

EFFECT OF DIFFERENT ENERGY LEVELS WITH OR WITHOUT XYLANASE ENZYME ON PRODUCTIVE PERFORMANCE AND PHYSIOLOGICAL STATUS OF BROILER CHICKS

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SUMMARY

An experiment was conducted to investigate the effect of xylanase supplemented diet by its role to remove anti-nutritive effect of non-starch polysaccharide (NSP) is well established and optimizing the ME utilization. A total of 315, one-day-old unsexed Cobb broiler chicks, were randomly assigned into seven experimental groups of 3 replicates each with 15 birds in each replicate. The chicks were offered corn-soybean meal basal mash diets that was prepared to contain 3000 kcal ME/kg and 23% crude protein during starter period till 21 days of age, followed by 3100 kcal ME/kg and 21% crude protein during grower period till 35 days of age, and 3200 kcal ME/kg and 19% crude protein during grower period till 42 days of age. One of the seven experimental groups was fed this diet as such to serve as control while, the remaining six groups were fed the lowered ME levels by 150 or 300 kcal compared basal diet and supplemented with 0, 100 and 200 mg xylanase/kg diet during starter, grower, and finisher periods, respectively. The obtained results revealed that the highest ($P \leq 0.05$) body weight and weight gain recorded of birds fed dietary T3 compared to control group. Birds fed dietary T3 and control group consumed approximately similar amounts of feed and recorded a significantly better feed conversion ratio (FCR) than the control. Relative carcass weight yielded of broilers fed dietary treatment and control basal diet were statically ($P \leq 0.05$) similar, except those fed dietary T4 recorded a significant lower value of carcass yield compared with either control or other treatment groups. Total edible parts were significantly heavier of birds fed xylanase-supplemented diets (T3, and T6) compared with that of the control and other groups. Birds fed dietary T3 recorded the highest ($P \leq 0.05$) value of relative thymus and spleen weight compared others. While, insignificant differences were observed of bursa among other treatments. The hematological parameters (Hb, PCV, RBCs and WBCs) were significantly ($p \leq 0.01$) improved of birds fed dietary T3 compared with counterparty of control. Total protein, albumin and globulin were significantly increased while, the concentration of triglycerides and cholesterol were significantly decreased of birds fed dietary T3 and T2 compared with the control group.

Keywords: *Xylanase, dietary energy, performance, broiler chickens*

INTRODUCTION

Energy continues to be economically important in broiler feeding. The metabolizable energy (ME) level of diet is one of the key factors for rapid growth of broiler chicks. Addition of enzymes to feed ingredients for improving energy availability has received much attention by animal nutritionists and feed manufacturers. Supplementation with enzymes can help to eliminate the effects of anti-nutritional factors and improve the utilization of dietary energy and amino acids, resulting in improved performance of chicks (YU *et al.*, 2007). A common feature of cereal grains, cereal co-products and protein crops other than corn and soybean are their generally higher non starch polysaccharides (NSP) content and fiber (NSP plus lignin) composition, particularly in soluble form (Theander *et al.*, 1989; Bach Knudsen, 1997). For instance, fiber, soluble fiber in particular, has been found to have a detrimental influence on the utilization of nutrients in broilers (Pettersson and Aman, 1989; Choct and Annison, 1990; McNab and Smithard, 1992). This is due to the physical presence of fiber in the gastrointestinal tract where the physical barrier of the cell walls (CW) can encapsulate potentially available nutrients (i.e., protein in the aleuronic cells). In addition, the viscous properties of soluble NSP may interfere with the digestion process and thereby reduce the digestibility of other nutrients i.e., fat and protein (Choct and Annison, 1992; Steinfeldt, 2001). Cereal grains constitute the largest part of NSP and fiber in the diet for broilers, most emphasis will be devoted to cereal cell walls (CW) polysaccharides. Xylanase supplementation of poultry diets is commonly used to optimize nutrient uptake particularly from the cereal fraction (Aftab and Bedford, 2018). Many studies showed that xylanase improves growth rate and feed efficiency in broilers Gonzalez-

Ortiz et al., (2019), who noted that body weights of broilers given a combination of xylanase (control diet with 16,000 BXU/kg of xylanase), were significantly heavier compared with their control group. In addition, broilers that received xylanase enzyme during periods 0 to 35 d and 0 to 42 d had higher body weights than those fed non-supplemented diet O'Neill *et al.*, (2012). Xylanase plays a vital role in many physiological and biochemical processes in the organism. Hajati, (2010), who found that serum total cholesterol, was significantly decreased in adding Endo feed-W multi-enzyme to broilers diet than of that the control group.

Objective of this study was to investigate to effect of xylanase supplemented diet by its role to remove anti-nutritive effect of NSP is well established and optimizing the ME utilization.

MATERIALS AND METHODS

Three hundred and fifteen (315) one-day-old unsexed Cobb broiler chicks, purchased from a commercial hatchery, were individually weighed to the nearest gram and randomly assigned into seven experimental groups of 3 replicates each with 15 birds in each replicate and were housed in a clean floor pens. The chicks were offered corn-soybean meal basal mash diets that was prepared to contain 3000 kcal ME/kg and 23% crude protein during starter period till 21 days of age, followed by 3100 kcal ME/kg and 21% crude protein during grower period till 35 days of age, and 3200 kcal ME/kg and 19% crude protein during grower period till 42 days of age. One of the seven experimental groups was fed this diet as such to serve as control while, the remaining six groups were fed the lowered ME levels by either 150 or 300 kcal ME compared with basal diet supplemented with 0,100 and 200 mg xylanase/kg diet during starter, grower, and finisher periods respectively. All chicks were subjected to similar managerial, hygienic and environmental conditions with ad-libitum supply of feed and water throughout the entire experimental period that lasted for 6 weeks. Generally, the experimental diet was distributed as follows:

Control fed basal diet. T1, T2 and T3 fed low ME by 150 kcal during starter, growing and finishing period and supplemented with 0,100 and 200 mg xylanase /kg diet, respectively.

T4, T5 and T6 fed low ME by 300 kcal during starter, growing and finishing period and supplemented with 0,100 and 200mg xylanase/kg diet, respectively. The compositions and calculated analysis of the diets are detailed in Table (1).

Measurements

The response of birds was assessed in terms of weekly body weights, weight gain, feed consumption, feed conversion ratio and mortality rate were estimated throughout the experimental period from day-old to 6 weeks of age. At 42 days of age, three birds from each replicate were taken randomly were sacrificed scalded de-feathered and carcass were eviscerated. Data on carcass yields and weights of visceral, lymphoid organs were collected. The heart, gizzard, liver, bursa and thymus were excised and weighed. 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 body weight of birds multiplied by 100. Two blood samples were collected from each bird during slaughtering; one test tube Edeta-congaing to analysis parameters of hematological examination such as white blood cells (WBCs), red blood cells (RBCs), hemoglobin (Hb), and packed cell volume (PCV), and other tubes in non Edeta to harvest serum by center fusion. Blood serum samples were analyzed for the concentration of total lipids (Frings and Dunn, 1970), cholesterol (Allain, 1974) and triglyceride (Fossati and Prencipe, 1982) were determined using commercial kits. Concentration of serum total proteins and albumin were calorimetrically estimated (Dumas *et al.*, 1971). While serum globulin concentration was obtained by subtracting the concentration of albumin from total proteins.

Statistical Analysis

Data were statistically analyzed by one-way analysis of variance using the General Linear Models (GLM) procedure of SPSS (1997). Tests of significance for the differences among means of different variables were done according to Duncan's new multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Growth performance

Live body weight and body weight gain of broiler chicken that fed different energy levels supplemented with Xylanase during experimental period are presented in Tables 2. From these results in Table 2, it can be noticed that initial body weights of chickens were nearly similarly, indicating an efficient well randomization process. At the end of experimental period, live body weight and body weight gain were significantly affected by dietary treatments. Whereas, at the end of finisher experimental period, birds fed dietary T3 recorded heavier live body weight (2511.3 gm) followed by statistically ($p < 0.05$) similar values (2381.5 gm, 2366.6 gm, 2308.5 gm and 2304.4 gm) of those fed basal control, T2, T6 and T5 respectively. While, the worst live body weights values were (2177.0 gm and 2188.0 gm) of those fed dietary T4 and T2 respectively.

From Table 2 it can be noticed that significant differences of body weight gain, the highest value (2467.5 gm) were observed of birds fed dietary T3 followed by (2337.3 gm, 2323.3 gm) of those fed basal control and T2 compared with other groups, respectively. But, the lighter body weight gain (2132.9 gm and 2143.7 gm) recorded of those fed dietary T4 and T1, respectively.

Generally, at the end experimental periods it can be concluded that birds fed dietary T3 achieved heavier live body weight and body weight gain by 5.5% and 5.6% compared to counterparty those fed control basal diet. The improving of growth performance may be partially due to the positive effect of xylanase supplemented diet by its role to remove anti-nutritive effect of NSP is well established and optimizing the ME utilization. In addition to enhancing nutrient utilization, the enzymes also offer other benefits. These include an overall decrease in the output of organic matter in the excreta due to the better utilization of nutrients, a reduction in the moisture content of the excreta due to decreased gut viscosity, and an improvement in animal health due to the prevention of diseases associated with the proliferation of gut micro flora. Xylanase supplementation of poultry diets is commonly used to optimize nutrient uptake particularly from the cereal fraction (Aftab and Bedford, 2018). There are several suggested mechanisms: firstly, the hydrolysis of soluble arabinoxylans to reduce digesta viscosity (Choct *et al.*, 2004); secondly, the abrasion of the cell walls of the feedstuff by the direct action of the xylanase, consequently reducing the lag time for bacterial attachment thus accelerating fermentation (Bedford, 2018); thirdly, releasing the nutrients trapped inside the cell walls also referred to as "cage effect" (Bedford, 2002).

The obtained results confirmed other studies by Masey O'Neill *et al.* (2014) reported that the majority of the available energy in wheat grains comes from starch that is stored intracellularly, and is partly inaccessible to poultry as their endogenous ability to degrade plant cell wall material is limited. Thus, supplementation with enzymes capable of degrading cell wall polysaccharides, i.e., xylanase, may allow pancreatic enzymes access to nutrients trapped within the cell and improve dietary metabolizable energy, however feeding a Xylanase would influence performance in part by generating butyrate in the ceca. This has been shown in the past to be a result of generation of fermentable XOS (Bedford, 2018) which preferentially select for butyrogenic pathways (Masey-O'Neill *et al.*, 2014). The results of the current investigation are consistent with the results observed Greenwood *et al.* (2004); Nunes *et al.* (2015); Niazi *et al.* (2017), and Hu *et al.* (2018), they observed that body weight and body weight gain were influenced by xylanase and energy containing diets.

Throughout the finishing experimental period feed consumption (g/bird) are presented in Table 2, birds fed diets containing dietary T3 and control consumed significantly ($p < 0.05$) less feed by (3945.9 gm and 3946.2 gm) followed by (4068.5 gm) of those fed dietary basal diet T2 compared with other groups respectively, additional birds fed dietary T6 by (4122.7 gm). While birds fed dietary T4 and T1 recorded the highest feed consumption by (4263.0 gm, 4224.4 gm), respectively, with no significant between two groups compared the control.

Finally, it was noticed that birds fed dietary T3 consumed significantly ($p < 0.05$) less feed consumed approximately similar amounts of feed compared with the control groups.

The lack of significant differences in feed intake of birds may be attributed to the low dose of xylanase, applied herein, and to the fact that birds were kept in similar hygienic conditions where there were no challenging factors affecting the gastrointestinal health of the birds. xylanase is routinely added to poultry diets at pharmacological concentrations for its growth-promoting effects Gonzalez-Ortiz *et al.* (2019). The present results agree with the findings of, Pirgozliev *et al.* (2015); Nunes *et al.* (2015), and Niazi *et al.* (2017) who indicated that dietary supplementation of birds with different energy with xylanase enzyme led to a significant decrease in feed consumption when compared with the control

group. Significant decreases of feed intake were also reported in xylanase supplemented diet in some studies Hajati (2010) and O'Neill *et al.* (2012).

Feed conversion ratio (g feed: g gain) illustrated in Table 2, birds fed dietary T3 displayed significantly better feed conversion ratio (FCR) by (1.599) followed by (1.688 and 1.751) of those fed dietary basal diet control and T2 respectively. But T4 recorded the worst feed conversion ratio by (1.998) compared with control.

Generally, from these results, for the reduction in feed consumption and weight gain the improvement of feed conversion ratio recorded in broilers fed dietary T3 by 18.36 % compared with counterparty of control. The improvement in feed conversion ratio may be related partially to the lower feed consumption and higher growth rate of the groups fed diet supplemented with xylanase or to the important role of xylanase as a growth promoter compared to the control group. Another possible reason for the improved feed conversion ratio (FCR) may be due to an increased utilization of dietary the energy as a result of adding xylanase. The current results harmonize with the results obtained by experimental work of Gonzalez-Ortiz *et al.* (2019), who noticed that Xylanase supplementation improved 42-D feed conversion ratio (FCR) by 5 points ($P = 0.006$). This effect is due to high content of healthy conditions of birds fed xylanase.

Mortality rate of birds was not related to the effects of dietary treatments. So, it can be noticed that mortality rate was not influenced by low energy levels with or without xylanase enzyme supplemented diet. The absence of deaths in most dietary treatments and the presence of some accidental mortality in others may indicate that the chicks had good healthy status. It can be the immune response of birds fed dietary xylanase improved as a result of antimicrobial and antiviral properties of xylanase enzyme supplementation. In line with the above results Nunes *et al.* (2015) the results showed that the mortality rate was not affected by xylanase levels in period of growth or trail. The same results were observed by O'Neill *et al.* (2012). They observed that, mortality was not influenced by xylanase supplementation.

Carcass traits

As given in Table (3), relative carcass weight yield of broilers fed dietary treatment and control basal diet were statically ($P \leq 0.05$) similar, except those fed dietary T4 recorded a significant lower value of carcass yield compared with either control or other treatment groups. From Table 3, relative total edible parts weights of broilers fed dietary treatment and control basal diet were significantly ($P \leq 0.05$) affected birds fed the xylanase-supplemented diets (T3, and T6) had significantly higher ($P \leq 0.05$) the total edible parts compared with that of the control group. Whereas the highest values (81.02 and 80.32) recorded of birds fed dietary T3 and T6 respectively and statically equal to that of the control. While the lowest values (77.05) of birds fed dietary T4 compared the control and other groups.

The current results showed also, average relative weight of lymphoid organs that mostly responsible for immunological response in birds are recorded in Table 4. Thymus and spleen as a relative weight were significantly ($P \leq 0.05$) affected by dietary treatments. While, insignificant differences were observed of bursa among treatments. The highest ($P \leq 0.05$) value (0.48) of relative thymus weight recorded of birds dietary T3 follow by (0.45, 0.43 and 0.42) of those fed dietary T6, T2 and T5 respectively. The same was observed with spleen relative weight, whereas, the highest weight (0.17) of spleen yielded from birds fed dietary T3 followed by 0.15, 0.15 and 0.14 % of those fed dietary T6, T2 and T5, respectively. While the lowest value (0.07) recorded of group fed dietary T4 compared with those of the control and other groups. The observed improvement in carcass yield and total edible parts may be related to increasing live body weight in response to dietary xylanase supplementation to broiler diet. In line with the present results, several authors reported that carcass yield of broiler chickens and ducklings were significantly increased by dietary inclusion of xylanase enzyme and energy levels as compared to the control diet as (Kassim and Suwanpradit 1996, and Hajati, (2010). On the other hand, Nunes *et al.* (2015) they found that enzymes combinations did not affect on ($p > 0.05$) carcass or parts yields. Hu *et al.* (2018) they noticed that liver, breast muscle, and gizzard were not influenced ($p > 0.05$) by dietary treatments. At the end of experimental period, weight of thymus, bursa and spleen significantly ($P \leq 0.05$) increased for groups received 100 and 200 mg xylanase /kg diet compared to the control, the observed increase in relative weights of lymphoid organs in increasing of lymphoid organs weight within the normal range. These results may be as response to dietary xylanase enzyme supplementation can be considered an indicator of good healthy status of chicks. In this regard, Bennett and Stephens (2006) reported that, the bursa functions are half of the bird's immune system and the size of the bursa reflects the bird's overall health status. Sick or stressed birds have small bursa. On contrast, Golian *et al.* (2010) they sustained that, the bursa of

fabricius and spleen relative weights were not significant different in chicks fed diets with various levels of energy.

Blood hematological parameters

The hematological parameters of broilers chicks as affected by low energy levels with xylanase supplementation are tabulated in Table 5. The hematological parameters of broilers chicks were significantly ($p \leq 0.01$) affected by dietary treatments. Whereas the highest values ($p \leq 0.05$) of hemoglobin were (13.80) of birds fed dietary T3 follow by (13.56, 13.03 and 13.20) of those fed dietary T6, T5 and T2, respectively. While the lowest values (12.46 and 12.50) were statistically equal of the control birds. The same trend was observed of packed cell volume (PCV) whereas the highest values (42.4, 41.7 and 40.6) recorded of broilers fed dietary T3, T6, and T2 compared with control and other groups respectively. While birds fed dietary T4 and T1 recorded the lowest values (38.4 and 38.5) with statistically equal to (38.6) of the control group respectively. Birds fed the xylanase-supplemented diets had significantly higher ($P \leq 0.05$) count of red blood cells (RBCs) compared with that of the control group. Whereas the highest RBCs count (3.6, 3.52, 3.4, and 3.34) recorded that fed dietary T3, T2, T6, and T5 respectively.

Concerning the white blood cells (WBCs), the WBCs count linearly increased in response to increasing xylanase supplementation levels. Whereas the superior ($P \leq 0.05$) values were (18.5) observed of birds fed dietary T3, followed by 18.26, 18.03 and 17.93 of those fed dietary T6, T2 and T5, that statistically equal (17.9) to those fed dietary control respectively. The slightly increased hemoglobin level, in response to xylanase supplementation observed in this study, could be explained assuming that xylanase improves the digestive utilization of Mineral elements, especially iron and the regeneration efficiency of hemoglobin.

The higher hematocrit level may be had enhanced oxygen delivery to the tissue (Zongo and Petitjean, 1990). Also, this increase is supposed to be caused by increased blood volume as a reaction to increasing body oxygen requirement. The results of hematological parameters of the present study may be indicator for good health and immune system of birds as affected by dietary xylanase supplementation.

Blood biochemical parameters

The biochemical parameters of broiler chicks affected by dietary treatments are tabulated in Table 6. Serum total protein of birds received dietary T3 and T2 recorded the highest ($P \leq 0.05$) values (4.46 and 4.30) statistically equal with (4.20) of those fed control basal diet respectively, while other birds groups achieved the lowest values as shown in Table 6. The same trend was observed with albumin concentration whereas birds fed dietary T3 and T2 recorded higher value (1.6 and 1.56) followed by (1.53) of those received dietary T6 that statistically equal with (1.5) of birds fed control diet. The obtained results indicated also, a low concentration of albumin (1.3, 1.33, and 1.4) was observed of birds fed dietary T4, T2, and T5 compared another group respectively.

From Table 6 it can be noticed that also, birds received dietary T3 exhibited significantly higher serum globulin (2.86), compared with other groups follow by (2.74, 2.70 and 2.23) of those fed dietary T2, control and T6 respectively. The increase in serum total protein, albumin, and globulin may interpret to some extent the increase of liver activity. Since globulin was statistically affected by xylanase supplementation whereas it's important role to improve the utilization of dietary nutrients.

Generally, it can conduce that serum total protein, albumin and globulin concentration were significantly increased by xylanase inclusion in lowered energy diets. From table 6, concentration of serum triglycerides and cholesterol were significantly ($P \leq 0.05$) decreased with increasing the level of xylanase supplementation. Whereas birds fed dietary T3 recorded significantly less concentration serum triglycerides compared with control by 42.05%, followed by birds fed dietary T2 and T6 the exhibited significant low serum triglycerides by 20.81%, and 17.49% compared with the control, with no significant between of these groups. While, there are not significantly different between the rest groups from that of the control group.

Finally, it could be concluded that concentration of triglycerides and cholesterol were significantly decreased of bird's groups fed dietary treatments compared with the control group, but chicks fed dietary T6 reduce approximately similar concentration of triglycerides and cholesterol in serum blood, compared with the control. Generally, it can observe that the concentration of serum triglycerides and cholesterol were significantly ($P \leq 0.05$) decreased with increasing the level of xylanase supplementation. The current results are supported the finding by Hajati (2010), who found that serum total cholesterol, was significantly decreased in adding Endo feed-W multi-enzyme to broilers diet than of that the control

group. Also, in the obtained results by Hu *et al.* (2018) and Ozek and bahtiyarca (2004). In addition to Hu *et al.* (2018) found that high energy levels and enzyme supplementation decrease plasma total cholesterol.

CONCLUSION

From our data, it can be concluded that the 150-kcal reduction in dietary ME energy can be compensated by the addition of 100 or 200 mg xylanase per kg diet without any adverse effects on productive performance and physiological of broiler chicks.

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تأثير المستويات المختلفة من الطاقة مع او بدون انزيم الزيلاينز على الاداء الإنتاجي والحالة الفسيولوجية لكتاكيت التسمين

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اجريت هذه التجربة لتحديد تأثير انزيم الزيلاينز المضاف لعلائق الدواجن في إزالة التأثير المضاد للمواد السكرية غير النشوية واستخدام الطاقة الغذائية بشكل جيد. استخدمت في هذه التجربة (315) كتكوت عمر يوم واحد من نوع كوب، تم تقسيمها عشوائياً إلى سبع مجموعات تجريبية من 3 مكررات، في كل مكررة 15 طائر. استخدمت عليقة تجريبية تحتوي على 3000 سعر حراري/كجم و 23% بروتين خام خلال فترة البدايه حتى عمر 21 يوم، تليها 3100 سعر حراري/كجم و 21% بروتين خام خلال فترة النمو حتى عمر 35 يوماً، و 3200 سعر حراري/كجم و 19% بروتين خام خلال فترة النمو حتى عمر 42 يوماً. تم تغذية إحدى المجموعات التجريبية السبع بهذا النظام الغذائي ليكون بمثابة مجموعة كنترول بينما تم تغذية المجموعات الست المتبقية بمستويات منخفضة من الطاقة الغذائية بمقدار 150 أو 300 سعر حراري تحتوي على نظام غذائي أساسي مكمل بـ 100 و 200 مجم زيلاينز/كجم خلال فترات الابداء، النامي، والنهائي على التوالي. أوضحت النتائج المتحصل عليها أن الطيور التي تغذت على الغذاء T3 سجلت أعلى زيادة في وزن الجسم ووزن الجسم المكتسب مقارنة بالكنترول. كما استهلكت الطيور المتغذية على النظام الغذائي T3 كميات مماثلة تقريباً من الأعلاف مع مجموعة الكنترول. وأظهرت الطيور التي تغذت على النظام الغذائي T3 نسبة معامل تحويل غذائي أفضل بكثير من مجموعة الكنترول. وكان معدل الوزن النسبي للذبيحة للدجاج الذي تم تغذيته على عليقة الكنترول وباقي العلائق متشابهة إحصائياً ($P > 0.05$)، توقع بينما التي تم تغذيتهم على علائق T4 سجلوا قيمة أقل معنوياً لمحصول الذبيحة مقارنة مع مجموعة الكنترول أو المعاملات الأخرى. كانت الطيور التي تغذت على العلائق التي تحتوي على انزيم الزيلاينز (T3 و T6) أعلى بكثير ($P > 0.05$) في إجمالي الأجزاء الصالحة للأكل مقارنة بمجموعة الكنترول. سجلت الطيور المتغذية على النظام الغذائي T3 أعلى قيمة ($P > 0.05$) للوزن النسبي لغدة الثيموث والطحال مقارنة بالكنترول، بينما لا توجد فروق معنوية لغدة البرسا بين المعاملات. تأثرت المتغيرات الدموية (الهيموجلوبين، حجم كرات الدم، كرات الدم الحمراء و كرات الدم البيضاء) لكتاكيت التسمين معنوياً ($p \leq 0.01$) بالطيور التي تغذت على T3 مقارنة بنظيرتها من الكنترول. الطيور التي تغذت على الغذاء T3 و T2 زادت معنوياً في البروتين الكلي والألبومين والجلوبولين وخفضت من تركيز الدهون الثلاثية والكوليسترول في الدم مقارنة بالكنترول.

Table (1): Composition and calculated analysis of the experimental diets.

| Ingredients | Starter period | | | Grower period | | | Finisher period | | |
|----------------------------|-----------------------------------|---------------------------|----------------------------|-----------------------------------|----------------------------|----------------------------|-----------------------------------|-----------------------------|-----------------------------|
| | 3000kcal /kg diet (control) | 2850kcal /kg diet □ | 2700 kcal /kg diet □ | 3100kcal /kg diet (control) | 2950kcal /kg diet □□ | 2800kcal /kg diet □□ | 3200kcal /kg diet (control) | 3050kcal /kg diet □□□ | 2900kcal /kg diet □□□ |
| Yellow corn | 55.00 | 53.00 | 49.00 | 57.30 | 60.00 | 56.90 | 62.00 | 65.40 | 64.30 |
| Soybean meal (44% CP) | 31.50 | 30.50 | 28.50 | 30.70 | 30.50 | 29.00 | 25.50 | 25.00 | 23.50 |
| Corn gluten meal (62%) | 8.00 | 8.00 | 8.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Wheat bran | 0.00 | 4.50 | 11.00 | 0.00 | 0.00 | 5.50 | 0.00 | 0.00 | 4.00 |
| Soybean oil | 2.00 | 0.50 | 0.00 | 3.60 | 0.90 | 0.00 | 4.30 | 1.40 | 0.00 |
| Limestone | 1.30 | 1.30 | 1.30 | 1.20 | 1.40 | 1.40 | 1.20 | 1.20 | 1.20 |
| Dicalcium phosphate | 1.60 | 1.60 | 1.60 | 1.60 | 1.60 | 1.60 | 1.40 | 1.40 | 1.40 |
| Salt | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| (Premix)* | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Calculated analysis | | | | | | | | | |
| Crude protein (%) | 23.06 | 23.18 | 23.00 | 21.02 | 21.14 | 21.10 | 19.09 | 19.13 | 19.02 |
| ME (kcal/kg) | 3014 | 2853 | 2715 | 3102 | 2953 | 2809 | 3204 | 3055 | 2915 |
| Ether extracte (%) | 2.74 | 2.82 | 2.90 | 2.74 | 2.84 | 2.92 | 2.84 | 2.97 | 3.06 |
| Crude fibre (%) | 3.72 | 4.10 | 4.57 | 3.65 | 3.70 | 4.13 | 3.38 | 3.42 | 3.73 |
| Calcium (%) | 0.94 | 0.94 | 0.95 | 0.90 | 0.97 | 0.98 | 0.84 | 0.84 | 0.84 |
| Available phosphorus (%) | 0.45 | 0.46 | 0.48 | 0.44 | 0.45 | 0.46 | 0.40 | 0.40 | 0.41 |
| Lysine (%) | 1.14 | 1.13 | 1.11 | 1.08 | 1.09 | 1.07 | 0.92 | 0.94 | 0.95 |
| Methionine + Cystine (%) | 0.83 | 0.84 | 0.84 | 0.75 | 0.75 | 0.76 | 0.70 | 0.70 | 0.69 |
| Methionine (%) | 0.53 | 0.54 | 0.56 | 0.48 | 0.49 | 0.50 | 0.46 | 0.47 | 0.48 |

*Each 3 kg premix contains: Vit. A, 12000 IU; Vit. D3, 22000 IU; Vit. E, 10 mg; Vit. K, 2000mg; Thiamin, 1000 mg; Riboflavin, 5000 mg; Pyridoxine, 1500 mg; Cyanocobalamia, 10 mg; Folic acid, 1000 mg; Biotin, 50 mg; Pantothenic acid, 10 mg; Niacin, 30 mg; Iron, 30 mg; Copper, 10 mg; Selenium, 100 mg; Zinc, 50 mg; Manganese, 60 mg; Cobalt, 100 mg; Iodine, 1000 mg Choline chloride, 300mg and CaCo₃to 3g.

Control diets containing 3000, 3100 and 3200 kcal ME/kg respectively, without Xylanase supplementation

□ Diets containing 2850 and 2700 kcal ME/kg diet were supplemented with (0, 100 and 200 mg/kg diet) Xylanase enzyme.

□□ Diets having 2950 and 2800 kcal ME/kg diet were supplemented with (0, 100 and 200 mg/kg diet) Xylanase enzyme.

□□□ Diets containing 3050 and 2900 kcal ME/kg diet were supplemented with (0, 100 and 200 mg/kg diet) Xylanase enzyme.

Table (2): Effect of dietary treatments on performance traits of broiler chicks during experimental periods.

| Dietary treatments | Initial live body weight (g) | Final live body weight | Dietary treatments | Initial live body weight (g) | Final live body weight |
|--------------------|------------------------------|------------------------|--------------------|------------------------------|------------------------|
| Control | 44.2 | 2381.5b | 2337.3b | 3946.2e | 1.688bc |
| T1 | 44.3 | 2188.0c | 2143.7c | 4224.4a | 1.970a |
| T2 | 44.3 | 2366.6b | 2323.3b | 4068.5d | 1.751b |
| T3 | 43.8 | 2511.3a | 2467.5a | 3945.9e | 1.599c |
| T4 | 44.1 | 2177.0c | 2132.9c | 4263.0a | 1.998a |
| T5 | 44.4 | 2304.4b | 2260.0b | 4171.8b | 1.845ab |
| T6 | 44.2 | 2308.5b | 2264.3b | 4122.7c | 1.820ab |
| SEM§ | +0.14 | + 12.38 | + 13.70 | +11.27 | +0.35 |
| Significance | NS | ** | * | ** | * |

^{a,b,c} Means within the same column bearing different superscripts differ significantly ($P < 0.05$). NS= not significant. * = $P < 0.05$. ** = $P < 0.01$.

§: Standard error of the means

Table (3): Effect of dietary treatments on relative weights (% of LBW) 1 of carcass traits during experimental periods of broiler chicks.

| Parameters | Control | T1 | T2 | T3 | T4 | T5 | T6 | SEM§ | Sig ² |
|-----------------|----------|----------|----------|--------|--------|---------|---------|--------|------------------|
| Carcass yield % | 75.07a | 74.79a | 73.08a | 74.68a | 69.23b | 72.26ab | 75.13a | + 0.58 | * |
| Liver % | 2.31bc | 2.16c | 2.55abc | 2.93a | 2.34bc | 2.33bc | 2.68ab | + 0.06 | * |
| Gizzard % | 2.25ab | 2.26ab | 2.05bc | 2.61a | 1.73c | 1.81c | 2.55a | + 0.08 | * |
| Heart % | 0.52ab | 0.50b | 0.59ab | 0.67a | 0.48b | 0.61ab | 0.63ab | + 0.22 | * |
| TEP3 % | 79.27abc | 79.71abc | 78.79bcd | 81.02a | 77.05d | 78.06cd | 80.32ab | + 0.34 | ** |

^{a,b,c} Means within the same column bearing different superscripts differ significantly ($P < 0.05$). NS= not significant. * = $P < 0.05$. ** = $P < 0.01$.

§: Standard error of the means.

¹⁻² Refers to, live body weight, Significance, total edible parts, respectively.

Table (4): Effect of dietary treatments on relative weights (% of LBW) of lymphoid organs during experimental periods of broiler chicks.

| Parameters | Control | T1 | T2 | T3 | T4 | T5 | T6 | SEM§ | Sig ² |
|------------|--------------------|--------------------|--------------------|-------------------|-------------------|--------------------|--------------------|--------|------------------|
| Thymus | 0.37 ^{bc} | 0.32 ^{cd} | 0.43 ^{ab} | 0.48 ^a | 0.28 ^d | 0.42 ^{ab} | 0.45 ^{ab} | + 0.02 | * |
| Bursa | 0.15 | 0.14 | 0.17 | 0.19 | 0.14 | 0.16 | 0.19 | + 0.08 | NS |
| Spleen | 0.15 ^{ab} | 0.11 ^{bc} | 0.15 ^{ab} | 0.17 ^a | 0.07 ^c | 0.14 ^{ab} | 0.15 ^{ab} | + 0.08 | * |

^{a,b,c} Means within the same column bearing different superscripts differ significantly ($P < 0.05$). NS= not significant. * = $P < 0.05$. ** = $P < 0.01$.

§: Standard error of the means.

¹⁻² Refers to, live body weight, Significance, total edible parts, respectively.

Table (5): Effect of dietary treatments on hematological parameters of broiler chicks at the end of experimental period.

| Parameters | Control | T1 | T2 | T3 | T4 | T5 | T6 | SEM§ | Sig ² |
|---|---------------------|--------------------|---------------------|--------------------|--------------------|---------------------|---------------------|--------|------------------|
| Hb ¹ (g/μl) | 12.53 ^c | 12.46 ^c | 13.20 ^{ab} | 13.80 ^a | 12.50 ^c | 13.03 ^{bc} | 13.56 ^{ab} | ± 0.13 | ** |
| PCV ² (%) | 38.60 ^c | 38.50 ^c | 40.60 ^{ab} | 42.40 ^a | 38.40 ^c | 40.10 ^{bc} | 41.70 ^{ab} | ± 0.38 | ** |
| RBCs ³ (x 10 ⁶ /μl) | 3.17 ^c | 3.15 ^c | 3.52 ^{ab} | 3.60 ^a | 3.16 ^c | 3.34 ^{bc} | 3.40 ^{ab} | ± 0.42 | ** |
| WBCs ⁴ (x10 ³ /μl) | 17.90 ^{ab} | 17.63 ^b | 18.03 ^{ab} | 18.50 ^a | 17.60 ^b | 17.93 ^{ab} | 18.26 ^{ab} | ± 0.92 | * |

^{a,b,c} Means within the same column bearing different superscripts differ significantly ($P < 0.05$). NS = not significant. * = $P < 0.05$. ** = $P < 0.01$.

§: Standard error of the means.

¹⁻² Refers to, live body weight, Significance, total edible parts, respectively.

Table (6): Effect of dietary treatments on biochemical traits of broiler chicks at the end of experimental period.

| Parameters | Control | T1 | T2 | T3 | T4 | T5 | T6 | SEM§ | Sig ² |
|-----------------------|---------------------|---------------------|---------------------|--------------------|----------------------|----------------------|----------------------|--------|------------------|
| Total protein (g/dl) | 4.20 ^a | 3.10 ^c | 4.30 ^a | 4.46 ^a | 2.66 ^d | 3.36 ^c | 3.76 ^b | ± 0.14 | * |
| Albumin (g/dl) | 1.50 ^{ab} | 1.33 ^c | 1.56 ^a | 1.60 ^a | 1.30 ^c | 1.40 ^{bc} | 1.53 ^{ab} | ± 0.03 | * |
| Globulin (g/dl) | 2.70 ^{ab} | 1.77 ^{cd} | 2.74 ^{ab} | 2.86 ^a | 1.36 ^c | 1.96 ^c | 2.23 ^b | ± 0.12 | ** |
| Triglycerides (mg/dl) | 86.46 ^a | 79.53 ^{ab} | 68.46 ^c | 50.10 ^d | 79.10 ^{ab} | 75.36 ^{abc} | 71.33 ^c | ± 2.80 | ** |
| Cholesterol (mg/dl) | 149.50 ^a | 128.26 ^b | 101.06 ^d | 79.76 ^e | 118.36 ^{bc} | 109.40 ^{cd} | 106.00 ^{cd} | ± 2.82 | ** |

^{a,b,c} Means within the same column bearing different superscripts differ significantly ($P < 0.05$). NS = not significant. * = $P < 0.05$. ** = $P < 0.01$.

§: Standard error of the means.

¹⁻² Refers to, live body weight, Significance, total edible parts, respectively.