Research Article **RJPP (2017) 1:1**

Research Journal of Pharmacology and Pharmacy (ISSN:2572-8377)

Effect of supplementation of xylanase on feed efficiency and serum biochemistry in broilers

Abida Niazi[1], Amber Khan[1], Zunaira Alina[2, 3], Anam Asghar[3], Bushra Ishfaq [3], Shaneel Kousar[2], Laiba Riaz[2], Ramsha Abbas[2], Faiza Naseer[*3]

[1]University of Veterinary and Animal Sciences Lahore, Pakistan; [2]Institue of pharmacy, Physiology and Pharmacology, University of Agriculture, Faisalabad, Pakistan; [3]Department of Pharmacy, Government College University Faisalabad, Pakistan

ABSTRACT

To study the working mechanisms for non-starch polysaccharides' to improve the growth performance of broiler chickens, a 35-day feeding trial was conducted. Two dietary treatments were included: 1) wheat diet (the control); 2) wheat+xylanase diet .There were 5 groups with 3 replicates ,each replicates having 8 birds each for each treatment and the experimental diets were given to birds from hatch. Group A was control and group B was treated with Xylanase concentration of 250IU/Kg feed, Group C was treated with Xylanase concentration of 500IU/Kg feed, Group D was treated with Xylanase concentration of 750IU/Kg feed and Group E was treated with Xylanase concentration of 1000IU/Kg feed.FCR and body weight were measured weekly. The vaccination was done according to schedule. Fresh Water provided at free labitum. The shed was properly maintained with respect to temperature and humidity. The Fumagination was properly and thoroughly done before the start of experiment. The xylanase supplement increased ($p<0.05$) body weight gain (BWG) and improved feed conversion ratio (FCR) at the end of the experiment but non-significant results were observed on serum biochemistry ($p>0.05$) by xylanase. (Key Words: Xylanase, weight gain, Serum biochemistry.

Key Words: Xylanase, weight gain, Serum biochemistry.

***Correspondence to Author:**
Faiza Naseer
Department of Pharmacy, Government College University Faisalabad, Pakistan. E-mail: faiza.naseer@ymail.com

How to cite this article:
Niazi et al.,. Effect of supplementation of xylanase on feed efficiency and serum biochemistry in broilers. Research Journal of Pharmacology and Pharmacy, 2017, 1:1

eSciencePublisher
eSciPub LLC, Houston, TX USA.
Website: http://escipub.com/

INTRODUCTION

In broiler poultry, wheat and barley having xylanase have improved the activity of broiler chickens (Wu *et al.*, 2004b). Xylanase is non-starch polysaccharides supplement could change the development of gut microflora (Hubener *et al.*, 2002).Xylanase is produced from different microbial species including bacteria and fungi. However, *Aspergillus Niger* is a potential source to synthesize this enzyme. Xylanase dose increases weight of chicken and had no effect on survivability. It is observed that chicks which fed on enzyme supplemented diets gained more weight, organic matter and crude protein metabolism. The boiled castor seed meal mixed with enzyme was found to be acceptable and have no side effects on growth performance or blood constituents. Xylanase has the effectiveness of breaking down hemicellulose and xylene component of the cell wall of the plant absorption. Xylanase is employed as an ingredient in animal feed to improve digestibility and enhancing the efficacy of nutrient absorption by facilitating the conversion of hemicellulose, originally locked in the cell walls of the grains, to sugars. As such the nutrients are easier to be released and the animal can then obtain better energy with less feed cost effectiveness of feed is thus attained. In poultry diets, wheat is becoming an important source of energy. The usage of high level of xylanase (Principle water soluble non polysaccharides), in wheat causes limited use. Xylanase increases the viscosity of digest an impending the digestion and absorption of nutrients and causing poor performance (Choct *et al.*, 2004). While the effect of xylanase on nutrient utilization and performance has documented already in broilers fed diet on wheat based, the influence of exogenous enzyme addition on microbial populations present in digestive tract is a growing interest of studying, because of restrictions on use of antibiotics in several countries. Some authors have discussed that the use of xylanase can change the undigested nutrients entering in the hindgut and change the microbial populations indirectly (Choct *et al.*, 1999; Cowieson *et al.*, 2005; Marron *et al.*, 2001) and as a result the energy used for production in broiler was improved. The effect of different levels of xylanase on intestinal development and hormonal levels of broiler fed wheat based diets was evaluated and determined. It is concluded that excess supplementation of xylanase enzyme complex had no effect on performance or even inhibited endogenous enzyme secretion and destroyed small intestine structure (Guo *et al.*, 2014; Wu *et al.*, 2004a).

MATERIALS AND METHODS

Experimental design and diets: A total of one hundred and twenty, day-old broiler chicks were purchased and were shifted to experimental shed of UVAS, Lahore. The shed were cleaned and fumigated before the arrival of the chicks. The birds were randomly divided into five groups (A, B, C, D and E), having 24 birds with 3 replicates in each group. Group A was kept as control group and was given corn-based basal feed while groups B, C, D and E were fed the same ration supplemented with xylanase at a dose rate of 250IU/kg, 500 IU/kg, 750 IU/kg and 1000 IU/kg feed respectively for 35 days. Water and diet were provided ad libitum. At completion of 5^{th}week, two birds from each replicate were bled using hypodermic needle and syringe. Blood was drained into two different carefully labelled bottles for serum biochemistry investigation. The blood samples for biochemical indices were collected in sample bottle contain no anti-coagulant. The sample was spurned in the centrifuge at 3000 rpm, and serum was preserved for further serum testing (albumin, globulin, uric acid, creatinine, ALT, AST, Liver function test, Kidney Function test.

Data analysis: All data generated on performance, serum biochemistry of the experimental birds were subjected to statistical Package for social science (SPSS for windows version 12, SPSS Inc. Chicago, IL, USA). The treatment means were compared using the Duncan's Multiple Range Test. Differences was considered significant at $P < 0.05$.

RESULTS

Performance characteristics of broilers fed the experimental diets

The results of body weight gain as an effect of supplementation of different doses of xylanase in broiler chicks of control and supplemented groups at week 1, 2, 3, 4 and 5 are shown in the figure 01-05. Non-significant weight gain was found in all the treated groups on week 1.Data is presented as mean ± standard error

of means. Group A: control; Group B (250IU/Kg) feed: Group C (500IU/Kg) feed: Group D (750IU/Kg) feed and Group E (1000IU/Kg) feed. In the second week, Groups C and D showed higher weight gain as compared to the control group, though they were found non-significant as compared to the Group A. The body weight gain of Group A (control) = 100.00±2.08g and Group B (supplemented) = 208.45±19.62g in week 2. ANOVA shows tendency (p=0.06) to differ in body weight gain among the groups. The weight gain of Group D (287.83±21.12a) was higher compared to Group A (210.0±12.34bg). The weight gain after 3rd week in Group D was significantly lower compared to Group A. Among Group A (586.67±10.47ag), Group B (595.86±24.22ag), Group C (567.57±27.22ag) and Group E (600.73±15.83ag) was significantly higher than Group D (490.33±24.48bg). After the fourth week, the weight gain of Group D (575.39±25.17ag) was significantly higher than control Group A (473.34±16.21bg).The result showed non-significant results of wt. gain in all treated groups than control group after fifth week.

FCR was recorded after every week. FCR recorded after first week is shown in Figure 01. After Ist week supplementation of Xylanase, this result showed higher FCR in groups B and C as compared to the control group. The FCR was found high tendency in Group C (0.4741±0.058ag), Group B (0.3651±0.064abg) than control Group A (0.4710±0.054ag) and Group C (0.3239±0.023abg), but was found similar in Group E (0.2991±0.023bg).FCR was also recorded after 2nd week of age of birds as shown in Figure 02. After 2nd week of age, higher FCR was recorded in Group B as compared to the control Group A, though it was found non-significant in Groups C, D and E. The feed conversion ratio was found non-significant in all groups after 2nd week. FCR was also observed after 3rd week of age of birds as shown in Figure 03. This result showed higher FCR in Group C and Group D as compared to control Group A. The Value of FCR was found significant higher in Group D (0.807±0.016ag) as compared to Group E (0.507±0.085dg) but was observed similar in Group C (0.690±0.098abg), control Group (0.644±0.059bcg) and Group B (0.555±0.020cdg).FCR was also observed after 4th week of age of birds as shown in Figure 04. This result showed no FCR change in all groups. Feed conversion ratio was significantly higher in Group C (1.136±4.69ag) and control Group (1.118±11.55ag) than Group B (0.9683±11.63bg) and Group D (0.9323±18.71bg) but was found similar in Group E (1.001±25.71abg).FCR was also observed after 5th week of age of birds as shown in Figure 05. This result showed that FCR among all groups was recorded non-significant statistically after last week of age of experimental birds. The result showed that feed conversion ratio showed significantly increasing tendency among all groups.

The feed intake was significantly found higher in Group B (80.77±4.69ag) and Group C (78.52±1.83ag) than Group A (64.38±4.12bg) and Group D (60.47±4.09bg) but was found similar in Group E (72.42±3.95abg).The feed intake during 2nd week of Group B (218.7567±1.16ag), Group C (209.7100±22.41ag) and Group D (214.6633±5.89ag) was significantly higher than Group E (173.8033±4.71bg) but was found similar in Group A (184.3767±4.136abg). The feed intake was significantly higher in Group C (391.4733±11.17ag) and Group D (396.0933±23.22ag) than Group E (307.0433±29.21bg) but was found similar in Group A (370.1900±11.94abg) and Group B (331.9000± 13.63abg).The Group C (574.2800±4.70ag) was significantly higher than Group E (476.8500±25.71cg) and the Group B (491.9467±11.63bcg), Group D (535.6167±18.71abg) and Group A (529.0467±11.55abcg) was showing trending to decrease feed intake after 4th week. The feed intake after fifth week was found non-significant among all groups.

Serum samples were analyzed for determination of serum concentrations of glucose, total protein and albumin concentrations, liver function tests (total bilirubin, AST and ALT), kidney function test (urea and creatinine), plasma lipid profile (total cholesterol, triglycerides) and proteins (total protein and albumin).The level of total cholesterol from result was found non-significant among the groups. The level of triglyceride was found non- significant in control Group as compared to all other treated groups ,Group A (38.20±8.16g), Group B (51.400±7.54g), Group C (53.20±11.22g), Group D (45.60±6.14g), Group E (53.80± 12.32g).The significant results for serum ALT level were found among

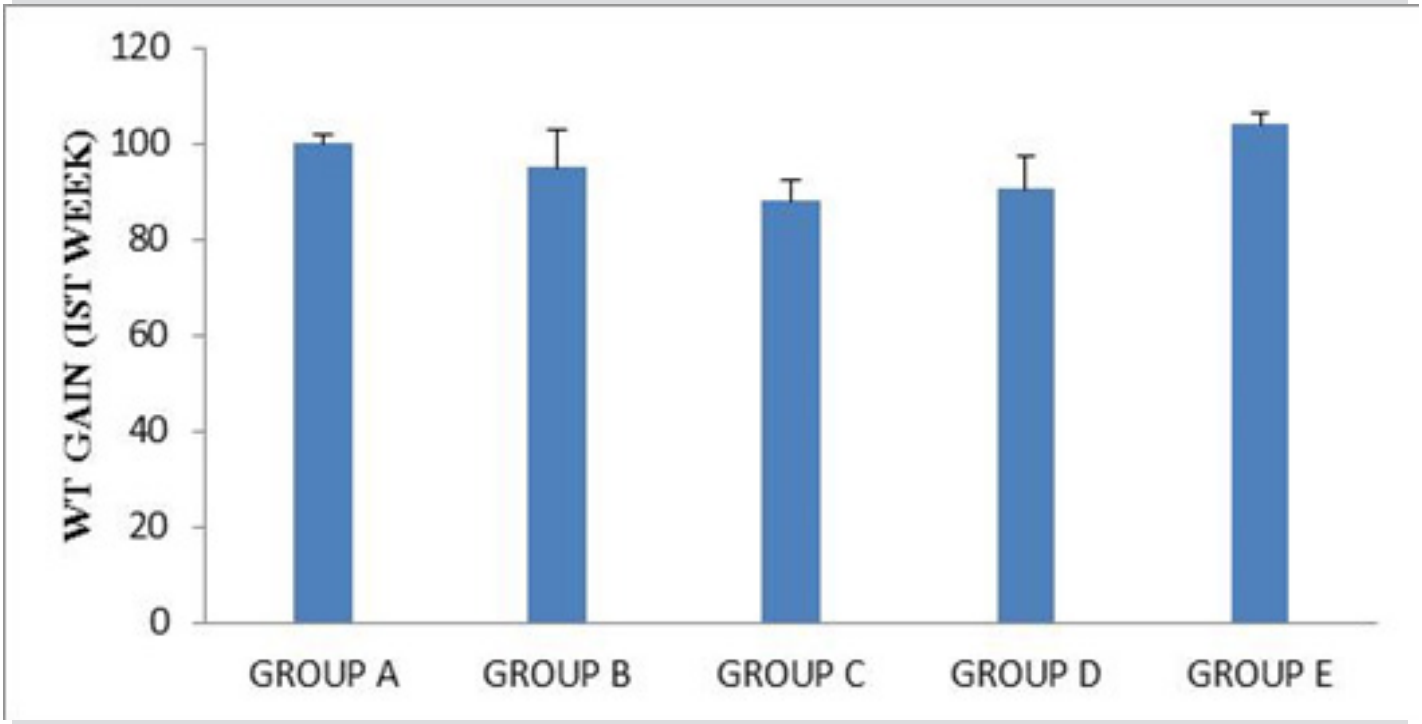

Figure 1: Effect of different concentrations of Xylanase supplementation on weight gain (g) in broiler chicks after 1st week. Data is presented as mean ± standard error of means. Group A: control; Group B (250IU/Kg) feed: Group C (500IU/Kg) feed: Group D (750IU/Kg) feed and Group E (1000IU/Kg) feed.

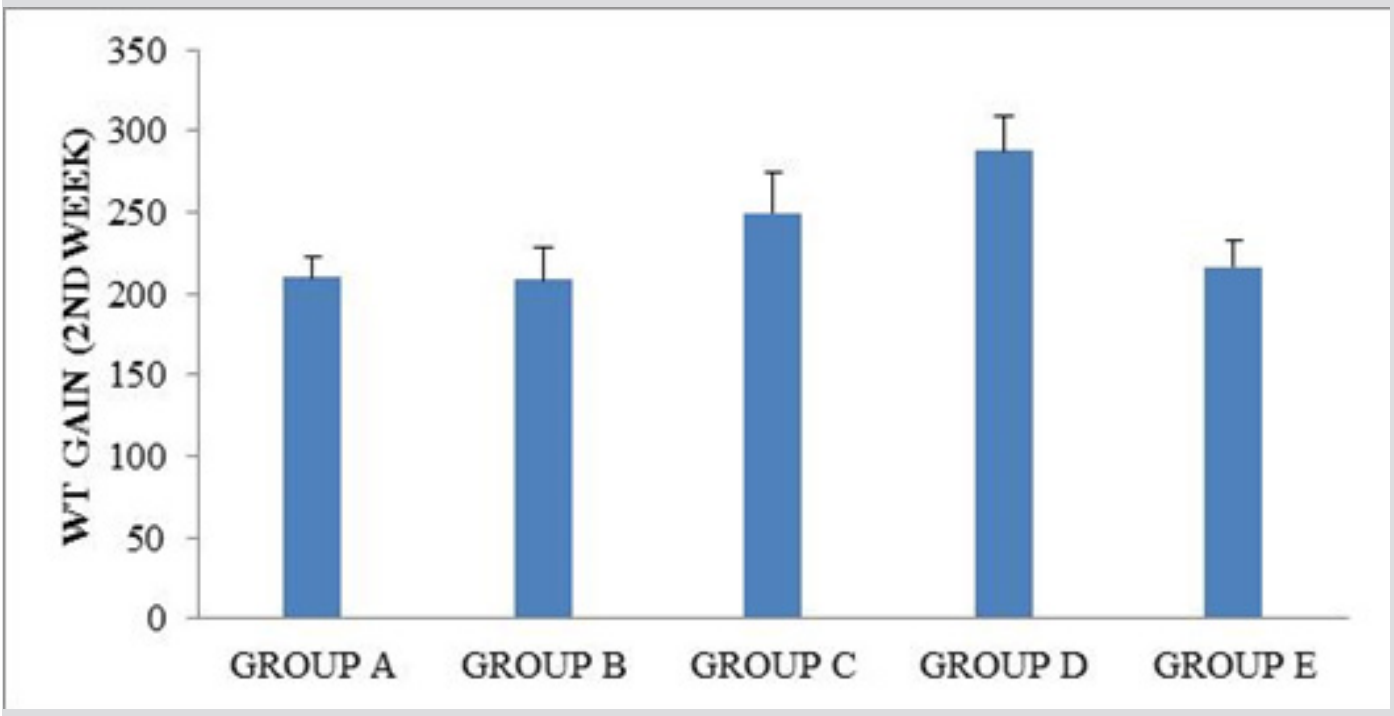

Figure 2: Effect of different concentrations of Xylanase supplementation on weight gain (g) in broiler chicks after 2nd week. Data is presented as mean ± standard error of means. Group A: control; Group B (250IU/Kg) feed: Group C (500IU/Kg) feed: Group D (750IU/Kg) feed and Group E (1000IU/Kg) feed.

the groups (P<0.05).The serum level of ALT of Group E (42.600±2.06ag) and Group C (41.800±3.73ag) was found significantly higher than Group A (25.600±4.20bg), Group B (26.20±2.22bg) and Group D (30.00±2.41bg). The significant results in serum AST level were found among the groups (P<0.05). The level of AST was found significantly lower in Group B (154.0±3.95bg), Group C (161.40±10.85bg) and Group D (163.40±8.77bg) than control Group A (169.20±10.80abg). Slight increase in AST was observed in Group E (196.2000±10.42ag) as compared to the other groups. ANOVA shows no significant change among the groups, however post-hoc test revealed that the plasma level of bilirubin in Group C (2.32±0.18g) was significantly higher than Control Group A (1.84±0.11g) but was found similar to Group B (2.1400±0.081g), Group D (2.0800±0.106g) and Group E (2.1800 ±0.086g).The result found that level of urea was significantly higher in Group B (15.00±1.048ag) than Group C(12.00±0.707bg) and Group D(11.40±0.812bg) and was found similar to Group A(13.400±0.509abg) and Group E (12.800±0.734abg).The significant results were found among the groups (p<0.05).The result found that the level of creatinine was non-significant in Group A (0.360±0.024ag) as compared to all other treated Group B (0.400±0.0316ag), Group C (0.400±0.031ag), Group D (0.400±0.048ag) and Group E (0.400±0.014ag).The level of total protein was found non -significantly higher in Group C (5.24±0.181g) and Group D (5.34±0.169g) than Group B (4.66±0.0.24g) but was found similar in Group E (4.82±0.0124g) and Group A (5.160±0.144g). ANOVA shows non-significant change among the groups however post hoc test revealed that plasma level of glucose was in Group A (310.80±12.33g) as compared to other treated Group B (322.80±27.57g), Group C (302.40±16.09g), Group D (307.40±12.97g) and Group E (307.60±20.46g).ANOVA shows non- significant change among the groups however post hoc test revealed that plasma level of albumin higher in Group D (2.46±0.231g) than Group B (2.02±0.11g). But was found similar in Group A (2.18±0.73g), Group C (2.16±0.103g) and Group E (2.06±0.087g).The level of globulin was non-significant in all groups. Group A (2.9800±0.153g), Group B (2.640±0.266g), Group C (3.080±0.171g), Group D (2.880±0.124g), Group E (2.76±0.078g).

DISCUSSION

The purpose of this study was to find the physiological and serological changes in broiler chicks after supplementation of Xylanase in broiler chicks. Xylanase was given to broiler chicks at a different dose concentration. Daily feed intake, weekly body weight gain and weekly FCR were calculated. Then after 35 days samples were collected to study the serological parameters. Xylanase supplementation has become an efficient tool to improve the bioavailability of non-starch polysaccharides present in the foodstuffs and to improve the digestion of diet, Glycerin max serves as a major human diet and animal feed component due to its beneficial nutritional and good health values. Xylanase has an important dietary source of protein, fat fiber, vitamins and minerals. Xylanase has act as growth activator factor that interfere with non-starch polysaccharides. Supplementation of exogenous carbohydrates Xylanase enhance the dietary utilization of essential nutrients which otherwise would be lost to the animal and wasted to the environment.

The current study showed that Groups C(500IU/Kg feed) and D(750IU/Kg feed) in 2nd week of age and only group D(750IU/Kg feed) gained higher weight gain as compared to control group while higher FCR was observed in groups B(250IU/Kg feed) and C(500IU/Kg feed) at Ist week of age, only in group B(250IU/Kg feed) in 2nd week of age and in group C(500IU/Kg feed) and D(750IU/Kg feed) at 3rd Week of age of birds as compared to the control group. There was no change of FCR observed in 4th and 5th week of age of birds in any test groups. Group C which was given 500IU/Kg of Xylanase showed higher weight gain in 2nd week and 4th week of age as compared to control group. The result of present study revealed that there were no significant changes found in the daily feed intake of boiler chicks throughout the experiment. Wu et al. (2004) showed that the Xylanase supplementation improved weight gain, Feed efficiency

Xylanase supplementation increased feed intake, body weight, feed intake and feed gain ratio (Ahmad et al; 2007).From the research, it was concluded that addition of Xylanase had no positive effects on growth performance of birds during the first week. Next two weeks from day 8 to 21 day, the BWG of birds was increased

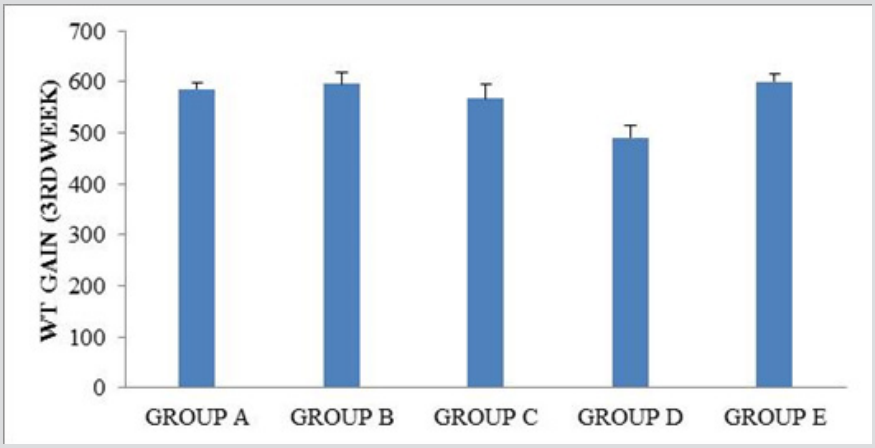

Figure 3: Effect of different concentrations of Xylanase supplementation on weight gain (g) in broiler chicks after 3rd week. Data is presented as mean ± standard error of means. Group A: control; Group B (250IU/Kg) feed: Group C (500IU/Kg) feed: Group D (750IU/Kg) feed and Group E (1000IU/Kg) feed.

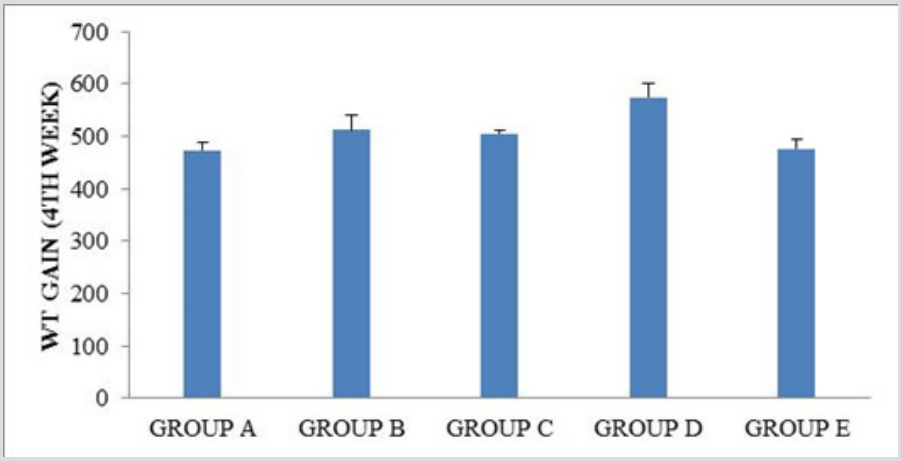

Figure 4: Effect of different concentrations of Xylanase supplementation on weight gain (g) in broiler chicks after 4th week. Data is presented as mean ± standard error of means. Group A: control; Group B (250IU/Kg) feed: Group C (500IU/Kg) feed: Group D (750IU/Kg) feed and Group E (1000IU/Kg) feed.

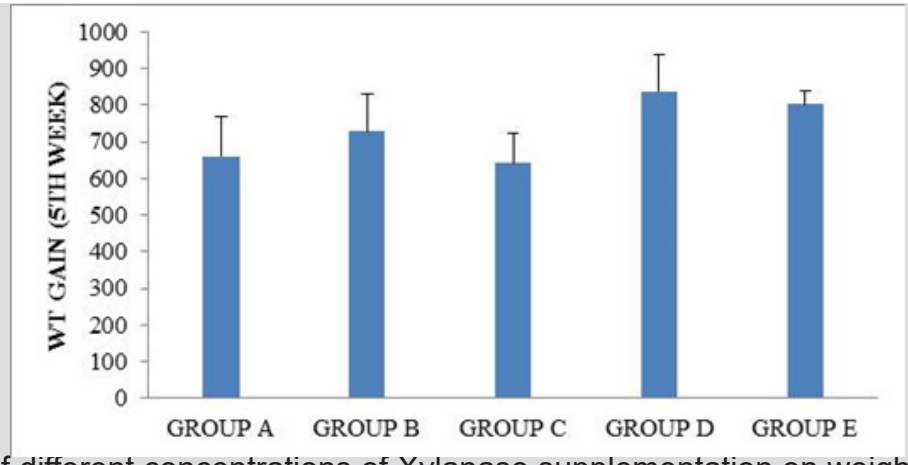

Figure 5: Effect of different concentrations of Xylanase supplementation on weight gain (g) in broiler chicks after 5th week. Data is presented as mean ± standard error of means. Group A: control; Group B (250IU/Kg) feed: Group C (500IU/Kg) feed: Group D (750IU/Kg) feed and Group E (1000IU/Kg) feed.

($p<0.05$) and the FCR was improved ($p<0.05$) by Xylanase. The supplementation of non-starch polysaccharides can improve the growth performance of birds fed on wheat/rye diet (Annison and Choct,1991;Bedford and Classen,1992;Selle et al.,2003;Wu etal.,2004a,2004b;Qioa et al.,2005).The slow performance of birds fed on a rye/wheat based diet was improved by exogenous enzymes through the breaking–down of the gel-forming capacity (viscosity)of non-starch Polysaccharides (NSP),which is reason of low nutrient digestibility and/or availability (Bedford and Classen,1992). Indeed, Choct et al, (1995, 1999) observed that starch and/or protein digestibility of birds on Xylanase treatment was better compared to the control. However, there was no significant difference in the ileal protein and starch digestibility between Xylanase treatment and the control at day 21 in the present trial although slight numerical increases were observed.

No statistical difference was observed among all tested groups as for as weight gain and Feed Conversion Ratio parameters. These results are contrary to the work of (Kongbuntad et al., 2006) whose results of growth performance of chicken showed increase in weight gain of chicken in both xylanase treatment groups significantly during 28 days of the experimental. However, there was no significant difference in the body weight between two xylanase supplement levels (10g and 30g/kg feed). This might be due to difference of dose rate of xylanase used by Kongbuntad et al., 2006.As there was no difference found in the feed intake and weight gain it might be the possibility of non-significant results of FCR. Veldman and Vahl (1994) showed that Xylanase supplementation increased feed conversion ratio 2.2-2.9% and body weight gain by 0.2-2.5%.Silverslides and Bedford noticed that Xylanase treatment had a positive body weight gain and the feed to gain ration. Supplementation of Xylanase showed that positive body weight gain and feed to gain ration (Silverslides and Bedford; 1999). Addition of Xylanase significantly improved the weight gain upto 21 days of age and decreased the feed to gain ration slightly (Danicke et al; 2001). Supplementation of Xylanase was improved the feed efficacy and body weight gain (Mathlouthi N, Jumin H, Larbir M; 2003).

In the present study there was no significant change found in the serum cholesterol level. Cholesterol level is higher in control group as compared to group E (1000IU/Kg feed) and found similar in group B (250IU/Kg feed), group C (500IU/Kg feed) and group D (750IU/Kg feed). From research the results showed that xylanase had no effect on cholesterol level of broiler chicks. The triglyceride values were found no-significant results in control group as compared to group B (250IU/Kg feed), group C (500IU/Kg feed), group D (750IU/Kg feed) and group E (1000IU/Kg feed). The current study in broilers showed that serum glucose level non- significantly raised in experimental groups of broilers treated with Xylanase. Greater raised in serum glucose level was not observed in groups. From the present study, there was significant effect on ALT, AST and Bilirubin; it showed that as we were increasing the dose concentration of xylanase, effect on ALT and AST was increasing. So from this experiment it was concluded that Xylanase effected on ALT and AST. Bilirubin level in serum showed higher result in group C (500IU/Kg feed) as compared to control group but was found similar to group B (250IU/Kg feed), group D (750IU/Kg feed) and group E (1000IU/Kg feed).From this research significant results observed for ALT and AST in all experimental groups. Different enzymes are considered as biomarkers and can be used to asses liver and kidney functions. The higher serum AST and ALT concentrations indicate the release of aminotransferase from cytoplasm to blood stream probably due to damage liver or different other tissues. Similar results have also been reported that Xylanase increased activities of serum AST and ALT (Kongbuntad et al 2006) have been reported in chickens. Xylanse affected on urea level of broiler chicks that was revealed from the research. Urea level was significantly higher in group B(250IU/Kg feed) than group C(500IU/Kg feed) and group D(750IU/Kg feed) and was found similar to control group and group E(1000IU/Kg feed).The significant results were found among the groups ($p<0.05$).The result showed that effect of Xylanse was non-significant effect on control group as compared to all other treated groups B(250IU/Kg feed), C(500IU/kg feed), D(750IU/Kg feed) and E(1000IU/Kg feed).

In the current study there was no significant change in total protein level .Total protein value

found higher in group C(500IU/Kg feed), group D (750IU/Kg feed)than B (250IU/Kg feed), but was found similar in group E and control group. The test result revealed that serum level of glucose was higher in control group as compared to other treated group B(250IU/Kg feed), C(500IU/Kg feed), D(750IU/Kg feed) and E(1000IU/Kg feed. The non-significant result of Albumin and Globulin was found in the current study. From the research it was found that Xylanase was no affected on Albumin and Globulin level. Present study results showed on serum parameters that xylanase supplementation in groups B (250IU/Kg feed), C(500IU/Kg feed), D(750IU/Kg feed) and E(1000IU/Kg feed) had no significant effects as compared to control group while slight increase in AST was observed in group E(1000IU/Kg feed) as compared to the other groups. In other study, non-significant results for erythrocyte and white blood cell counts while decreased levels of pack cell volume and hemoglobin concentrations have been reported (Apata, 2010).

In present study, statistical analysis had shown that xylanase supplementation had no toxic effect on different liver enzymes including ALP, AST and ALT and total bilirubin concentrations. Similar results had also been reported that xylanase given as supplementary in feed in broiler chicken had no adverse effects on liver, kidneys and various internal organs (Gao et al., 2008).

REFERENCES

Ahmad Z, Butt MS, Hussain R, Ahmed A and Riaz M. 2013. Effect of Oral Application of Xylanase on Some Hematological and Serum Biochemical Parameters in Broilers. Pak Vet J, 33(3), 388-390.

Apata DF. 2010. Effects of treatment methods on the nutritional value of cotton seed cake for laying hens. Agricultural Sciences, 1(02), 51.

Barekatain MR, Antipatis C, Rodgers N, Walkden-Brown SW, Iji PA and Choct M. 2013a. Evaluation of high dietary inclusion of distillers dried grains with solubles and supplementation of protease and xylanase in the diets of broiler chickens under necrotic enteritis challenge. Poult Sci, 92(6), 1579-1594.

Barekatain MR, Choct M and Iji PA. 2013b. Xylanase supplementation improves the nutritive value of diets containing high levels of sorghum distillers' dried grains with solubles for broiler chickens. J Sci Food Agric, 93(7), 1552-1559.

Bedford MR and Classen HL. 1992. Reduction of intestinal viscosity through manipulation of dietary rye and pentosanase concentration is effected through changes in the carbohydrate composition of the intestinal aqueous phase and results in improved growth rate and food conversion efficiency of broiler chicks. J Nutr, 122(3), 560-569.

Bedford MR and Classen HL. 1993. An in vitro assay for prediction of broiler intestinal viscosity and growth when fed rye-based diets in the presence of exogenous enzymes. Poult Sci, 72(1), 137-143.

Bedford MR, Classen HL and Campbell GL. 1991. The effect of pelleting, salt, and pentosanase on the viscosity of intestinal contents and the performance of broilers fed rye. Poult Sci, 70(7), 1571-1577.

Choct M and Annison G. 1992. Anti-nutritive effect of wheat pentosans in broiler chickens: roles of viscosity and gut microflora. Br Poult Sci, 33(4), 821-834.

Choct M, Hughes RJ and Bedford MR. 1999. Effects of a xylanase on individual bird variation, starch digestion throughout the intestine, and ileal and caecal volatile fatty acid production in chickens fed wheat. Br Poult Sci, 40(3), 419-422.

Choct M, Kocher A, Waters DL, Pettersson D and Ross G. 2004. A comparison of three xylanases on the nutritive value of two wheats for broiler chickens. Br J Nutr, 92(1), 53-61.

Cowieson AJ, Hruby M and Faurschou Isaksen M. 2005. The effect of conditioning temperature and exogenous xylanase addition on the viscosity of wheat-based diets and the performance of broiler chickens. Br Poult Sci, 46(6), 717-724.

Cowieson AJ, Singh DN and Adeola O. 2006. Prediction of ingredient quality and the effect of a combination of xylanase, amylase, protease and phytase in the diets of broiler chicks. 1. Growth performance and digestible nutrient intake. Br Poult Sci, 47(4), 477-489.

Danicke S, Simon O, Jeroch H and Bedford M. 1997. Interactions between dietary fat type and xylanase supplementation when rye-based diets are fed to broiler chickens. 1. Physico-chemical chyme features. Br Poult Sci, 38(5), 537-545.

Gao F, Jiang Y, Zhou GH and Han ZK. 2008. The effects of xylanase supplementation on performance, characteristics of the gastrointestinal tract, blood parameters and gut microflora in broilers fed on wheat-based diets. Animal Feed Science and Technology, 142(1–2), 173-184.

Gehring CK, Bedford MR and Dozier WA, 3rd.

2013. Extra-phosphoric effects of phytase with and without xylanase in corn-soybean meal-based diets fed to broilers. Poult Sci, 92(4), 979-991.

Ghazi S, Rooke JA, Galbraith H and Bedford MR. 2002. The potential for the improvement of the nutritive value of soya-bean meal by different proteases in broiler chicks and broiler cockerels. Br Poult Sci, 43(1), 70-77.

Guo S, Liu D, Zhao X, Li C and Guo Y. 2014. Xylanase supplementation of a wheat-based diet improved nutrient digestion and mRNA expression of intestinal nutrient transporters in broiler chickens infected with Clostridium perfringens. Poult Sci, 93(1), 94-103.

Henry RJ. 1985. A comparison of the non-starch carbohydrates in cereal grains. J Sci Food Agric, 36(12), 1243-1253.

Hubener K, Vahjen W and Simon O. 2002. Bacterial responses to different dietary cereal types and xylanase supplementation in the intestine of broiler chicken. Arch Tierernahr, 56(3), 167-187.

Jozefiak D, Rutkowski A, Kaczmarek S, Jensen BB, Engberg RM and Hojberg O. 2010. Effect of beta -glucanase and xylanase supplementation of barley- and rye-based diets on caecal microbiota of broiler chickens. Br Poult Sci, 51(4), 546-557.

Kongbuntad W, Khanongnuch C and Lumyong S. 2006. Efficacy of xylanase supplementation produced from Thermoascus aurantiacus SL16W in diet on Thai native chicken performance. International Journal of Poultry Science, 5(5), 463-469.

Liu D, Guo S and Guo Y. 2012. Xylanase supplementation to a wheat-based diet alleviated the intestinal mucosal barrier impairment of broiler chickens challenged by Clostridium perfringens. Avian Pathol, 41(3), 291-298.

Luo D, Yang F, Yang X, Yao J, Shi B and Zhou Z. 2009. Effects of Xylanase on Performance, Blood Parameters, Intestinal Morphology, Microflora and Digestive Enzyme Activities of Broilers Fed Wheat-based Diets FAU - Luo, Dingyuan FAU - Yang, Fengxia FAU - Yang, Xiaojun FAU - Yao, Junhu FAU - Shi, Baojun FAU - Zhou, Zhenfeng. Asian Australas. J. Anim. Sci, 22(9), 1288-1295.

Marron L, Bedford MR and McCracken KJ. 2001. The effects of adding xylanase, vitamin C and copper sulphate to wheat-based diets on broiler performance. Br Poult Sci, 42(4), 493-500.

Mushtaq T, Sarwar M, Ahmad G, Nisa MU and Jamil A. 2006. The influence of exogenous multienzyme preparation and graded levels of digestible lysine in sunflower meal-based diets on the performance of young broiler chicks two weeks posthatching. Poult Sci, 85(12), 2180-2185.

Nian F, Guo YM, Ru YJ, Peron A and Li FD. 2011. Effect of xylanase supplementation on the net energy for production, performance and gut microflora of broilers fed corn/soy-based diet. Asian - Australasian Journal of Animal Sciences, 24(9).

Ravindran V, Selle PH and Bryden WL. 1999. Effects of phytase supplementation, individually and in combination, with glycanase, on the nutritive value of wheat and barley. Poult Sci, 78(11), 1588-1595.

Sheng QK, Yang LQ, Zhao HB, Wang XL and Wang K. 2013. Effects of Low Level Water-soluble Pentosans, Alkaline-extractable Pentosans, and Xylanase on the Growth and Development of Broiler Chicks. Asian-Australas J Anim Sci, 26(9), 1313-1319.

Silva SS and Smithard RR. 2002. Effect of enzyme supplementation of a rye-based diet on xylanase activity in the small intestine of broilers, on intestinal crypt cell proliferation and on nutrient digestibility and growth performance of the birds. Br Poult Sci, 43(2), 274-282.

Silversides FG and Bedford MR. 1999. Effect of pelleting temperature on the recovery and efficacy of a xylanase enzyme in wheat-based diets. Poult Sci, 78(8), 1184-1190.

Wongputtisin P, Khanongnuch C, Kongbuntad W, Niamsup P, Lumyong S and Sarkar PK. 2014. Use of Bacillus subtilis isolates from Tua-nao towards nutritional improvement of soya bean hull for monogastric feed application. Lett Appl Microbiol, 59(3), 328-333.

Wu YB, Ravindran V, Thomas DG, Birtles MJ and Hendriks WH. 2004a. Influence of method of whole wheat inclusion and xylanase supplementation on the performance, apparent metabolisable energy, digestive tract measurements and gut morphology of broilers. Br Poult Sci, 45(3), 385-394.

Wu YB, Ravindran V, Thomas DG, Birtles MJ and Hendriks WH. 2004b. Influence of phytase and xylanase, individually or in combination, on performance, apparent metabolisable energy, digestive tract measurements and gut morphology in broilers fed wheat-based diets containing adequate level of phosphorus. Br Poult Sci, 45(1), 76-84.