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**Cooperation program**

# COMPARATIVE STUDY TO INVESTIGATE DIFFERENT ENZYME SOURCES ON THE ENERGY UTILIZATION IN BROILER DIETS

**BY**

**Wesam Sadeq Abdallah Abu Suliman**

**A Thesis Submitted As Partial Fuifillment of the**

**Requirements for the Master Degree**

**THESIS**

**Submitted in Partial Fulfillment of the Requirements for the Degree of Master**

**In**

**Agriculture Science (Poultry Nutrition)**

**Department of Animal and Poultry Production**

**Faculty of Agriculture,**

**AL-Azhar University Gaza - Palestine.**

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## Supervision Sheet

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بسم الله الرحمن الرحيم

قال تعالى :

وَقُلِ اعْمَلُوا فَسَيَرَى اللهُ عَمَلَكُمْ وَرَسُولُهُ والْمُؤْمِنُون

صَدَقَ اللهُ العَظِيم

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# 1- INTRODUCTION

The application of feed enzymes to poultry diets for the enhancement of nutrient availability has been practiced for long time ago. Early research conducted on feed enzymes in poultry nutrition focused on non-starch polysaccharide (NSPs) degrading enzymes, specifically xylanase and β-glucanase, in diets containing wheat, rye and barley **(Choct, 2006)**. Poultry do not synthesize the enzymes necessary for the digestion of cellulose, β-glucans, arabinoxylans or pectin. Non-starch polysaccharides are complex sugars that occur in the cell walls of cereal grains **(Bedford** and **Schulze, 1998)**. It includes arabinoxylans in rye and wheat (**Beg** *et al*., **2001)**. Enzymes such as xylanase and β-glucanase, have the ability the break down these structural polysaccharides, making the nutrients available to the animal **(Bedford, 2000**, and **Choct, 2006)**.

The application of exogenous fibrolytic enzymes in the poultry industry have been used to neutralise the effects of NSPs present in wheat, barley, rye and oats and this has proven to be a successful means of improving broiler production performance **(Choct** *et al*., **1995, Brufau** *et al*., **2001, Engberg** *et al*., **2004, Cowieson** *et al*., **2005, Scott, 2005, Wang** *et al*., **2005,** and **Pettersson** and **Åman, 2007)**. A summary of some published results presented by **Cowieson (2005)** reveals that the use of a combination of xylanase, protease, and amylase resulted in significant improvements in feed:gain (from 0.8 to 10.5%) and BW gain (from 1.9 to 6.9%). The same enzyme combination increased AME by 3% and nitrogen retention by 11.7% of both adequate and reduced energy and amino acid diets **(Cowieson** and **Ravindran, 2008).**

The effects of phytase in poultry have recently been extensively reviewed by **Selle** and **Ravindran (2007).** They concluded that phytase increases phosphorus retention and tibia ash, but it has also positive effects on weight gain, feed intake, nitrogen retention, feed gain ratio, apparent metbolisable energy, and Ca retention.

Studies have shown that supplementing enzymes to broiler could increase the AMEn of th**e** diets **(Fuente** *et al.,* **1995, Huyghebaert, 1997, Choct** *et al.,***1999,** and **Cowieson** and **Ravindran, 2008))** which could participate to decrease the cost of the diets

The objective of this study was to compare production performance of broilers receiving diets containing optimum or low metabolisable energy levels supplemented with a phytase, enzyme mixture, or a combination of the phytase and the enzyme mixture supplemented to wheat based diets.

# 2. REVIEW OF LITERATURE

## 2.1. Dietary energy level

**Cheng** *et al.,* **(1997)** reported that male broilers fed high energy diet (3250 kcal/kg) across temperatures ranged from 21.1ºC-35ºC had significantly improved feed conversion compared to broilers fed with 3000 kcal ME/kg diet.

**El-Husseini** *et al.,* **(2002)** reported that decreasing the dietary metabolizable energy from 3200 to 3000 kcal/kg reduced significantly the body weight gain of the broilers.

**Maiorka** *et al.,* **(2004)** showed that broilers fed the diet containing 3,200 kcal ME/kg had higher weight gain (P=0.015), better feed conversion (P=0.001), and higher abdominal fat deposition (P=0.001) as compared to those fed the diet containing 2,900 kcal ME/kg.

**Downs** *et al.,* **(2006)** reported that decreasing dietary ME level about 100 kcal/kg during each growth phase resulted in comparable live body weight for broilers. While feed conversion ratio was significantly improved with increasing dietary ME level. Carcass yield and abdominal fat percentages were not significantly affected by dietary ME level.

**El Tazi** *et al.,* **(2009)** studied the effect of dietary metabolizable energy levels (3000 *vs.* and 3200 Kcal/kg) on body weight, feed efficiency and dressing percentage was not significant, while the feed intake was decreased significantly by increasing the level of metabolizable energy.

**Golian** *et al.,* **(2010)** reported that live body weight and feed conversion ratio were improved as the dietary energy level was increased (2900, 3000, 3100 and 3200 kcal ME/ kg diet).

**Jafarnejad and Sadegh (2011)** reported no significant difference on live weight of broilers fed 3200 *vs.* 3000 kcal /kg diet.

### 2.2. Enzymes

Monogastrics do not synthesize enzymes capable of hydrolyzing cereal structural carbohydrates, but do possess microorganisms in the large intestine and caecum that have this capability. Enrichment of their digestive system with exogenous enzymes is of utmost importance in practical feeding especially in young broiler chicks that have a relatively low level of posterior small intestine fermentation **(Engberg** *et al.,* **2004,** and **Meng** *et al.,* **2004**, and **2005)**. It is hypothesized that the response to enzyme supplementation of cereal-based diets is significantly higher in younger compared to older animals, as young chicks are sensitive to the water-soluble and highly viscose carbohydrates **(Boros** *et al.,* **1998).**

#### 2.2.1. Non starch polysaccharides

Non-starch polysaccharides mostly present in raw materials used for poultry diets are pectins, cellulose, mixed-linked β-glucans and arabinoxylans **(Parsippany, 2008)**. Non-starch polysaccharides (NSPs) can be divided into two groups, soluble and insoluble NSPs **(Castanon** *et al*, **1997)**. Starch can function as a major nutritional component of the diet, but a number of NSPs can have negative effects on poultry. Poultry cannot digest the insoluble NSPs, only soluble NSPs have the potential to be digested by poultry **(Parsippany, 2008)**. According to **Carre** *et al.,* **(1995)** the degradation of soluble NSP can be as high as 80-90 %, while the insoluble NSPs remain un-digested.

After the ingestion of NSPs, the NSPs bind to the water in the intestinal tract of the bird due to the water-holding capacity of the soluble fibres and this leads to an increase in the viscosity of the digestant **(Classen, 1996)**. This increase in the intestinal viscosity leads to adecreased rate of digestion, which in turn leads to a reduction in performance **(Bedford, 1993, Classen, 1996,** and **Chesson, 2001)**. Also, NSPs leads to an increase in the thickness of the intestinal contents and result in gelatinous droppings (sticky droppings). The moisture content of litter is increased by the sticky droppings and this leads to wet litter. **(Selinger** *et al.*, **1996, Bedford** and **Schulze, 1998, Bhat, 2000, Hetland** *et al.*, **2004**, and **Nnenna** *et al.*, **2006)**.

Depolymerisation of these NSPs requires specific enzymes; these enzymes are specific to the main and side chain structure of the NSPs **(Bedford** and **Schulze, 1998, Andersson** *et al.,* **2003, Bhat, 2000,** and **Botha, 2011)**.

The major NSPs found in wheat are arabinoxylans and it is the major contributor to the soluble NSPs fraction of wheat and barley **(Beg** *et al.*, **2001**, and **Chesson, 2001)**. The endosperm and the bran of wheat is the major source of soluble arabinoxylans. Arabinoxylan from the bran contributes 33.3 % to the total soluble arabinoxylan content of wheat and bran contributes 64.2 % **(Chesson, 2001)**. The NSPs content of wheat according to **Knudsen (1997)** is 119 g/kg, 25 g/kg of the total NSPs are soluble. The largest contributors to the soluble non-cellulosic polysaccharide fraction of wheat are xylose, arabinose and glucose at 9 g/kg, 7 g/kg and 4 g/kg respectively **(Knudsen, 1997**, and **Fourie, 2007)**. NSPs of concern in wheat are the insoluble non-cellulosic polysaccharide and cellulose. The insoluble non-cellulosic polysaccharide content of wheat is 74 g/kg of the DM content of wheat, 62 % of the total

NSP content of wheat. Cellulose contributes 17 % to the total NSPs content of wheat and 2 % of the DM content of wheat **(Knudsen, 1997)**.

Addition of the appropriate enzyme diminishes these constraints and allows digestion to occur more rapidly and completely. Exogenous enzyme is, therefore, likely to supplement the digestive capacity of the younger bird, and again the response to such will be more apparent with poorly digested compared with highly digestible diets. It is likely that as a bird age and their digestive ability increases, as does their microbial population, the effect of exogenous enzymes is more and more mediated through the microbial route **(Bedford, 2000)**.

The beneficial effects of exogenous enzyme supplementation depend on a number of factors. These factors include the dietary components, processing of the diet and the type of enzymes used **(Acamovic, 2001).**

### 2.2.2. Carbohydrases

Carbohydrases' enzymes may hydrolyze the aleurone layer thus reducing barrier to nutrient digestibility and thus enhance the utilization of the feedstuffs. All cereals have aleurone layer which shields the starchy endosperm thus presenting a first barrier to digestibility and nutrient availability **(Oluyinka** and **Adeola, 2008).**

Wheat arabinoxylans act as anti-nutrient by increasing digesta viscosity thus impair nutrients utilization **(Evers** *et al.,* **1999). Bedford** and **Classen (1992)** demonstrated that improvement in feed conversion ratio and weight gain in broiler chickens given wheat-based diets supplemented with xylanase was significantly correlated with a reduction in viscosity of the jejunum and ileum content. Xylanase enzymes hydrolyse the soluble arabinoxylans and thus prevent high intestinal viscosities and improve nutrient absorption **(Van der Klis** *et al.,* **1995)**.

It is worth noting that the beneficial effects of xylanase addition to a wheat-based broiler diet were slightly dependent on wheat content since increased inclusion level of wheat induced higher digesta viscosity **(Veldman and Vahl, 1994)**. Also, the beneficial effect of the use of exogenous enzymes may depended on the wheat cultivar used **(Gutierrez** *et al.,* **2008).**

**Marsman** *et al.,* **(1997)** conducted a study where a cell wall degrading enzyme preparation (EnergexTM) was added to a maize-SBM based diet for broilers. The carbohydrase preparation consisted of cellulase, hemicellulase and pectinase. Their results indicated that body weight gain, feed intake and feed conversion ratio were not affected by the enzyme supplementation.

**Steenfeldt** *et al.,* **(1998)** reported that supplementation with xylanase enzymes containing endoxylanase 350 U/g or endoxylanase 400 U/g had a significant effect on broiler performance during the first 3 weeks, and from 21-42 days of age compared to control group. Feed conversion efficiency was in general similarly affected.

**Zanella** *et al.,* **(1999)** supplemented a maize-SBM based diet with a commercial enzyme preparation, Avizyme®1500, it was added to the diet at 0.1 %. Avizyme®1500 consists of 800 μ/g xylanase from the fungus *Trichoderma longibrachiatum*, 6,000 μ/g protease from the gram-positive bacterium *Bacillus subtilis*, and 2,000 μ/g amylase from the gram-positive bacterium *Bacillus amyloliquifaciens*. Enzyme supplementation also led to the significant increase of 1.9 % in live weight and improvement of 2.2 % in feed conversion ratio. Abdominal fat content of broilers was not significantly affected by treatment.

**Saleh** *et al*., **(2005)** revealed that the enzyme preparation had no effect on the abdominal fat content of broilers. The enzyme preparation used for this study was a pure cellulase (1, 4-(1,3:1,4)-b-D-Glucan 4- glucano-hydrolase) obtained from the fungus *Trichoderma viride*. The addition of the pure cellulose to the maize-SBM based diet had no effect on body weight gain and feed conversion ratio.

**Pettersson** and **Aman (2007)** tested the addition of an enzyme cocktail, consisting of xylanase and β-glucanase to broiler diet containing rye and wheat. The addition of the enzyme cocktail resulted in a significant increase in body-weight and feed intake.

**Oluyinka** and **Adeola (2008)** reported wheat-based diets benefit from supplementation of microbial xylanase because of the high level of arabinoxylans in wheat.

**Owens** *et al.,* **(2008)** compared between different xylanses sources and reported improved total live weight gain (+12%) and feed conversion ratio (+9%) for all enzyme-supplemented diets compared to the control fed broilers. They added that Allzyme, the preparation of endo-1, 4-beta-xylanase with an activity level of 600 U/g, alone was as effective as any of the combinations with organic acids or mannan oligosaccharides.

**Lϋ** *et al.,* **(2009)** found that broiler diet supplemented with Avizyme 1302 (300 g/ton feed to supply 2000 xylanase units/kg diet) had no significant on broiler performance.

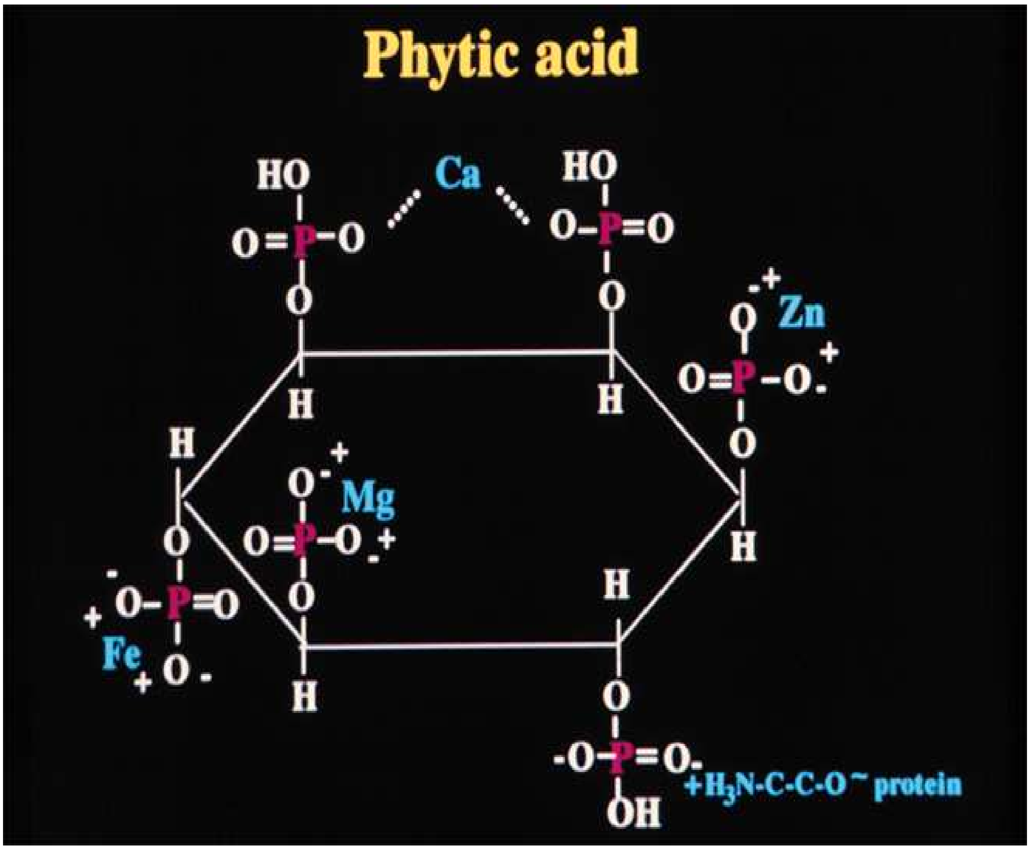
**Kwakernaaka** *et al.,* **(2011)** added endo-xylanase (0, 100 and 200 U/kg) to turkey diets. Dietary supplementation at 200 U/kg significantly improved body weight gain and feed conversion ratio over a 16-week period.

### 2.2.3. Phytase

#### 2.2.3.1. Phytate

Phytate, the mixed salt of phytic acid (myoinositol hexaphosphate, IP6), is a ubiquitous component of plant-source feed ingredients; consequently, it is invariably present in practical broiler diets at levels ranged from 2.5 to 4 g/phytate-P/kg **(Ravindran, 1995)**. It has been estimated by **Lott** *et al.*, **(2000)** that the total global harvest of barley, maize, sorghum, wheat, cottonseed, rapeseed and soyabean, which are considered key feed ingredients for poultry, contains approximately 16 million tones of phytate. Phytate is predominantly present as the myo-inositol hexaphosphate ester (IP6) **(Kasim** and **Edwards, 1998)** coupled with magnesium (Mg) and potassium (K) as a mineral–phytate complex. Indeed, **Lott** *et al.*, **(2000)** proposed that the model substrate is one in which IP6 is complexed with three $Mg^{2+}$ and six $K^{+}$ ions.

The majority of P in plant-source feed ingredients is present as phytate-P, as the phytate-P proportion of total P ranges from 60% (soyabean meal) to 80% (rice bran). That phytate-P which is only partially utilised by poultry is reflected in the poor bio-availability of P. The dietary phytate concentration should govern the magnitude of responses to microbial phytase and such indications have been reported in poultry (**Cabahug** *et al.,* **1999, Ravindran** *et al.,* **2000,** and **2006).**




**Edwards (1991)**

### 2.2.3.2. Phytic acid content in feedstuffs

Data presented in Table (1) declared the phytic acid contents of feedstuffs and its intrinsic phytase activity as well as optima pH and temperature.

**Table (1): Phytin content in some common feedstuffs used in dietary formulation for poultry and their intrinsic phytase activity (Godoy *et al*., 2005[1], Kornegay *et al.,* 1996[2], and Greiner and Konietzny, 2006).**

| **Feedstuffs** | **Phytate** | | **Phytase activity, U/ kg** | **Optimum[3]** | |
|---|---|---|---|---|---|
| | % | % of total P | | pH | Temperature ºC |
| Maize[1] | 0.17 | 73 | 24 | 4.8 | 55 |
| Sorghum[1] | 0.17 | 66 | 24 | NR | NR |
| Wheat[1] | 0.18 | 55 | 1193 | 5-6 | 45-50 |
| Wheat bran[1] | 0.63 | 69 | 2957 | NR | NR |
| Triticale[2] | | | 1500 | NR | NR |
| Barley[2] | 0.27 | 64 | 582 | 5-6 | 45-55 |
| Oats[2] | 0.29 | 67 | 40 | 5.0 | 38 |
| Rice polishing[1] | 1.13 | 72 | 134 | NR | NR |
| Soybean | 0.37 | 65 | 62 | 4.5-5.0 | 55-58 |
| Canola meal[2] | 0.70 | 59 | 16 | NR | NR |
| Sunflower meal[2] | 0.89 | 77 | 60 | NR | NR |
| Peanut meal[2] | 0.48 | 80 | 3 | NR | NR |
| Cottonseed meal[1] | 0.84 | 63 | 36 | NR | NR |
| Palm oil meal[1] | 0.29 | 57 | 34 | NR | NR |
| Coconut meal[1] | 0.24 | 56 | 37 | NR | NR |
| Brewery grains[1] | 0.30 | 24 | 39 | NR | NR |
| Sesame seed meal[4] | 3.57 | NR | | | |

NR, not reported, [4] **Eardman (1979).**

### 2.2.3.3. Phytase and broiler performance

**Qian** *et al.,* **(1996)** reported that live weight gain of broilers was improved by the addition of 400, 600, and 800 FTU/kg to 0.34%, 0.27%, and 0.20% non-phytate phosphorus diets, respectively.

**El-Saady (1999)** reported that 750 FTU/kg broiler diet improved significantly live weight gain, feed intake and feed conversion ratio, but had no effect on dressing % compared to the control.

**Cabahug** *et al.,* **(1999)** revealed that increasing dietary phytic acid from 10.4 to 15.7 g/kg (from rice pollard) negatively impacted live body weight gain, feed intake, and feed conversion ratio, and these adverse effects were partially overcame by phytase addition at 400 and 800 U/kg diet. The improvements occurred in broilers live body weight gain and feed conversion ratio by phytase were greater in high-phytic acid containing diets.

**Raw** *et al.,* **(1999)** found that phytase addition at 250 and 500 U/kg diet improved live body weight gain and feed conversion ratio of broilers.

**El-Deeb** *et al.,* **(2000)** observed that microbial phytase (Natuphos®) addition at 500 or 1000 U/kg of broiler diets significantly increased live weight gain, but had no effect on feed intake or feed conversion ratio.

**Abd El-Samee (2002)** reported that when diets containing medium level of crude protein and fungal phytase (750 U/kg) were fed, the broiler growth performance was improved significantly compared to the control group. Moreover, results obtained showed no significant effect on carcass characteristics of 7 weeks age that could be attributed to phytase supplementation, irrespective of protein level.

**Balasubramanian** *et al*., **(2002)** noticed that supplementation of different levels of fungal phytase at 500, 750 and 1000 U/kg diet of low available P level (0.3%) significantly increased live body weight gain and improved feed conversion ratio.

**Qota** *et al*.**, (2002)** reported that phytase addition at 500 U/kg diet contained 10% linseed cake did not affect live weight gain, and feed conversion ratio. Also, they found that phytase addition at 500 U/kg of 10% soaked linseed cake-diet had no effect on plasma total protein, triglycerides, and cholesterol. Moreover, it did not significantly affect dressing or giblets %.

**Abdo (2004)** studied the effect of phytase addition (0.0, 500, and 1000 U/kg diet contained 0, 25 and 50% level of *Nigella sativa* seed meal to substitute soybean meal. Phytase addition at 500 or 1000 U/kg diet with 25% *Nigella sativa* seed meal resulted in the highest live body weight gain compared to the control group. Phytase had no significant effect on carcass percentage, or liver function (AST activity).

**Aggoor** *et al.* **(2004)** found that phytase addition at 600 U/kg diet containing rapeseed meal increased live weight gain and improved feed conversion ratio of broilers.

**Hassanabadi** *et al.* **(2004)** found that phytase at the rate of 250, 500, 750 and 1000 U/kg diet improved live weight gain, feed intake, and feed conversion ratio of broilers.

**Onyango** *et al*., **(2005)** found that *Escherichia coli* phytase at 500 or 1000 U/kg of diet increased significantly live weight gain, and feed intake of broilers.

**Pillai** *et al*., **(2006**) observed that *Escherichia coli* phytase addition at 250, 500, and 1000 U/kg increased live weight gain and carcass yield of broilers.

**Selim (2007)** reported that either Natuphos® (Phytase-3) or Phyzyme (Phytase-6) at 500 U/kg diet decreased significantly growth of Sasso chicks from 35 to 56 day of age compared to the un-supplemented control. However, Natuphos® increased significantly growth of chicks from 56 to 64 d of age compared to the un-supplemented control and Phyzyme supplemented groups. Meanwhile, difference was insignificant from one-day old to 35 and one-day old to 64 day of age.

### 2.2.4. Integration between carbohydrases and phytase enzymes

The use of an enzyme complex containing carbohydrases and phytase should allow the reduction of dietary available P and energy, as well as crude protein, amino acids, and Ca concentrations in feed. Some attempts have been made to assess the magnitude of dietary nutrient reduction, which can be compensated by xylanase, amylase, protease, and phytase to maintain performance to that of the positive control, containing adequate nutrient concentrations (**Cowieson** *et al.,* **2006)**.

Carbohydrases, which are able to break down the cell wall NSPs matrix, can facilitate the access of phytase to phytate molecule **(Olukosi** *et al.,* **2007),** supporting the hypothesis that the use of a combination of carbohydrases and phytase can fully strengthen their effects.

**Ravindran** *et al.,* **(1999)** studied the response of broiler chicks to microbial phytase (Natuphos® 5000) added at the rate of 120 g/ton, individually and in combination with glucanase preparations with predominantly xylanase (Natugrain Blend) and glucanase (Natugrain) enzymes. Performance of broilers fed a wheat-based diet was not influenced by the addition of individual enzymes, but increasing inclusion levels of the xylanase plus phytase combination linearly improved live weight gain and feed efficiency.

**Francesch** and **Geraert (2009)** reported improved weight gain and feed intake and energy utilization in broilers fed corn-soybean diets deficient in available phosphorus. This might indicate that the first limiting nutrient was phosphorus and once the phosphorus deficiency was overcome by phytase and feed intake was restored, the carbohydrases could increase the nutritive value of diet compensating for the reduction in AME (+ 2.8%).

## 2.3. Interaction between dietary energy level and enzyme supplementation

The main objective of the use of NSPs-degrading enzymes in wheat and barley based diets is to increase the apparent metabolisable energy of the wheat **(Botha, 2011)**. The variability of the apparent metabolisable energy content of wheat is related to the anti-nutritional effects of the NSPs present in the wheat and barley **(Choct** *et al.,* **1995, 1996,** and **1999).**

**Choct** *et al.,* **(1995)** tested the supplementation of fibrolytic enzymes to broiler diets containing low apparent metabolisable wheat. Their enzyme cocktail was added at 1 g per kg of feed and consisted of xylanase, β-glucanase and pectinase. A 24.3 % increase in apparent metabolisable energy was observed when the enzyme cocktail was added to the low apparent metabolisable energy wheat diet. The most interesting observation in this trail was the improvement of 34.1 % in the feed conversion efficiency. The most important characteristic of low apparent metabolisable wheat is the incomplete starch digestion with the excretion of starch in the faeces as a consequence. However, starch digestion in the small intestine of broilers is increased with enzyme supplementation.

**Fuente** *et al.,* **(1995)** found that enzyme mixture addition significantly increased the AMEn of diets in 30-d-old chicks, but did not see any increase in 10-d-old chicks.

**Huyghebaert (1997)** indicated that adding multi-enzyme preparations to a diet containing 25 or 50% wheat increased diet metabolizable energy by 4.9 and 9.4%, respectively.

**Choct** *et al.,* **(1999)** revealed that the use of xylanase significantly increased the AMEn of the wheat and starch digestibility in the jejunum and ileum of the bird. AMEn increased from 13.7 to 14.5 MJ/kg DM intake.

**Zanella** *et al.* **(1999)** found that a combination of xylanase, protease, and α-amylase allowed restoring a reduction of 3.4% in dietary AME in broilers fed corn-soybean meal diet.

**Marron** *et al.,* **(2001)** also used xylanase for supplementing a wheat based broiler diet and they also found that enzyme supplementation increased AMEn and starch digestibility.

**Kocher** *et al.,* **(2003)** found that the combined addition of pectinase, protease, and amylase significantly improved AMEn when added to a corn soybean meal basal diet with lower energy and protein levels.

**Cowieson** and **Ravindran (2008)** reported that a combination of xylanase, amylase, and protease was able to increase the availability of energy by 3% for broiler chicks.

**El Tazi** *et al.,* **(2009)** reported that studied the interaction between the dietary microbial phytase (zero *vs.* 500 U/kg diet) and metabolisable energy (3000 *vs.* and 3200 kcal/kg) did not significantly affect the weight gain, feed intake, feed efficiency and dressing percentage of broilers.

# 3. MATERIALS AND METHODS

The growth trial of the present study was conducted at a private sector poultry farm at Beit-Lahia, North Governorate, Palestine during the period of March to May 2010, while, slaughter test and blood serum measurements were done at Faculty of Agriculture-Al-Azhar University, Gaza strip.

The work aimed at comparative study to investigate different enzyme sources on the energy utilization in broilers fed wheat-base diets.

## 3.1. Experimental design

Three hundred and twenty one-day-old unsexed Cobb chicks were randomly distributed between 8 experimental groups of 40 chicks, each to study to investigate the effect of supplementing different enzyme sources (phytase *vs.* enzyme mixture) to different dietary metabolisable energy levels (optimum *vs.* low) by broilers fed wheat-based diets on growth performance, carcass traits and some blood serum constituents. Diets were as follows:

Treat. 1: Diet containing the ideal ME energy level without enzyme supplement (control).

Treat. 2: Control + Avizyme 1500 (100 g/100 kg)

Treat. 3: Control + Phyzyme XP TPT 10000 (50g /100 kg)

Treat.4: Control + Avizyme 1500 (50 g) + Phyzyme XP TPT 10000 (25 g /100 kg)

Treat. 5: Diet containing a low-ME (low 100 kcal/kg diet) without enzyme supplement.

Treat. 6: Low-ME diet + Avizyme 1500 (100 g / 100 kg)

Treat.7: Low-ME diet + Phyzyme XP TPT 10000 (50g /100 kg)

Treat. 8: Low-ME diet + Avizyme 1500 (50 g) +
Phyzyme XP TPT 10000 (25g / 100 kg)

### 3.2. Experimental diets

Throughout the 6 week growth trial, broilers were fed one phase-diet. Composition and calculated analyses of the basal experimental diet were calculated according to **NRC (1994)** are presented in Table 2.

### 3.3. Management

Feed, light, and water were continuously made available from 1st day old up till 42 days old. Common management practice was used for brooding and rearing. Vaccination and medical care were applied according to the common veterinary practice for broiler chicks. The medical care applied include vaccination against New-Castle disease three times, first by Hitchner B1 strain at the 6th day of age and twice with Lasota strain in drinking water at 18 and 35 days of age, respectively. Chicks were also vaccinated against infectious bursal disease (Gumboro) in drinking water, once at 12 and the other 22 days of age. Feed consumption and live body weight for all experimental groups were recorded on a replicate base weekly through the feeding period.

**Table (2): Formulation and nutrient composition of the basal diet**

| Ingredients | Basal diet % |
|---|---|
| Yellow corn | 36.0 |
| Wheat | 20.5 |
| Soybean meal(44%) | 36.0 |
| Dry-fat | 3.8 |
| Limestone | 1.5 |
| Di calcium phosphate | 0.10 |
| Nacl | 0.35 |
| Vitamins & minerals premix* | 0.30 |
| Dl- methionine | 0.1 |
| L-lysine | 0.05 |
| **Total** | 100.0 |
| **Chemical composition** | |
| Cp | 21.63 |
| ME (kcal/kg) | 2945 |
| EE | 4.59 |
| Ca | 1.00 |
| P | 0.46 |
| Lysine | 1.10 |
| methionine | 0.55 |

*Vit. & Min. Premix supplied per 1 kg of diet: vit. A.,12000 IU; Vit.D3, 220 IU; Vit. E, 10 mg; Vit.K3, 2 mg; Vit.B1, 1 mg; Vit.B2, 4 mg; Vit.B6, 1.5 mg; Vit.B12, 10 µg; Vit.B3, 20 mg; Vit.B5, 10 mg; Vit.B9, 1 mg; Vit.B8, 50 µg; Choline chloride, 500 mg; Cu, 10 mg; I, 10 mg; Fe, 30 mg; Mn, 55 mg; Zn, 850 mg; Se, 0.1 mg and Co, 0.25 mg.

Wheat bran was included at the rate of 6% to diets 5 up to 8, in order to decrease the energy density of the basal diet by about 100 kcal/kg.

Avizyme 1500 contains xylanase derived from genetically modified *Trichoderma longibrachiatum*, protease derived from genetically modified *Bacillus subtilis*, alpha-amylase produced by *Bacillus amyloliquefaciens* and polygalacturonase produced by *Aspergillus aculeatus,* and is intended for inclusion in feed rich in starch and non-starch polysaccharides (mainly arabinoxylans and beta-glucans). Avizyme 1500 was provided by Multi vita Animal Nutrition, Egypt.

Phyzyme XP-TPT10000 is 6-phytase (EC.3.1.3.26) contains 10000 U/g (supplied by Danisco Animal Nutrition, UK).

### 3.4. Measurements and methods of results' interpretation

#### 3.4.1. Live weight gain (g)

Broilers were individually weighed, weekly to the nearest gram. Live body weight gain was calculated by subtracting the live body weight in gram at the beginning of each experimental week from live body weight at the end the same experimental week.

### 3.4.2. Feed intake (g).

Average weekly feed intake was individually calculated by the difference between weekly offered feed and the weekly residual in g/replicate.

### 3.4.3. Feed conversion ratio (kg feed/kg gain)

It represents the mount of feed in kilograms required to produce one kilogram of weight gain.

### 3.4.4. Slaughter test

At the end of growth period (42 day of age), 6 birds were randomly taken from each treatment to carry out the slaughter test to determine the carcass traits. Before slaughtering, the birds were starved for 12 hours, then weighed, slaughtered and allowed to bleed freely for about 5 minutes. Absolute weight of carcass, heart, gizzard, liver, and abdominal fat were proportioned to the live body weight upon slaughtering.

### 3.4.5. Biochemical constituents of blood serum

Blood samples were collected from four birds of blood serum measurements. Concentrations of total protein (**Henry** *et al*., **1974**), albumin (**Doumas** *et al*., **1977**), total cholesterol (**Watson, 1960**), triglycerides (**Zollner and Kirsch, 1962),** glucose **(Trinder, 1969)**, creatinine **(Husdan and Rapaport, 1968)**, liver enzymes AST (aspartate amino transferase) and ALT (alanine amino transferase), according to

**Retiman** and **Frankel (1957),** were determined. Globulin was calculated by difference between total protein and albumin. Also, albumin to globulin ratio was calculated.

### 3.4.6. Production index

= {[daily weight gain × (100 − mortality)]/(10 × feed conversion)}.

### 3.4.7. Statistical procedures

Data from all response variables were subjected to a two factorial analysis using **SAS (1990).** Variables having significant differences were compared using Duncan's Multiple Range Test (**Steel** and **Torrie**, **1960).**

The following model was applied;

$Y_{ij}= \mu+S_i+P_j+(SP)_{ij}+E_{ij}$; where;

$Y_{ij}$ = Individual observation.

$\mu$ = Overall mean.

$S_i$ = Effect of dietary ME level (i= 1, 2).

$P_j$ = Effect of supplemental enzyme source (j= 1, 2, 3, and 4).

$(SP)_{ij}$ =Effect of the interaction between dietary ME level.

and supplemental enzyme source.

Eij= experimental error

# 4. RESULTS AND DISCUSSION

Data presented in Table (3) illustrate the main effect of dietary ME levels and supplemental enzyme source on growth performance (live weight gain and feed conversion ratio) of broilers during 0-3, 4-6, and 0-6 weeks of age. Initial live weights of broilers were not significantly affected by main factors under investigation, indicating the randomization of allocation process. Concerning, dietary ME level, it is clear that optimum dietary ME level had a superior on live growth performance rather than the low dietary ME level, in terms of significant ($p$<0.01) improved live weight gains and feed conversion ratios throughout the studied experimental intervals. Total weight gain and total feed conversion of optimum ME diet fed broilers were improved by 9.49% and 9.63 %, respectively over that of the low ME fed broilers. Enzyme supplementation had positive significant effect on growth performance of broilers, except for live weight gain during 0-3 weeks of age. It is worth noting that the combination between Avizyme 1500 + Phzyme XP TPT 10000 had inferior result on live weight gain during 0-3 weeks of age, it turned to the best formula during 4-6, and 0-6 weeks of age, while each enzyme source alone gave comparable results to the control concerning live weight gains. Regarding the effect of supplemental enzyme sources on feed conversion ratio, Phyzyme XP TPT 10000 or Avizyme 1500 + Phzyme XP TPT 10000 significantly ($p$<0.01) were better than the control or Avizyme 1500 fed diet broilers either during 4-6 or 0-6 weeks intervals, while no significant effect during the 0-3 weeks had been reported for the studied enzyme sources.

Effect of the interaction between dietary ME level and supplemental enzyme source on live growth performance of broilers is presented in (4). Concerning the live weight gain, the broilers fed on optimum ME level within each treatment surpassed its equivalent group with low ME diet ($p<0.01$) during the 0-3 weeks of age. The same was true during the 4-6 and 0-6 weeks of age period, except for the group fed low ME-Avizyme + Phyzyme which gave comparable results for its equivalent group on optimum ME level. Feed conversion ratio was not significantly affected by dietary treatments during 0-3 weeks of age, then turned in similar manner resemble that with weight gain results, where each treatment within the optimum ME level was better than its match within the low ME groups, except for the group fed low ME-Avizyme + Phyzyme that gave similar results to its equivalent on optimum ME diet.

Results recorded on the effect of dietary ME level on growth performance are in accord with those of **Cheng** *et al.,* **(1997), El-Husseini** *et al.,* **(2002), Maiorka** *et al.,* **(2004), Golian** *et al.,* **(2010)** that live weight gain and feed conversion ratio of broilers were significantly improved as dietary ME level increased. **Downs** *et al.,* **(2006)** reported no difference in live weight gain, but improved feed conversion ration with increasing dietary ME level of the broilers. **Jafarnejad and Sadegh (2011)** reported no effect on live weight gain of broilers with increasing the energy density of the diet. While, **El Tazi** *et al.,* **(2009)** reported neither live weight gain nor feed conversion ratio were affected by dietary energy level.

Results on Avizyme 1500 agree with those reported by **Steenfeldt** *et al.,* **(1998)** and **Lϋ** *et al.,* **(2009)** that using xylanase enzyme supplementation had no effect on broiler performance. However, **Zanella** *et al.,* **(1999)** reported that Avizyme®1500 supplemented to a maize-SBM based diet resulted in an increase of 1.9 % in live weight and improvement of 2.2 % in feed conversion ratio**. Pettersson** and **Aman (2007)** using an enzyme cocktail, consisting of xylanase and β-glucanase resulted in a significant increase in body-weight. **Owens** *et al.,* **(2008)** compared between different xylanses sources and reported improved total live weight gain (+12%) and feed conversion ratio (+9%) for all enzyme-supplemented diets compared to the control fed broilers

It is clear that adding a phytase-enzyme source with more efficacious than adding a versatile of enzyme mixture (Avizyme 1500**)** to improve the growth performance of the broilers. Also, Phzyme XP TPT 10000 improved growth performance (feed conversion ratio) of broilers compared to the control. Nevertheless, the difference between live weight gains of broilers fed the diet supplemented with Phzyme XP TPT 10000 and the control did not reach significant level. Some researchers have shown significant increases in live body weight with phytase supplementation to broiler diets (**El-Saady, 1999, Zanini** and **Sazzad, 1999, Sohail** and **Roland, 1999, Cabahug** *et al.,* **1999, Raw** *et al.,* **1999, El-Deeb** *et al.,* **2000, Waldroup** *et al.,* **2000, Yan** *et al.,* **2000, Zyla** *et al.,* **2000, Abd El-Samee, 2002, El-Medany** and **El-Afifi, 2002, Balasubramanian** *et al*., **2002, Lan** *et al*.**, 2002, Qota** *et al*.**, 2002, Salem** *et al.,* **2003, Abdo, 2004, Aggoor** *et al.* **2004, El-Nagmy** *et al*.**, 2004, Abou El-Wafa** *et al*.**, 2005, Onyango** *et al*., **2005, Watson** *et al*., **2005, Pillai** *et al*., **2006, Pirgozliev** *et al.,* **2007, Liu** *et al.,* **2008, Ravindran** *et al.,* **2008, Zhou** *et al.,* **2009,** and

**Jalali** *et al.,* **2009),** Others have demonstrated that phytase supplementation had no effect on live weight gain of broilers (**Vetési** *et al.,* **1998, Applegate** *et al.* **2003, Miles** *et al.,* **2003, Karimi, 2005,** and **Akyurek** *et al.,* **2005)** or negatively affected growth performance **(Powell, 2005)**.

Following the same manner, phytase supplementation significantly improved feed conversion ratio of broilers. These findings are in accordance with some other reports (**Vetési** *et al.,* **1998, El-Saady, 1999, Ravindran** *et al.,***1999, Raw** *et al.,* **1999, Waldroup** *et al.,* **2000, Abd El-Samee, 2002, Balasubramanian** *et al.*, **2002, Lan** *et al.*, **2002, El-Nagmy** *et al.*, **2004, Aggoor** *et al.,* **2004, El-Nagmy** *et al.,* **2004, Hassanabadi** *et al.,* **2004, Liu** *et al.,* **2008, Ravindran** *et al.,* **2008, Zhou** *et al.,* **2009** and **Jalali** *et al.,* **2009).** Other studies did not detect beneficial response to phytase supplementation on broilers' feed conversion ratio (**Sebastian** *et al.,* **1996, El-Deeb** *et al.,* **2000, Qota** *et al.*, **2002, Applegate** *et al.*, **2003, Salem** *et al.,* **2003, Karimi, 2005,** and **Akyurek** *et al.,* **2005).**

The improvement in feed conversion due to phytase supplementation may be interpreted on the base that phytate limited the availability of several nutrients such as minerals **(Farrel** and **Martin, 1998)**, protein **(Cheryan, 1980)**, energy **(Ravindran, 1999)** and digestive enzymes **(Deshpande** and **Cheryan, 1984).** The synergistic effect between Avizyme 1500 and Phzyme XP TPT 10000 is clear compared to the effect of each enzyme preparation, alone. It is assumed that the positive effect of supplementing Phzyme XP TPT 10000 (phytase enzyme) was further enhanced when combined with Avizyme 1500. The latter may be increased the digestibility of the nutrients, as it set free by the action of the phytase enzyme. The reduction in the amount of highmolecular-weight arabinoxylan fragments leads to a decrease in gut viscosity and therefore an increase in the digestion and uptake of nutrients (**Andersson** *et al.,* **2003**).

Results provided in Table (5) indicate that dietary ME level had no significant effect on carcass characteristics of the broilers (carcass, liver, heart, gizzard, total edible parts, and abdominal fat percentages). Among studied supplemental enzyme sources, Phyzyme XP TPT 10000, alone significantly increased carcass percentage compared to the control ($p<0.05$). The latter, had significantly ($p<0.01$) the highest liver, and gizzard percentages. Each enzyme source, separately, showed lower abdominal fat percentage ($p<0.05$) compared to the control or enzyme combination source. Heart or total edible part percentage did not significantly affected by enzyme source.

Results presented in Table (6) indicate that the interaction between dietary ME level and supplemental enzyme source had no significant effect on any of the studied carcass traits (carcass, liver, heart, gizzard, total edible parts and abdominal fat percentages).

In agreement with the current findings, **Maiorka** *et al.,* **(2004)** reported that dietary ME level (3200 *vs.*2900 kcal/kg) had no significant effect on carcass percentage of broilers. While, abdominal fat percentage was decreased with the high dietary ME level. **Downs** *et al.,* **(2006)** found that carcass yield and abdominal fat percentages were not significantly affected by dietary ME level. Also, **El Tazi** *et al.,* **(2009)** agree that dietary energy level had no significant effect on dressing percentage of broilers.

Little studies focused on the effect of supplemental enzyme mixture on carcass traits. In agreement with the results of the current study **Saleh** *et al.,* **(2005)** found that the addition of cellulase led to a significant decrease in the abdominal fat pad weight of the broilers. **Zanella** *et al.* **(1999)** also looked at the effect of enzyme supplementation (xylanase, amylase, and protease) on the abdominal fat content of broilers, no significant results were found.

Concerning the effect on carcass characteristics, the supplemental enzyme sources had no effect on total edible parts percentage. In agreement with the present findings, **El-Saady (1999), Scheideler** and **Ferket (2000**), **El-Medany** and **El-Afifi (2002), Abdo (2004), El-Nagmy** *et al.***, (2004)** found that phytase did not significantly affect carcass yield. While**, Salem** *et al.,* **(2003),** and **Pillai** *et al*., **(2006**) found that phytase supplementation significantly increased dressed carcass percentage and abdominal fat of broilers compared with those fed the control diet without phytase supplementation. **Viveros** *et al.,* **(2002)** reported that the inclusion of phytase in diets had no significant effect on dressing percentage of the broilers. However, **Scheidelor** and **Ferket (2002)**, and **El-Medany** *et al.,* **(2002)** stated that the addition of phytase to diet improved significantly the dressing percentage of the broilers.

Results on the effect of dietary ME level or supplemental enzyme sources on blood serum constituents (total protein, albumin, globulin, albumin/globulin ratio, glucose, triglycerides, cholesterol, creatinine, ALT and AST) are shown in Table (7). Optimum ME level significantly increased serum total protein ($p<0.05$), globulin ($p<0.01$), glucose ($p<0.01$), triglycerides ($p<0.05$), ALT ($p<0.01$), and AST ($p<0.05$), while decreased albumin/globulin ratio ($p<0.01$) compared to low ME level. On the other hand, supplemental enzyme level had no significant effect on all studied serum parameters, except the kidneys' creatinine ($p<0.05$) as the control fed broilers showed the highest level.

Results on the effect of the interaction between dietary ME level and supplemental enzyme source on serum constituents of broilers are provided in Table (8). Dietary treatments significantly affected serum total protein ($p<0.05$), globulin ($p<0.05$), glucose ($p<0.01$), and creatinine ($p<0.05$). Serum albumin, albumin/globulin ratio, triglycerides, cholesterol, ALT and AST were not significantly affected by dietary treatments.

No data are available considering the effect of dietary energy level on the studied blood constituents. Phytase had no effect on plasma, total protein, total lipids, and cholesterol, which agree with other reports (**Kornegay** *et al*., **1998, Attia** *et al*., **2001,** and **Qota** *et al*.**, 2002**). However, **Jalali** *et al.,* **(2009)** found that serum total protein and albumin concentrations were increased by phytase addition. Concerning liver functions, **Viveros** *et al.,* **(2002)** reported that phytase supplementation increased serum AST but decreased serum ALT activity. Meanwhile, **Abdo (2004)** found that phytase in broiler diet had no significant effect on AST activity. **Selim (2007)** found that phytase decreased plasma cholesterol of broilers.

Results presented in Table (9) reveal the economic index study. It is clear that feeding broilers on optimum dietary energy level was better (331.4) than feeding the low energy diet (275.0). Concerning supplemental enzyme sources, feeding a phytase enzyme alone or combined with enzymes' mixture was rather than feeding the enzymes' mixture alone or feeding diets without supplemental enzymes in leveling up the performance index. Individual treatments had fluctuated effect on economic study. Alongside the optimum energy level, all supplemental enzyme sources showed higher economic index than the control group without enzyme supplementation. Only feeding a phytase enzyme combined with the enzymes' mixture showed the highest economic index, while other supplemental enzymes' source failed to increase the economic index over that obtained by the control with low energy level.

**Table (3): Main effect of dietary energy levels and enzyme sources on live weight gain and feed conversion ratio of broilers**

| | | ME level | | Significance | Enzyme source | | | | Significance |
|---|---|---|---|---|---|---|---|---|---|
| | | Optimum | Low | | Control | Avizyme 1500 | Phyzyme XP TPT 10000 | Avizyme 1500 +Phzyme XP TPT 10000 | |
| Initial live weight | | 40±0.08 | 40±0.07 | ns | 40±0.09 | 40±0.09 | 40±0.14 | 40±0.11 | ns |
| Live weight gain | 0-3 wks | $833^{A}$±5.45 | $779^{B}$±5.95 | ** | $810^{A}$±15 | $809^{A}$±16 | $817^{A}$±5.56 | $787^{B}$±10 | * |
| | 4-6 wks | $1532^{A}$±17 | $1381^{B}$±28 | ** | $1425^{C}$±26 | $1400^{C}$±39 | $1467^{B}$±63 | $1533^{A}$±14 | ** |
| | 0-6 wks | $2365^{A}$±18 | $2160^{B}$±27 | ** | $2236^{BC}$±41 | $2209^{C}$±54 | $2285^{AB}$±67 | $2320^{A}$±17 | ** |
| Feed conversion ratio | 0-3 wks | $1.37^{B}$±0.01 | $1.47^{A}$±0.01 | ** | 1.46±0.02 | 1.40±0.02 | 1.40±0.02 | 1.43±0.03 | ns |
| | 4-6 wks | $2.01^{B}$±0.02 | $2.27^{A}$±0.04 | ** | $2.22^{A}$±0.03 | $2.22^{A}$±0.07 | $2.16^{B}$±0.10 | $1.97^{C}$±0.02 | ** |
| | 0-6 wks | $1.69^{B}$±0.01 | $1.87^{A}$±0.02 | ** | $1.84^{A}$±0.02 | $1.81^{AB}$±0.05 | $1.78^{B}$±0.05 | $1.70^{C}$±0.02 | ** |

$^{A\text{-}C}$ Means within the same row differ significantly, ns=not significant, *= $P$>0.05, **=$P$>0.01

**Table (4): Effect of dietary treatments on live weight gain and feed conversion ratio of broilers**

| | Initial live weight | Live body weight gain | | | Feed conversion ratio | | |
|---|---|---|---|---|---|---|---|
| | | 0-3 wks | 4-6 wks | 0-6 wks | 0-3 wks | 4-6 wks | 0-6 wks |
| Optimum ME-Control | 40 ±0.11 | 847[a] 11± | 1485[c] 18± | 2333[b] 29± | 1.41 0.01± | 2.16[c] 0.04± | 1.78[b] 0.02± |
| Optimum ME-Avizyme1500® | 40 ±0.15 | 849[a] 5.5± | 1500[c] 17± | 2349[b] 22± | 1.33 0.01± | 2.02[d] 0.01± | 1.68[cd] 0.01± |
| Optimum ME-Phyzyme XP TPT 10000 | 40.42 ±0.22 | 827[ab] 5.42± | 1633[a] 19± | 2460[a] 24± | 1.36 0.02± | 1.88[e] 0.01± | 1.62[d] 0.00± |
| Optimum ME-Avizyme1500+Phyzyme XP TPT10000 | 40.35 ±0.18 | 809[b] 7.00± | 1509[bc] 15± | 2318[b] 22± | 1.37 0.04± | 1.99[d] 0.04± | 1.68[cd] 0.04± |
| Low ME-Control | 40.25 ±0.15 | 774[c] 5.5± | 1366[d] 25± | 2140[c] 30± | 1.51 0.01± | 2.27[b] 0.04± | 1.89[a] 0.02± |
| Low ME-Avizyme1500® | 40.12 ±0.11 | 769[c] 11.9± | 1300[e] 13.5± | 2070[c] 21.9± | 1.47 0.01± | 2.41[a] 0.01± | 1.94[a] 0± |
| Low ME-Phyzyme XP TPT 10000 | 40.30 ±0.20 | 807[b] 7.13± | 1301[e] 14.5± | 2109[c] 14.6± | 1.43 0.04± | 2.43[a] 0.01± | 1.93[a] 0.01± |
| Low ME-Avizyme1500+Phyzyme XPTPT10000 | 40.30 ±0.15 | 766[c] 10.9± | 1556[b] 19.19± | 2322[b] 29.5± | 1.48 0.04± | 1.96[de] 0.01± | 1.72[bc] 0.02± |
| Significance | ns | ** | ** | ** | ns | ** | ** |

[a-e] Means within the same column differ significantly, ns=not significant, **=*P*>0.01.

**Table (5): Main effect of dietary energy levels and enzyme sources on carcass characteristics**

| Item | ME level | | Sig. | Enzyme source | | | | Sig. |
|---|---|---|---|---|---|---|---|---|
| | Optimum | Low | | Without | Avizyme 1500 | Phyzyme XP TPT 10000 | Avizyme 1500+Phzyme XP TPT 10000 | |
| Carcass % | 73.3±0.3 | 72.7±0.2 | ns | $72.6^{B}\pm0.4$ | $73.2^{AB}\pm0.5$ | $73.7^{A}\pm0.3$ | $72.4^{B}\pm0.4$ | * |
| Liver % | 1.98±0.04 | 1.89±0.04 | ns | $2.12^{A}\pm0.05$ | $1.94^{B}\pm0.05$ | $1.76^{C}\pm0.04$ | $1.94^{B}\pm0.06$ | ** |
| Heart % | 0.54±0.02 | 0.54±0.02 | ns | 0.59±0.02 | 0.52±0.02 | 0.52±0.04 | 0.53±0.03 | ns |
| Gizzard % | 1.41±0.05 | 1.48±0.03 | ns | $1.57^{A}\pm0.06$ | $1.35^{B}\pm0.06$ | $1.39^{B}\pm0.05$ | $1.47^{AB}\pm0.07$ | * |
| Total edible part % | 77.2±0.3 | 76.6±0.2 | ns | 76.9±0.3 | 77.1±0.4 | 77.4±0.3 | 76.3±0.3 | ns |
| Abdominal fat % | 2.11±0.05 | 2.21±0.05 | ns | $2.17^{AB}\pm0.09$ | $2.04^{B}\pm0.05$ | $2.10^{B}\pm0.06$ | $2.33^{A}\pm0.08$ | * |

$^{A-C}$ Means within the same row differ significantly, ns=not significant, *= $P$>0.05, **=$P$>0.01

**Table (6): Effect of dietary treatments on carcass characteristics**

| Treatment | Carcass % | Liver % | Heart % | Gizzard % | Total edible % | Abdominal fat % |
|---|---|---|---|---|---|---|
| Optimum ME-Control | 72.6 ±0.06 | 2.09 ±0.08 | 0.60 ±0.02 | 1.62 ±0.11 | 77.00 ±0.54 | 2.16 ±0.15 |
| Optimum ME-Avizyme 1500® | 73.32 ±0.87 | 2.02 ±0.05 | 0.53 ±0.03 | 1.31 ±0.08 | 77.20 ±0.84 | 2.03 ±0.07 |
| Optimum ME-Phyzyme XP TPT 10000 | 74.20 ±0.58 | 1.77 ±0.06 | 0.52 ±0.05 | 1.36 ±0.09 | 77.87 ±0.44 | 2.05 ±0.09 |
| Optimum ME-Avizyme1500+Phyzyme XP TPT 10000 | 73.05 ±0.39 | 2.01 ±0.09 | 0.50 ±0.02 | 1.33 ±0.06 | 76.91 ±0.35 | 2.20 ±0.07 |
| Low ME-Control | 72.48 ±0.43 | 2.13 ±0.06 | 0.58 ±0.04 | 1.52 ±0.04 | 76.73 ±0.46 | 2.16 ±0.09 |
| Low ME-Avizyme 1500® | 73.16 ±0.36 | 1.85 ±0.08 | 0.49 ±0.02 | 1.38 ±0.09 | 76.90 ±0.35 | 2.04 ±0.05 |
| Low ME-Phyzyme XP TPT 10000 | 73.25 ±0.13 | 1.73 ±0.05 | 0.51 ±0.05 | 1.41 ±0.05 | 76.91 ±0.11 | 2.15 ±0.06 |
| Low ME-Avizyme1500+Phyzyme XP TPT10000 | 71.70 ±0.46 | 1.85 ±0.06 | 0.56 ±0.04 | 1.59 ±0.09 | 75.72 ±0.38 | 2.46 ±0.11 |
| Significance | Ns | | | | | |

ns = not significant

**Table (7): Main effect of dietary energy levels and enzyme sources on some blood serum constituents**

| Constituent | ME level | | Significance | Enzyme source | | | | Significance |
|---|---|---|---|---|---|---|---|---|
| | Optimum | Low | | Control | Avizyme 1500 | Phyzyme XP TPT 10000 | Avizyme 1500+Phzyme XP TPT 10000 | |
| Total Protein | $5.45^{A}$±0.14 | $4.94^{B}$±0.14 | * | 4.69±0.23 | 5.25±0.20 | 5.33±0.19 | 5.23±0.26 | ns |
| Albumin (A) | 3.08±0.05 | 3.00±0.09 | ns | 2.96±0.12 | 3.06±0.09 | 3.02±0.07 | 3.11±0.14 | ns |
| Globulin (G) | $2.38^{A}$±0.09 | $1.99^{B}$±0.07 | ** | 2.00±0.12 | 2.26±0.14 | 2.31±0.13 | 2.17±0.13 | ns |
| A/G ratio | $1.30^{B}$±0.04 | $1.48^{A}$±0.03 | ** | 1.46±0.06 | 1.34±0.14 | 1.31±0.05 | 1.45±0.05 | ns |
| Glucose | $127^{A}$±5.93 | $104^{B}$±5.04 | ** | 109±7.55 | 122±9.05 | 122±9.31 | 199±9.47 | ns |
| Triglycerides | $88^{A}$±1.20 | $85^{B}$±0.87 | * | 86±1.30 | 89±1.82 | 86±1.04 | 86±1.92 | ns |
| Cholesterol | 74±2.74 | 79±2.16 | ns | 79±3.39 | 77±4.20 | 71±2.74 | 81±3.32 | ns |
| Creatinine | 0.22±0.01 | 0.18±0.01 | ns | $0.25^{A}$±0.02 | $0.17^{B}$±0.01 | $0.20^{AB}$±0.02 | $0.18^{B}$±0.01 | * |
| ALT | $2.71^{A}$±0.18 | $1.92^{B}$±0.16 | ** | 2.40±0.24 | 2.66±0.33 | 2.08±0.15 | 2.12±0.36 | ns |
| AST | $235^{A}$±17 | $174^{B}$±17 | * | 217±25 | 233±24 | 196±22 | 172±33 | ns |

$^{A-B}$ Means within the same row differ significantly, ns=not significant, *= $P$>0.05, **=$P$>0.01

**Table (8): Effect of dietary treatments on some blood serum constituents**

| Treatment | Total Protein | Albumin (A) | Globulin (G) | A/G ratio | Glucose | Triglycerides | Cholesterol | Creatinine | ALT | AST |
|---|---|---|---|---|---|---|---|---|---|---|
| Optimum ME-Control | $5.37^{abc}$ ±0.24 | 3.15 ±0.08 | $2.22^{abc}$ ±0.17 | 1.36 ±0.08 | $100^{b}$ ±6.48 | 86 ±2.39 | 73 ±5.39 | $0.22^{abc}$ ±0.03 | 2.47 ±0.39 | 207 ±43 |
| Optimum ME-Avizyme1500® | $5.72^{a}$ ±0.17 | 3.12 ±0.04 | $2.60^{a}$ ±0.14 | 1.21 ±0.06 | $143^{a}$ ±5.54 | 92 ±1.49 | 75 ±7.08 | $0.19^{bc}$ ±0.02 | 3.17 ±0.30 | 265 ±30 |
| Optimum ME-Phyzyme XP TPT 10000 | $5.72^{a}$ ±0.13 | 3.12 ±0.04 | $2.60^{a}$ ±0.09 | 1.20 ±0.03 | $122^{ab}$ ±13.00 | 86 ±1.79 | 69 ±4.73 | $0.25^{ab}$ ±0.03 | 2.42 ±0.17 | 217 ±38 |
| Optimum ME-Avizyme1500+Phyzyme XP TPT10000 | $5.00^{abc}$ ±0.40 | 2.92 ±0.20 | $2.10^{bc}$ ±0.20 | 1.42 ±0.08 | $142^{a}$ ±7.00 | 89 ±3.09 | 80 ±5.12 | $0.22^{abc}$ ±0.01 | 2.77 ±0.54 | 252 ±29 |
| Low ME-Control | $4.55^{c}$ ±0.28 | 2.77 ±0.19 | $1.77^{c}$ ±0.11 | 1.56 ±0.06 | $119^{ab}$ ±12.80 | 87 ±1.43 | 85 ±1.65 | $0.28^{a}$ ±0.04 | 2.32 ±0.34 | 228 ±31 |
| Low ME-Avizyme1500® | $4.77^{bc}$ ±0.14 | 3.00 ±0.18 | $1.92^{bc}$ ±0.04 | 1.4 ±0.07 | $101^{b}$ ±7.36 | 86 ±2.59 | 79 ±5.43 | $0.16^{bc}$ ±0.02 | 2.15 ±0.50 | 202 ±36 |
| Low ME-Phyzyme XP TPT 10000 | $4.95^{abc}$ ±0.25 | 2.92 ±0.13 | $2.02^{bc}$ ±0.13 | 1.41 ±0.06 | $102^{b}$ ±12.92 | 85 ±1.31 | 73 ±3.17 | $0.15^{c}$ ±0.03 | 1.75 ±0.10 | 174 ±22 |
| Low ME-Avizyme1500+Phyzyme XP TPT 10000 | $5.5^{ab}$ ±0.34 | 3.30 ±0.16 | $2.25^{ab}$ ±0.18 | 1.48 ±0.05 | $96^{b}$ ±4.95 | 83 ±1.08 | 82 ±5.01 | $0.13^{c}$ ±0.01 | 1.47 ±0.17 | 92 ±3.49 |
| Significance | * | ns | * | ns | ** | ns | ns | * | ns | ns |

$^{a-c}$ Means within the same column differ significantly, ns=not significant, *= *P*>0.05, **=*P*>0.01

**Table (9): Economic study**

| Main effect | Performance index | Treatment | Performance index |
|---|---|---|---|
| **Energy level** | | Optimum ME-Control | 312.1 |
| Optimum ME | 331.4 | Optimum ME-Avizyme1500® | 332.9 |
| Low ME | 275.0 | Optimum ME-Phyzyme XP TPT 10000 | 361.6 |
| **Enzyme source** | | Optimum ME-Avizyme1500+Phyzyme XP TPT10000 | 328.5 |
| Without | 289.3 | Low ME-Control | 269.6 |
| Avizyme1500® | 285.6 | Low ME-Avizyme1500® | 254.1 |
| Phyzyme XP TPT 10000 | 305.6 | Low ME-Phyzyme XP TPT 10000 | 260.2 |
| Avizyme1500+Phyzyme XP TPT 10000 | 324.9 | Low ME-Avizyme1500+Phyzyme XP TPT 10000 | 321.4 |

# 4. SUMMARY

The work aimed at comparative study to investigate different enzyme sources on the energy utilization in broilers fed wheat-base diets.

Three hundred and twenty one-day-old unsexed Cobb chicks were randomly distributed between 8 experimental groups of 40 chicks, each to study to investigate the effect of supplementing different enzyme sources (phytase *vs.* enzyme mixture) to different dietary metabolisable energy levels (optimum *vs.* low) by broilers fed wheat-based diets on growth performance, carcass traits and some blood serum constituents. Diets were as follows:

Treat. 1: Diet containing the ideal ME energy level without enzyme supplement (control).

Treat. 2: Control + Avizyme 1500 (100 g/100 kg)

Treat. 3: Control + Phyzyme XP TPT 10000 (50g /100 kg)

Treat.4: Control + Avizyme 1500 (50 g) + Phyzyme XP TPT 10000 (25 g /100 kg)

Treat. 5: Diet containing a low-ME (low 100 kcal/kg diet) without enzyme supplement.

Treat. 6: Low-ME diet + Avizyme 1500 (100 g / 100 kg)

Treat.7: Low-ME diet + Phyzyme XP TPT 10000 (50g /100 kg)

Treat. 8: Low-ME diet + Avizyme 1500 (50 g) + Phyzyme XP TPT 10000 (25g / 100 kg).

**Results could be summarized as follows:**

- Optimum dietary ME level had a superior on live growth performance rather than the low dietary ME level, in terms of significant ($p$<0.01)

improved live weight gains and feed conversion ratios throughout the studied experimental intervals.

-Enzyme supplementation had positive significant effect on growth performance of broilers, except for live weight gain during 0-3 weeks of age.

**-** Dietary ME level had no significant effect on carcass characteristics of the broilers.

- Among studied supplemental enzyme sources, Phyzyme XP TPT 10000, alone significantly increased carcass percentage compared to the control ($p$<0.05). The latter, had significantly ($p$<0.01) the highest liver, and gizzard percentages. Each enzyme source, separately, showed lower abdominal fat percentage ($p$<0.05) compared to the control or enzyme combination source. Heart or total edible part percentage did not significantly affected by enzyme source.

**-** Optimum ME level significantly increased serum total protein ($p$<0.05), globulin ($p$<0.01), glucose ($p$<0.01), triglycerides ($p$<0.05), ALT ($p$<0.01), and AST ($p$<0.05), while decreased albumin/globulin ratio ($p$<0.01) compared to low ME level.

-Supplemental enzyme level had no significant effect on all studied serum parameters, except the kidneys' creatinine ($p$ <0.05) as the control fed broilers showed the highest level.

**-** Feeding optimum energy level diet had higher economical index than feeding low energy diet.

-Feeding a phytase enzyme alone or combined with enzymes' mixture give higher economical index than feeding the enzymes' mixture alone or feeding diets without supplemental enzymes

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# 7. APPENDIX

## Live weight gain

General Linear Models Procedure

Dependent Variable: W0

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 0.36468750 | 0.05209821 | 0.46 | 0.8528 |
| Error | 24 | 2.71250000 | 0.11302083 | | |
| Corrected Total | 31 | 3.07718750 | | | |

| | R-Square | C.V. | Root MSE | W0 Mean |
|---|---|---|---|---|
| | 0.118513 | 0.835050 | 0.33618571 | 40.25937500 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 0.00781250 | 0.00781250 | 0.07 | 0.7949 |
| ENZ | 3 | 0.23593750 | 0.07864583 | 0.70 | 0.5637 |
| INT | 3 | 0.12093750 | 0.04031250 | 0.36 | 0.7847 |

Dependent Variable: Weight gain (0-3 wks)

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 32115.56468750 | 4587.93781250 | 15.93 | 0.0001 |
| Error | 24 | 6911.11250001 | 287.96302083 | | |
| Corrected Total | 31 | 39026.67718751 | | | |

| | R-Square | C.V. | Root MSE | WGS Mean |
|---|---|---|---|---|
| | 0.822913 | 2.104194 | 16.96947320 | 806.45937500 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 23355.00781250 | 23355.00781250 | 81.10 | 0.0001 |
| ENZ | 3 | 4045.78593750 | 1348.59531250 | 4.68 | 0.0103 |
| INT | 3 | 4714.77093750 | 1571.59031250 | 5.46 | 0.0053 |

Dependent Variable: Weight gain (4-6 wks)

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 413244.46875000 | 59034.92410714 | 44.23 | 0.0001 |
| Error | 24 | 32030.75000000 | 1334.61458333 | | |
| Corrected Total | 31 | 445275.21875000 | | | |

| | R-Square | C.V. | Root MSE | WGF Mean |
|---|---|---|---|---|
| | 0.928065 | 2.507961 | 36.53237719 | 1456.65625000 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 182257.03125000 | 182257.03125000 | 136.56 | 0.0001 |
| ENZ | 3 | 80600.84375000 | 26866.94791667 | 20.13 | 0.0001 |
| INT | 3 | 150386.59375000 | 50128.86458333 | 37.56 | 0.0001 |

Dependent Variable: WG (0-6 wks)

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 536111.83968750 | 76587.40566964 | 30.83 | 0.0001 |
| Error | 24 | 59627.96250005 | 2484.49843750 | | |
| Corrected Total | 31 | 595739.80218755 | | | |

| R-Square | C.V. | Root MSE | WGT Mean |
|---|---|---|---|
| 0.899909 | 2.202483 | 49.84474333 | 2263.11562500 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 336097.50781250 | 336097.50781250 | 135.28 | 0.0001 |
| ENZ | 3 | 58488.06093750 | 19496.02031250 | 7.85 | 0.0008 |
| INT | 3 | 141526.27093750 | 47175.42364583 | 18.99 | 0.0001 |

## Feed conversion ratio

General Linear Models Procedure

Dependent Variable: FC (0-3 wks)

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 0.11152099 | 0.01593157 | 5.06 | 0.0012 |
| Error | 24 | 0.07555567 | 0.00314815 | | |
| Corrected Total | 31 | 0.18707665 | | | |

| R-Square | C.V. | Root MSE | FCS Mean |
|---|---|---|---|
| 0.596125 | 3.935533 | 0.05610840 | 1.42568750 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 0.08618168 | 0.08618168 | 27.38 | 0.0001 |
| ENZ | 3 | 0.01947915 | 0.00649305 | 2.06 | 0.1319 |
| INT | 3 | 0.00586015 | 0.00195338 | 0.62 | 0.6086 |

Dependent Variable: FC (4-6 wks)

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 1.22455511 | 0.17493644 | 58.89 | 0.0001 |
| Error | 24 | 0.07129950 | 0.00297081 | | |
| Corrected Total | 31 | 1.29585461 | | | |

| R-Square | C.V. | Root MSE | FCF Mean |
|---|---|---|---|
| 0.944979 | 2.540293 | 0.05450516 | 2.14562500 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 0.50635339 | 0.50635339 | 170.44 | 0.0001 |
| ENZ | 3 | 0.31306419 | 0.10435473 | 35.13 | 0.0001 |
| INT | 3 | 0.40513753 | 0.13504584 | 45.46 | 0.0001 |

Dependent Variable: FC (0-6 wks)

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 0.43466520 | 0.06209503 | 28.86 | 0.0001 |
| Error | 24 | 0.05163601 | 0.00215150 | | |
| Corrected Total | 31 | 0.48630122 | | | |

| R-Square | C.V. | Root MSE | FCT Mean |
|---|---|---|---|
| 0.893819 | 2.597604 | 0.04638427 | 1.78565625 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 0.25258278 | 0.25258278 | 117.40 | 0.0001 |
| ENZ | 3 | 0.08421927 | 0.02807309 | 13.05 | 0.0001 |
| INT | 3 | 0.09786316 | 0.03262105 | 15.16 | 0.0001 |

## Carcass characteristics

General Linear Models Procedure

Dependent Variable: CARCASS

| Source | DF | sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 22.14286667 | 3.16326667 | 1.90 | 0.0953 |
| Error | 40 | 66.63793333 | 1.66594833 | | |
| Corrected Total | 47 | 88.78080000 | | | |

| R-Square | Coeff Var | Root MSE | CARCASS Mean |
|---|---|---|---|
| 0.249411 | 1.768468 | 1.290716 | 72.98500 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 5.24040833 | 5.24040833 | 3.15 | 0.0837 |
| ENZ | 3 | 13.79295000 | 4.59765000 | 2.76 | 0.0546 |
| ME*ENZ | 3 | 3.10950833 | 1.03650278 | 0.62 | 0.6048 |

Dependent Variable: LIVER

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 0.95923333 | 0.13703333 | 4.29 | 0.0013 |
| Error | 40 | 1.27826667 | 0.03195667 | | |
| Corrected Total | 47 | 2.23750000 | | | |

| R-Square | Coeff Var | Root MSE | LIVER Mean |
|---|---|---|---|
| 0.428708 | 9.226543 | 0.178764 | 1.937500 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 0.08333333 | 0.08333333 | 2.61 | 0.1142 |
| ENZ | 3 | 0.78151667 | 0.26050556 | 8.15 | 0.0002 |
| ME*ENZ | 3 | 0.09438333 | 0.03146111 | 0.98 | 0.4098 |

General Linear Models Procedure

Dependent Variable: HEART

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 0.07193125 | 0.01027589 | 0.97 | 0.4635 |
| Error | 40 | 0.42211667 | 0.01055292 | | |
| Corrected Total | 47 | 0.49404792 | | | |

| R-Square | Coeff Var | Root MSE | HEART Mean |
|---|---|---|---|
| 0.145596 | 18.98696 | 0.102727 | 0.541042 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 0.00025208 | 0.00025208 | 0.02 | 0.8779 |
| ENZ | 3 | 0.05010625 | 0.01670208 | 1.58 | 0.2086 |
| ME*ENZ | 3 | 0.02157292 | 0.00719097 | 0.68 | 0.5686 |

Dependent Variable: GIZZARD

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 0.60404792 | 0.08629256 | 1.98 | 0.0819 |
| Error | 40 | 1.74215000 | 0.04355375 | | |
| Corrected Total | 47 | 2.34619792 | | | |

| R-Square | Coeff Var | Root MSE | GIZZARD Mean |
|---|---|---|---|
| 0.257458 | 14.44050 | 0.208695 | 1.445208 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 0.05535208 | 0.05535208 | 1.27 | 0.2663 |
| ENZ | 3 | 0.35787292 | 0.11929097 | 2.74 | 0.0559 |
| ME*ENZ | 3 | 0.19082292 | 0.06360764 | 1.46 | 0.2398 |

Dependent Variable: FAT

| Source | DF | Sum of Squares | Mean Square | F Value | Pr >F |
|---|---|---|---|---|---|
| Model | 7 | 0.82786458 | 0.11826637 | 2.11 | 0.0650 |
| Error | 40 | 2.24541667 | 0.05613542 | | |
| Corrected Total | 47 | 3.07328125 | | | |

| R-Square | Coeff Var | Root MSE | FAT Mean |
|---|---|---|---|
| 0.269375 | 10.97212 | 0.236929 | 2.159375 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 0.10546875 | 0.10546875 | 1.88 | 0.1781 |
| ENZ | 3 | 0.58432292 | 0.19477431 | 3.47 | 0.0248 |
| ME*ENZ | 3 | 0.13807292 | 0.04602431 | 0.82 | 0.4906 |

## Blood constituents

General Linear Models Procedure

Dependent Variable: Total Protein

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 5.51000000 | 0.78714286 | 2.84 | 0.0263 |
| Error | 24 | 6.65000000 | 0.27708333 | | |
| Corrected Total | 31 | 12.16000000 | | | |

| | R-Square | C.V. | Root MSE | TP Mean |
|---|---|---|---|---|
| | 0.453125 | 10.12283 | 0.52638706 | 5.20000000 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 2.10125000 | 2.10125000 | 7.58 | 0.0111 |
| ENZ | 3 | 0.64250000 | 0.21416667 | 0.77 | 0.5205 |
| INT | 3 | 2.76625000 | 0.92208333 | 3.33 | 0.0365 |

General Linear Models Procedure

Dependent Variable: Albumin

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 0.76968750 | 0.10995536 | 1.26 | 0.3090 |
| Error | 24 | 2.08750000 | 0.08697917 | | |
| Corrected Total | 31 | 2.85718750 | | | |

| | R-Square | C.V. | Root MSE | ALB Mean |
|---|---|---|---|---|
| | 0.269386 | 9.699398 | 0.29492231 | 3.04062500 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 0.05281250 | 0.05281250 | 0.61 | 0.4435 |
| ENZ | 3 | 0.09593750 | 0.03197917 | 0.37 | 0.7770 |
| INT | 3 | 0.62093750 | 0.20697917 | 2.38 | 0.0947 |

General Linear Models Procedure

Dependent Variable: Globulin

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 2.47500000 | 0.35357143 | 4.24 | 0.0036 |
| Error | 24 | 2.00000000 | 0.08333333 | | |
| Corrected Total | 31 | 4.47500000 | | | |

| | R-Square | C.V. | Root MSE | GLOB Mean |
|---|---|---|---|---|
| | 0.553073 | 13.19658 | 0.28867513 | 2.18750000 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 1.20125000 | 1.20125000 | 14.42 | 0.0009 |
| ENZ | 3 | 0.45250000 | 0.15083333 | 1.81 | 0.1723 |
| INT | 3 | 0.82125000 | 0.27375000 | 3.29 | 0.0381 |

General Linear Models Procedure

Dependent Variable: Albumin/Globulin ratio

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 0.46820000 | 0.06688571 | 3.37 | 0.0119 |
| Error | 24 | 0.47595000 | 0.01983125 | | |
| Corrected Total | 31 | 0.94415000 | | | |

| R-Square | C.V. | Root MSE | AGR Mean |
|---|---|---|---|
| 0.495896 | 10.10393 | 0.14082347 | 1.39375000 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 0.27380000 | 0.27380000 | 13.81 | 0.0011 |
| ENZ | 3 | 0.14122500 | 0.04707500 | 2.37 | 0.0953 |
| INT | 3 | 0.05317500 | 0.01772500 | 0.89 | 0.4586 |

General Linear Models Procedure

Dependent Variable: Glucose

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 10108.37500000 | 1444.05357143 | 4.12 | 0.0042 |
| Error | 24 | 8411.50000000 | 350.47916667 | | |
| Corrected Total | 31 | 18519.87500000 | | | |

| R-Square | C.V. | Root MSE | GLU Mean |
|---|---|---|---|
| 0.545812 | 16.14757 | 18.72108882 | 115.93750000 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 3960.50000000 | 3960.50000000 | 11.30 | 0.0026 |
| ENZ | 3 | 855.62500000 | 285.20833333 | 0.81 | 0.4988 |
| INT | 3 | 5292.25000000 | 1764.08333333 | 5.03 | 0.0076 |

General Linear Models Procedure

Dependent Variable: Triglycerides

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 223.71875000 | 31.95982143 | 1.97 | 0.1023 |
| Error | 24 | 389.75000000 | 16.23958333 | | |
| Corrected Total | 31 | 613.46875000 | | | |

| R-Square | C.V. | Root MSE | TRI Mean |
|---|---|---|---|
| 0.364678 | 4.620379 | 4.02983664 | 87.21875000 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 81.28125000 | 81.28125000 | 5.01 | 0.0348 |
| ENZ | 3 | 64.34375000 | 21.44791667 | 1.32 | 0.2908 |
| INT | 3 | 78.09375000 | 26.03125000 | 1.60 | 0.2148 |

General Linear Models Procedure

Dependent Variable: Cholesterol

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 796.71875000 | 113.81696429 | 1.17 | 0.3583 |
| Error | 24 | 2343.75000000 | 97.65625000 | | |
| Corrected Total | 31 | 3140.46875000 | | | |

| | R-Square | C.V. | Root MSE | CHOL Mean |
|---|---|---|---|---|
| | 0.253694 | 12.78721 | 9.88211769 | 77.28125000 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 215.28125000 | 215.28125000 | 2.20 | 0.1506 |
| ENZ | 3 | 465.09375000 | 155.03125000 | 1.59 | 0.2184 |
| INT | 3 | 116.34375000 | 38.78125000 | 0.40 | 0.7563 |

General Linear Models Procedure

Dependent Variable: Creatinine

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 0.07538750 | 0.01076964 | 3.39 | 0.0116 |
| Error | 24 | 0.07620000 | 0.00317500 | | |
| Corrected Total | 31 | 0.15158750 | | | |

| | R-Square | C.V. | Root MSE | CRE Mean |
|---|---|---|---|---|
| | 0.497320 | 27.57047 | 0.05634714 | 0.20437500 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 0.01201250 | 0.01201250 | 3.78 | 0.0636 |
| ENZ | 3 | 0.03206250 | 0.01068750 | 3.37 | 0.0352 |
| INT | 3 | 0.03131250 | 0.01043750 | 3.29 | 0.0380 |

General Linear Models Procedure

Dependent Variable: ALT

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 8.16375000 | 1.16625000 | 2.36 | 0.0556 |
| Error | 24 | 11.88500000 | 0.49520833 | | |
| Corrected Total | 31 | 20.04875000 | | | |

| | R-Square | C.V. | Root MSE | ALT Mean |
|---|---|---|---|---|
| | 0.407195 | 30.34870 | 0.70371040 | 2.31875000 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 4.96125000 | 4.96125000 | 10.02 | 0.0042 |
| ENZ | 3 | 1.72625000 | 0.57541667 | 1.16 | 0.3448 |
| INT | 3 | 1.47625000 | 0.49208333 | 0.99 | 0.4126 |

General Linear Models Procedure

Dependent Variable: AST

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 80916.71875000 | 11559.53125000 | 2.87 | 0.0250 |
| Error | 24 | 96556.25000000 | 4023.17708333 | | |
| Corrected Total | 31 | 177472.96875000 | | | |

| | R-Square | C.V. | Root MSE | AST Mean |
|---|---|---|---|---|
| | 0.455938 | 30.94546 | 63.42851948 | 204.96875000 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| ME | 1 | 29951.28125000 | 29951.28125000 | 7.44 | 0.0117 |
| ENZ | 3 | 16878.59375000 | 5626.19791667 | 1.40 | 0.2675 |
| INT | 3 | 34086.84375000 | 11362.28125000 | 2.82 | 0.0602 |

## ملخص الدراسة

قال ﷻ: ﴿وَقُلِ اعْمَلُوا فَسَيَرَى اللَّهُ عَمَلَكُمْ وَرَسُولُهُ وَالْمُؤْمِنُونَ وَسَتُرَدُّونَ إِلَى عَالِمِ الْغَيْبِ وَالشَّهَادَةِ فَيُنَبِّئُكُمْ بِمَا كُنْتُمْ تَعْمَلُونَ﴾(1).

الحمد لله رب العالمين، الأول بلا بدايةٍ، والآخِرُ بلا نهاية، والصلاةُ على مَن لا نبيَّ بعده، **وبعد،**

فقد هدفت الدراسة إلى مقارنة تأثير مصادر مختلفة من الأنزيمات على استخدام الطاقة الممثلة في علائق الدجاج اللاحم التي تحتوى على القمح.

**ولتحقيق هدفِ الدراسة:**

**تم توزيع ثلاثمائة وعشرين كتكوتاً** عمر يوم واحد، غير مجنسة من **سلالة كوب** عشوائيا على ( 8 ) ثماني مجموعات تجريبية بحيث كان كل ( **40**) أربعون كتكوتاً لكل معاملة **وتم إضافة ( 4)** أربعة مصادر للأنزيم مع مستويين للطاقة الممثلة على أداء النمو، وصفات الذبيحة، وبعض مكونات مصل الدم.

**وكانت العلائق المستخدمة على النحو التالي:**

*** **عليقة1:** مستوى أمثل للطاقة الممثلة دون إضافة للأنزيم.

*** **عليقة2:** مستوى أمثل للطاقة الممثلة مع إضافة لأنزيم Avizyme 1500 (100 جم/100 كجم).

*** **عليقة3:** مستوى أمثل للطاقة الممثلة مع إضافة لأنزيم Phyzyme XP TPT 10000(50 جم/100 كجم).

*** **عليقة4:** مستوى أمثل للطاقة الممثلة مع إضافة لأنزيم Avizyme 1500 (50 جم/100 كجم)+ أنزيم Phyzyme XP TPT 10000 (25 جم/100 كجم).

*** **عليقة5:** مستوى طاقة ممثلة يقل( 100) مائة كالوري/ كجم عليقة عن المستوى الامثل للطاقة الممثلة دون إضافة للأنزيم.

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**(1)سورة التوبة: من الآية{ 105}.**

*** **عليقة6:** مستوى طاقة ممثلة يقل ( 100)مائة كالوري/ كجم عليقة عن المستوى الأمثل للطاقة الممثلة مع إضافة لأنزيم Avizyme 1500 (100 جم/100 كجم).

*** **عليقة7:** مستوى طاقة ممثلة يقل( 100) مائة كالوري/ كجم عليقة عن المستوى الأمثل للطاقة الممثلة مع إضافة لأنزيم Phyzyme XP TPT 10000 (50 جم/100 كجم).

*** **عليقة8:** مستوى طاقة ممثلة يقل( 100)مائة كالوري/ كجم عليقة عن المستوى الأمثل للطاقة الممثلة مع إضافة لأنزيم Avizyme 1500 (50 جم/100 كجم)+ أنزيم PhyzymeXP TPT 10000 (25 جم/100 كجم).

**يمكن تلخيص النتائج على النحو التالي:**

– **مستوى** الطاقة الممثلة الأمثل أفضل معنوياً من المستوى الأقل في معدل النمو والكفاءة التحويلية للغذاء.

– **إضافة** الأنزيمات أعطى تأثيراً إيجابيّاً لحدٍّ ما على أداء النمو والخليط بين مصدري الأنزيم أعطى أفضل أداء.

– **مستوى** طاقة الغذاء لم يكن له تأثير معنوي على أي من صفات الذبيحة.

– **إضافة** أنزيم Phyzyme XP TPT 10000 أعطى معنويا أعلى نسبة تصافٍ للذبيحة بين مصادر الأنزيمات المستخدمة، بينما عليقة المقارنة كانت الأعلى في وزني الكبد والقانصة، والأقل في وزن دهن البطن مقارنة بإضافة الأنزيمات للعلائق.

– **مستوى** طاقة الغذاء الأمثل أعطى معنويا زيادة في محتوى مصل الدم من البروتين الكلى، الجلوبيولين، الجلوكوز، الجلسريدات الكلية، ووظائف الكبد، بينما أدى إلى انخفاض نسبة الألبيومين/ الجلوبيولين مقارنةً بالمستوى الأقل للطاقة الممثلة.

– **إضافة** الأنزيمات لم يكن له تأثير معنوي على قياسات مصل الدم.

– **مستوى** طاقة الغذاء الأمثل كان أعلى في مقياس الأداء مقارنة بالمستوى الأقل.

– **إضافة** أنزيم Phyzyme XP TPT 10000 كان الأفضل بالنسبة لمقياس الأداء.

التوصيات :-

من نتائج الدراسة نخلص إلى أنه يمكن إضافة مخاليط الإنزيمات إلى علائق الدواجن منخفضة المحتوى من الطاقة الممثلة لتحسين الأداء الإنتاجي، وصفات الذبيحة للدجاج اللاحم.

ونوصي بتجارب أخرى لدراسة تأثير تلك الإضافات الإنزيمية على بعض المخلفات الزراعية المتوفرة في الأراضي الفلسطينية، مثل، جفت الزيتون، مسحوق نوى البلح، لتحسين الاستفادة منها، وإدخالها في تكوين علائق اقتصادية لفراريج اللحم.

جامعة الأزهر ـ غزة

## البرنامج المشترك

جامعة القاهرة ج.م.ع

# لجنـــة الإشـراف

اسم الطالب: *وسام صادق عبدالله أبو سليمان*

**عنوان الرسالة: دراسة مقارنة لتأثير مصادر مختلفة من الإنزيمات على الاستفادة من طاقة العليقة في دجاج التسمين**

**لجنة الإشراف:**

**الأستاذ الدكتور/ حاتم عايش الشنطي ....................**
**أستاذ الإنتاج الحيواني**
**كلية الزراعة – جامعة الأزهر غزة – فلسطين**

**الأستاذ الدكتور/ عبدالله علي غزالة .................**
**أستاذ تغذية الدواجن**
**كلية الزراعة – جامعة القاهرة – القاهرة– مصر**

**الدكتور/ أحمد محمد عبدالخالق .....................**
**باحث في تغذية الدواجن**
**معهد بحوث الإنتاج الحيواني**
**وزارة الزراعة – الجيزة – مصر**

البرنامج المشترك

جامعة الأزهر ـ غزة

جامعة القاهرة ج.م.ع

# دراســة مقارنــة
# لتأثير مصادر مختلفة من الإنزيمات على الاستفادة من طاقة العليقة في دجاج التسمين


رسالة مقدمة من/

***وسام صادق عبدالله أبو سليمان***

**بكالوريوس العلوم الزراعية (قسم الإنتاج الحيواني والدواجن)**

**كلية الزراعة – جامعة الأزهر – غزة – فلسطين2007م**


**كجزء من متطلبات الحصول على درجة الماجستير في العلوم الزراعية**
**( إنتاج حيواني ودواجن )**


**قسم الإنتاج الحيواني والدواجن – كلية الزراعة والبيئة**
**جامعة الأزهر – غزة**
**فلسطين**


**2012**