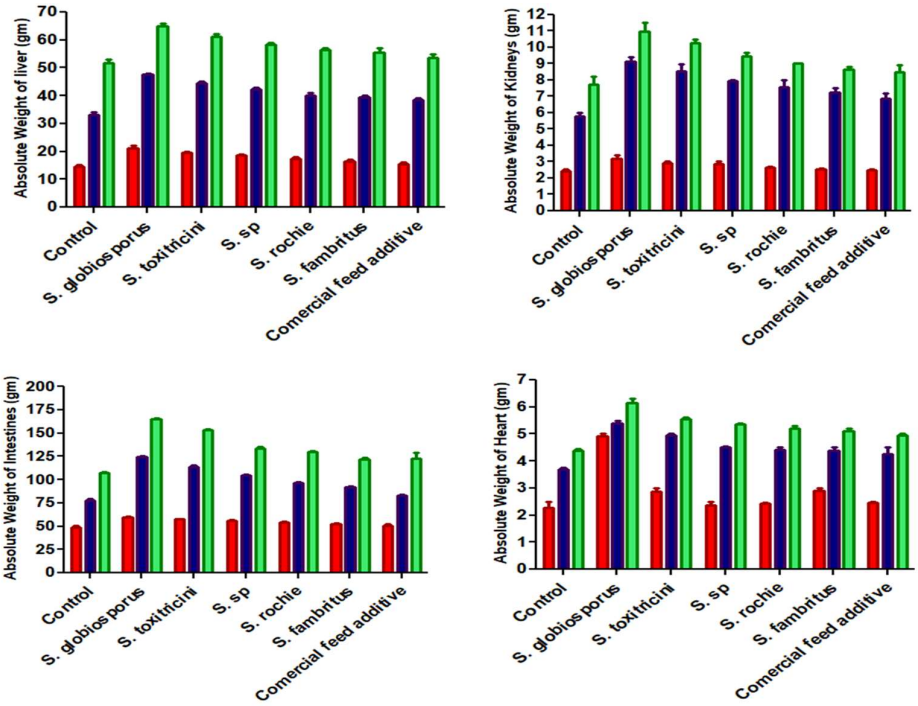

Fig. 3: Body weights of different organs of broiler birds with different treatments at 15, 30 and 45th day of experiment (A= Control–, B=*Streptomyces globiosporus*, C= *Streptomyces toxitricin*, D= WSN2, E= *Streptomyces rochie*, F= *Streptomyces fambritus,* G = Commercially available probiotics).

Table 3: Carbon clearance assay and lymphoproliferative response to avian tuberculin in chicks treated with *Streptomyces* species.

	Carbon clearance assay		Lymphoproliferative response (cm)	
Groups	3 mints	15 mints	24 hours	48 hours
A	138.85 ±11.50^{f}	108.10 ±10.80^{f}	0.543 ±0.03^{c}	0.378 ±0.03^{b}
B	67.38 ±19.57^{g}	46.67 ±19.88^{g}	0.478 ±0.02^{e}	0.253 ±0.03^{d}
C	65.27 ±16.14^{e}	76.57 ±18.67^{e}	0.675 ±0.03^{b}	0.422±0.02^{ab}
D	74.57 ±12.80^{g}	43.51 ±14.17^{g}	0.682 ±0.02^{a}	0.446 ±0.02^{a}
E	65.60 ±12.30^{c}	49.38 ±10.11^{c}	0.256 ±0.03^{i}	0.245 ±0.03^{e}
F	79.76 ±12.70^{a}	51.65 ±11a	0.436 ±0.02^{f}	0.287 ±0.01^{d}
G	64.54 ±10.72^{d}	45.61 ±14.81d	0.532 ±0.02^{d}	0.379 ±0.03^{c}

Note: Values (Means ± SD) having similar alphabets in a column are statistically non-significant (p>0.05): A= Control –, B=*Streptomyces globiosporus*, C= *Streptomyces toxitricin*, D= WSN2, E= *Streptomyces rochie*, F= *Streptomyces fambritus*, G = Commercially available probiotics.

Carbon clearance assay and lymphoproliferative response to avian tuberculin in treated birds: In the current study, it was recorded that all the birds treated with *streptomyces* species supplements have better efficiency for the carbon clearance as compared to the Control group A as shown in Table 3. The data indicated that the immune response was better in probiotic supplemented groups both at 3 and 15 mins after injection of India ink. The response shown by experimental groups B to F was also comparable to the commercially available probiotic group (G). Another parameter observed for immune system stimulation was lymphoproliferative response to the avian tuberculin and result obtained has been shown in Table 3. The skin thickness (mm) was significantly increased in group C and D as compared to all other groups at 24 hours and a similar response was recorded at 48 hours.

DISCUSSION

In Pakistan, poultry industry has major contribution in GDP as a component of livestock and intensive farming has not only contributed towards animal origin protein for the humans as well as a major role in poverty alleviation in terms of employment generation. So it has much potential to enhance the productivity as well safe meat and egg production for the people (Mashkoor *et al.,* 2023; Du *et al.,* 2023). This kind of studies will help to achieve this objective. Briefly, the results obtained has been discussed. The body weight of all the groups was not significantly different during the period of acclimatization (1st week). Later on, a significant increase in the body weight was recorded in all the groups supplemented with different strains of the *Streptomyces* as a probiotic. All the groups have significantly higher body weight as compared to the control group (group A) and highest weight was recorded in Group B supplanted with *Streptomyces globiosporus.* These results were in accordance to the Zhang *et al.* (2005), who reported that addition of probiotic in basal feed led to body weight gain in broiler birds. Many other scientists also reported the similar finding about the use of probiotics (bacteria and yeast based) in broiler birds (Mohan *et al.,* 1996; Jin *et al.,* 1996; 1998, Khaksefidi and Rahimi, 2005). Weight gain along with hepatoprotective effects of *Saccharomyces cerevisiae* has been documented by the Hiss and Sauerwein (2003). In terms of FCR, the feed intake of all the groups was not significantly different during the period of acclimatization (1st week). Latterly, a significant increase in the feed intake was observed in all the groups supplemented with different strains of the *Streptomyces* as a probiotic. Published literature also supports these findings that the supplementation of yeast as probiotics results in body weight gain and improved FCR in broiler birds which is also evident from the current study (Vineetha *et al.*, 2017; He *et al.,* 2019; Mousavi *et al.,* 2018; Zhang *et al.,* 2021; Ebeid *et al.*, 2021).

A significant difference in the absolute weight of the organs including liver, kidney and heart was observed in the groups supplemented with the different isolated *Streptomyces* species on 15th day of the experiment as compared to the control. Highest liver weight was recorded in group B supplemented with *Streptomyces globiosporus* followed by other groups. The similar trend was observed on 30th and 45th days of experiment. The previous studies by the Zhang *et al.* (2021) and Ebeid *et al.* (2021) supports the current findings. However, in few studies, it has been mentioned by the Fathi *et al.* (2017) and Ebeid *et al.* (2021), that probiotics supplementation does not always have promising effects due to animal or environmental related factors.

A significant difference in the absolute weight of the of intestines was observed in the groups supplemented with the different isolated *Streptomyces* species on 15th day of the experiment as compared to the control. Highest intestinal weight was recorded in group B supplemented with *Streptomyces globiosporus* followed by other groups and similar trend was observed on 30th and 45th. These positive effects of the probiotic supplementation have been supported by many scientific studies including Gheisari and Kholeghipour (2006), Gao *et al.* (2008) and Ghosh *et al.* (2012). This increase in the weight of the intestine has been attributed to the flourishing of the beneficial microflora in the tract that replaces the pathogens alongwith physiological alterations in absorption surface of intestines. The metabolites produced by the *Streptomyces* are closely related to the bacterial strains like organic acids, oligosaccharides and peptides etc. which results in better protein and vitamins absorption from the intestines. The morphological changes in the intestines are also similar to the other probiotics as described above (Gheisari and Kholeghipour 2006; Gao *et al.*, 2008; Ghosh *et al.*, 2012).

A significant difference in the absolute weight of the immune organs including thymus and spleen was seen in the groups supplemented with the different isolated *Streptomyces* species on 15th day of the experiment as compared to the control. The highest thymus weight was recorded in group B supplemented with *Streptomyces globiosporus* followed by other groups. Even these groups B, C, D and E have higher weight as compared to the group supplemented with commercial probiotic (group G). The similar trends in immune parameters were observed on 30th and 45th day of trail. These findings have been strongly endorsed by the literature that the probiotics supplementation stimulates the immune mechanisms of the poultry through enhanced secretions of immunoglobulins

from primary and secondary lymphoid organs. Mainly IgA, IgG and IgM are in more concentration and among these IgM particularly take part (Haghighi *et al*., 2006. Tung and Herzenberg, 2007). The immunostimulatory effect has been described differently in literature and the most commonly reported school of thought is that when viable microflora starts to multiply in the intestine, at the same time the pathogenic microflora becomes dead due to competition, hence it starts to secrete antigens, they are absorbed through intestines and boosts immune system (Otutumi *et al.,* 2012).

Conclusions: The use of locally isolated species of streptomyces have significant additive effects on the broiler's performance in all treatment groups as compared to the control in terms of weight gain, feed consumption etc. This supplementation also has not resulted in any kind of negative effects on internal organs including liver, kidney, heart and intestines. The birds supplemented with *Streptomyces globiosporus* revealed the better growth and improve feed consumption as compare to all other tested species. Immunostimulatory effects of these species is also indicative from the no morbidity and mortality during the trail. The Carbon clearance assay is evident of improved phagocytic response through the macrophages. Hence, it has been concluded that these local isolates of the streptomyces have potential to be promoted as the probiotic in the poultry feed which will be more economical and profitable to the farmers.

Authors contribution: BM, MA, SK, SUR and KA, all were active members during this research trial. They conceived the idea, executed the project, performed data analysis and helped in write up of the manuscript.

REFERENCES

Aftabuddin S, Kashem MA, Kader MA, *et al*., 2013. Use of *Streptomyces fradiae* and *Bacillus megaterium* as probiotics in the experimental culture of tiger shrimp Penaeusmonodon (Crustacea, Penaeidae). AACL Bioflux 6:253-67.

Akhtar M, Hafeez MA, Muhammad F, *et al*., 2008. Immunomodulatory and protective effects of sugar cane juice in chickens against Eimeria infection. Turkish J Vet Ani Sci 32:463-67.

Bhogoju S, Khwatenge CN, Taylor-Bowden T, *et al*., 2021. Effects of *Lactobacillus reuteri* and *Streptomyces coelicolor* on Growth Performance of Broiler Chickens. Microorganisms 9:1341.

Coniglio MV, Luna MJ, Provensal P, *et al*., 2023. The Impact of Saccharomyces cerevisiae var. Boulardii RC009 on productive parameters in weaned calves and cull cows. Agrobiol Records 13:1-6.

Das S, Lyla P and Ajmal SK, 2006. Application of *Streptomyces* as a probiotic in the laboratory culture of *Penaeusmonodon* (Fabricius). Isr J Aquac 58:198-204.

Das S, Ward LR and Burke C, 2010. Screening of marine Streptomyces spp. for potential use as probiotics in aquaculture. Aquaculture 305:32-41.

Devaraja TN, Yusoff FM and Shariff M, 2002. Changes in bacterial populations and shrimp production in pond streated with commercial microbial products. Aquaculture 206:245-56.

Du XX, Gul ST, Ahmad L, *et al.,* 2023. Fowl typhoid: Present scenario, diagnosis, prevention and control measures. Int J Agri Biosci 12:172-79.

Ebeid TA, Al-Homidan IH and Fathi MM, 2021. Physiological and immunological benefits of probiotics and their impacts in poultry productivity. World's Poult Sci J 77:883-99.

Fathi MM, Ebeid TA, Al-Homidan I, *et al*., 2017. Influence of Probiotic Supplementation on Immune Response in Broilers Raised under Hot Climate. British Poult Sci 58:512-16.

Gao J, Zhang HJ, Yu SH, *et al*., 2008. Effects of yeast culture in broiler diets on performance and immunomodulatory functions. Poult Sci 87:1377-84.

Gheisari A and Kholeghipour B, 2006. Effect of dietary inclusion of live yeast (Saccharomyces cerevisiae) on growth performance, immune responses and blood parameters of broiler chickens. In XII European Poultry Conference, Verona, Italia, p3

Ghosh TK, Haldar S, Bedford MR, *et al*., 2012. Assessment of yeast cell wall as replacements for antibiotic growth promoters in broiler diets: effects on performance, intestinal histo-morphology and humoral immune responses. J Anim Physiol Anim Nutr 96:275-84.

Gonzalez RM and Angeles HJC, 2017. Antibiotic and synthetic growth promoters in animal diets: review of impact and analytical methods. Food Contr 72:255-67.

Gul ST and Alsayeqh AF, 2022. Probiotics as an alternative approach to antibiotics for safe poultry meat production. Pak Vet J 42:285-291.

Gul ST and Alsayeqh AF, 2023. Probiotics improve physiological parameters and meat production in broiler chicks. Int J Vet Sci 12:182-191.

Haghighi HR, Gong J, Gyles CL, *et al*., 2006. Probiotics stimulate production of natural antibodies in chickens. Clin Vaccine Immunol 13:975-80.

Harir M, Bendif H, Bellahcene M, *et al*., 2018. Streptomyces secondary metabolites. Basic Biology and Applications of Actinobacteria 6:99-122.

He T, Long S, Mahfuz S, *et al*., 2019. Effects of probiotics as antibiotics substitutes on growth performance, serum biochemical parameters, intestinal morphology, and barrier function of broilers. Animals 9:985.

Hiss S and Sauerwein H, 2003. Influence of dietary ß-glucan on growth performance, lymphocyte proliferation, specific immune response and haptoglobin plasma concentrations in pigs. J Anim Physiol Anim Nutr 87:2-11.

Jin LZ, Ho YW, Abdullah N, *et al*., 1996. Influence of dried Bacillus substillis and lactobacilli cultures on intestinal microflora and performance in broilers. Asian-Australasian J Anim Sci 9:397-404.

Jin LZ, Ho YW, Abdullah N, *et al*., 1998. Growth performance, intestinal microbial populations, and serum cholesterol of broilers fed diets containing Lactobacillus cultures. Poult Sci 77:1259-65.

Khaksefidi A and Rahimi S, 2005. Effect of probiotic inclusion in the diet of broiler chickens on performance, feed efficiency and carcass quality. Asian-Australasian J Anim Sci 18:1153-56.

Khater HF, Ziam H, Abbas A, *et al*., 2020. Avian coccidiosis: Recent advances in alternative control strategies and vaccine development. Agrobiol Records 1:11-25.

Latha S, Vinothini G and Dhanasekaran D, 2015. Chromium [Cr (VI)] biosorption property of the newly isolated actinobacterial probiont Streptomyces werraensis LD22. 3 Biotech 5:423-32.

Lee J, Kim Y, Nam N, *et al*., 2019. Primary and secondary antibiotic resistance of Helicobacter pylori in Korea from 2003 to 2018. Helicobacter 24:e12660.

Mashkoor J, Al-Saeed FA, Guangbin Z, *et al.,* 2023. Oxidative stress and toxicity produced by arsenic and chromium in broiler chicks and application of vitamin E and bentonite as ameliorating agents. Front Vet Sci 10:1128522

Mohan B, Kadirvel R, Natarajan A, *et al*., 1996. Effect of probiotic supplementation on growth, nitrogen utilisation and serum cholesterol in broilers. Br Poult Sci 37:395-401.

Mousavi ASMA, Mahmoodzadeh HH and Mirhosseini SA, 2018. A review of dietary probiotics in poultry**.** J Appl Biotechnol Rep 5:48-54.

Nikaido H, 2009. Multidrug resistance in bacteria. Annu Rev Biochem 78:119-46.

Otutumi LK, Góis MB, Garcia EM, *et al.,* 2012. Variations on the efficacy of probiotics in poultry. Probiotic in Animals. EC Rigobelo, Ed. InTech, Rijeka, Croatia, 203-220.

Rashad FM, Fathy HM, El-Zayat AS, *et al*., 2015. Isolation and characterization of multifunctional Streptomyces species with antimicrobial, nematicidal and phytohormone activities from marine environments in Egypt. Microbiol Res 175:34-47.

Sarker N, Tsudzuki M, Nishibori M, *et al*., 2000. Cell mediated and humoral immunity and phagocytic ability in chicken lines divergently selected for serum immunoglobulin M and G levels. Poult Sci 79:1705-9.

Sarmah AK, Meyer MT and Boxall AB, 2006. A global perspective on the use, sales, exposure pathways, occurrence, fate and effects of veterinary antibiotics (VAs) in the environment. Chemosphere 65:725-59.

Trafalska E and K Grzybowska, 2004. Probiotics An alternative for antibiotics? Wiad Lek 57: 491-498.

Tung J and Herzenberg L, 2007. Unraveling B-1 progenitors. Curr Opin Immunol 19:1–6.

Vineetha PG, Tomar S, Saxena VK, *et al*., 2017. Effect of laboratory-isolated Lactobacillus plantarum LGFCP 4 from gastrointestinal tract of guinea fowl on growth performance, carcass traits, intestinal histomorphometry and gastrointestinal microflora population in broiler chicken. J Anim Physiol Anim Nutr 101:62-70.

Willemse J, Borst JW, de Waal E, *et al*., 2011. Positive control of cell division: FtsZ is recruited by SsgB during sporulation of Streptomyces. Genes Dev 25:89.

Zhang AW, Lee BD, Lee SK, *et al.,* 2005. Effects of yeast (*Saccharomyces cerevisiae*) cell components on growth performance, meat quality, and ileal mucosa development of broiler chicks. Poult Sci 84:1015-21.

Zhang L, Zhang R, Jia H, *et al*., 2021. Supplementation of probiotics in water beneficial growth performance, carcass traits, immune function and antioxidant capacity in broiler chickens. Open Life Sci 16:311-22.