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Effect of Exogenous Enzymes on the Growing Performance of Broiler Chickens Fed Regular Corn/Soybean-Based Diets and the Economics of Enzyme Supplementation

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Abstract: A study was conducted to compare the effects of two sources of exogenous enzymes on performance of broilers fed regular corn/soybean diets and economics of enzyme supplementation. Bergazym P (Berg) and Hemicell-D (Hemi) were added at rates of 0.025 and 0.05%, respectively, to a control diet (Con) for starter (1-21 d) and finisher (22-42) phases in a completely randomized design. Birds were randomly allotted according to body weight to 3 dietary treatments with 12 replicate per treatment (50 chicks per replicate). Enzyme supplementation had no significant effect of feed intake (FI) at 21 and/or 42 days, even though, enzyme-supplemented birds consumed more feed than Con. Birds fed Berg and Con diets had comparable feed conversion ratios (FCR) at 42 days and were significantly ($P<0.05$) more efficient than Hemi diet. Body weight (BW) was not significantly affected by enzyme supplementation, however, birds fed Con and Berg weighed heavier than Hemi group at 42 days. Body weight gain (BWG) was numerically greater for birds fed Con and Berg diets at 21 and/or 42 days compared to Hemi diet, despite no significance reported. Economic analysis showed no monetary benefits from including the enzymes in poultry diets as there were no significant differences in final BW among the three diets. Furthermore, birds fed Con diets weighed heavier than birds fed enzyme-supplemented diets. Calculations for the three budgets show a reduction in gross margins and cost-benefit ratio when Berg and Hemi were added compared to Con diet due to reductions in final BW.

Key words: Enzyme, broiler chicken, performance, corn-soybean diets, economic analysis

Introduction

Feed ingredients of plant origin contain a number of components that are refractive to monogastric digestive enzymes because of lack of and/or insufficiency of endogenous enzyme secretions (Ravindran *et al.,* 1999). These components also lower the utilization of other dietary nutrients, leading to a reduced bird performance. Examples of such antinutritive components include $-glucans in barley, pentosans in wheat, and certain oligosaccharides in soybean meal (Annison and Choct, 1991). Therefore, development of commercially-available feed enzymes to target specific substrates and ameliorate antinutritive effects has received increased attention in the last decade.

The use of exogenous substrate specific enzymes (xylanase, beta-glucanase, amylase, etc...) in poultry feeds to improve bird performance is not a new concept and had been extensively researched (Bedford and Schulze, 1998; Bedford, 2000; Acamovic, 2001; Cowieson and Adeola, 2005). These improvements are related to greater digestion and absorption of nutrients in cereal grains caused by the degradation of cell wall nonstarch polysaccharides (NSP) (Bedford and Schulz, 1998). The degradation of NSP has been proposed as the underlying mechanism to improve bird performance by releasing nutrients trapped within the cell and lowering digesta viscosity to enhance nutrient digestion and subsequent absorption (Classen and Bedford, 1991; Bedford and Schulze, 1998).

Therefore the purpose of this study was to determine the effects of two sources of exogenous enzymes on production parameters in straight run broiler chickens fed corn-soybean based diets and evaluate the economics of their supplementation.

Materials and Methods

Animal trial: A total of 900 straight run Hubbard broilers obtained from a local commercial hatchery were used in a growth performance trial. Birds were randomly allotted according to body weight uniformity to three dietary treatments with 12 replicate floor pens of 50 chicks per replicate (300 chicks per treatment). A regular corn/soybean-based diet was formulated and used as a control diet without enzyme for both starter (0-21 days) and finisher phases (22-42 days) (Table 1). The control diet (Con) was supplemented separately with the commercial enzymes Bergazym P® (Berg) and Hemicell® (Hemi) to make up diets 2 and 3, respectively, for both starter and finisher phases. Bergazym P® is a non-genetically modified multi-microbial enzyme (Berg and Schmidt[1]) produced by *Trichoderma longibrachiatum* containing a leading activity of 6,000 units of endo-1,4-$-xylanase/g (activity determined by manufacturer) with adjusted side activities ($ - glucanase, amylases and galactomannase). Hemicell-D® is a non-genetically modified enzyme (Chem Gen Corporation[2]) produced by *Bacillus lentus* containing a minimum of activity of 14,000 of 1,4-$-mannanase/g. Berg and Hemi were added to Con diet at rates of 0.025% (substitute 50 ME kcal/kg feed) and 0.05% (substitute 100 kcal ME/kg) of the diet, respectively.

Chicks were reared from 1 d old on the experimental diets and were allowed ad libitum access to feed and water throughout the study. All diets were fed in mesh form. Pens had a daily lighting regimen of 20 h of light and 4 h of dark; room temperature was maintained at 35°C in the first week and was reduced by 2°C every week until maintained at 25°C. Birds were reared in an open-sided house on floor pens. All animals used in this trial were handled in accordance with guidelines set forth by the Jordanian Society for the Protection of Animals.

Parameters measured on a weekly basis included feed intake (FI), feed conversion ratio (FCR), bodyweight (BW), bodyweight gain (BWG) and mortality. Experimental diets were formulated according to the breeder's manual (Hubbard S.A.S) to meet National Research Council (1994) requirements of broilers. The duration of the trial was 42 days.

Data was analyzed using the Proc Mixed procedure of SAS® for repeated measures analysis for a completely randomized design and was tested for main effect of treatment. The following general linear model was used:

$Y_{ij} = \mu + "_{i} + ,_{ij}$

Where Y_{ij}= measured response; μ = overall Mean; $"_{i}$ = dietary treatment effect; $,_{ij}$= residual error.

Data was also tested for the following contrasts:

Con vs. Enzymes (Control Diet vs. Enzyme-Supplemented Diets).

Berg vs. Hemi (Bergazym Diet vs. Hemicell Diet).

Level of significance used was p = 0.05

Economic analysis: The economic evaluation was conducted to assess the feasibility of using the two enzymes in broiler feed. Enterprise budgets are usually used in economic analysis to estimate the profitability of any agricultural activity. In this research several enterprise budgets for Hubbard broilers were constructed using day-to-day collected data. The budget shows the total revenue from selling the broiler at the local market evaluated at the farm gate price. The budgets also show the different types of costs involved in the production process. The costs are classified into variable and fixed costs. The variable costs are those cost items that change with the variation of the production level while the fixed costs do not change with the variation in production. The enterprise budget shows the costs of the different items involved in the production process for each treatment of 300 chicks.

Different economic indicators are used in this paper including: 1) gross margins per 300 chicks; 2) net returns and 3) benefit cost ratio. Gross margin per each 300 chicks is estimated by deducting the total variable costs from the total revenues. The net returns represent the net profit per 300 chicks that is estimated by deducting the total costs from total revenues. The benefit cost ratio is obtained by dividing the total revenues by the total costs per 300 chicks.

The three economic indicators were used in this paper to evaluate in economic terms the impact of using the two enzymes on the broiler production compared to traditional methods (control group).

Table 1: Diet composition

Ingredients	Starter (0-21 days)	Finisher (21-42 days)
	(%)	
Corn	53.750	62.360
Soybean meal (48.5 % CP)	39.800	30.000
Soybean oil	2.600	3.760
Limestone	0.860	0.900
Dicalcium phosphate	1.770	1.700
NaCl	0.430	0.430
DL-methionine (98%)	0.220	0.250
L-Lysine-HCl	0.220	0.250
Vitamin premix[1]	0.125	0.125
Mineral premix[2]	0.125	0.125
Choline chloride (60%)	0.100	0.100
Calculated Nutrient Composition:		
ME, kcal/kg	3,000	3,150
Protein, %	22.50	19.00
TSAA, %	0.92	0.83
Methionine, %	0.53	0.49
Lysine, %	1.38	1.28
Ca, %	0.96	0.92
P, nonphytate, %	0.45	0.43
Na, %	0.18	0.18

[1]Vitamin premix provided per kilogram of diet: vitamin A, 120000 IU; vitamin D_3, 3500 IU; vitamin E, 40 mg; vitamin B_1, 2.5 mg; vitamin B_2, 8 mg; vitamin B_6, 5.0 mg; vitamin, riboflavin, 150 µg; B_{12}, 30 µg; biotin, 150 µg; folic acid, 1.5 mg; niacin, 45 mg; pantothenic acid, 13 mg. [2]Trace mineral premix provided per kilogram of diet: Fe, 30 mg; Cu, 15 mg; Mn, 60 mg; Zn, 550 mg; I, 1 mg; Se, 0.80 mg.

Results and Discussion

Enzyme supplementation had no significant effect on feed intake in contrast to the Con at 21 and/or 42 days, even though birds fed diets supplemented with enzymes

[1]Berg and Schmidt, An der Alster 81, D-20099 Hamburg, Germany.
2ChemGen Corporation, 211 Perry Parkway, Gaithersburg, MD 20877-2144, USA.

Table 2: Production data - feed intake, feed conversion, body weight and body weight gain

Production Parameter	Feed Intake (g/bird)		Feed Conversion Ratio (g feed:g weight gain)		Body Weight (g)		Body Weight Gain (g/bird)	
Days	21	42	21	42	21	42	21	42
Diets:[1]								
1) Con	828.48	3550.72	1.57	1.82[a]	572.21	1929.03	528.21	1884.14
2) Berg[2]	840.61	3595.65	1.70	1.82[a]	539.78	1916.67	495.15	1872.96
3) Hemi[2]	854.77	3481.79	1.82	2.06[b]	517.61	1760.81	473.15	1716.34
SEM	11.77	75.07	0.127	0.077	25.01	80.70	24.73	80.31
Diet Effect	NS	NS	NS	0.03	NS	NS	NS	NS
Contrasts:								
Con vs Enzymes	NS	NS	NS	NS	NS	NS	NS	NS
Berg vs. Hemi	NS	NS	NS	0.02	NS	NS	NS	NS

[a-b] Means with varying superscripts differ significantly (P<0.05). [1]Diets: Control (Con), Bergazym P (Berg)[2], Hemicell (Hemi)[2].
[2]Berg = Bergazym P (Berg and Schmidt, An der Alster 81, D-20099 Hamburg, Germany); Hemi = Hemicell-D (ChemGen Corporation, 211 Perry Parkway, Gaithersburg, MD 20877-2144, USA).

Table 3: Input-output data and gross margin for broiler enterprise [Unit of 900 broilers per one cycle (42 days)] – Control Diet

	Unit	Quantity	Price Per unit	Value JD
Broilers: (900 - 6 (mortality)=894 sold birds@1.92kg)	Kg	1716.48	0.88	1510. 5
Manure :	JD	1	11	11. 0
A. Gross revenue				1521. 5
Variable costs				
Purchase of day old chicks:	chick	900	0.2	180. 0
Feed mixture	kg	2700	0.25	675. 0
Bed preparation	sack	27	1.55	41. 9
Gas (Liquid propone)	Jar	45	3.5	157. 5
Water	Cubic meter	15	5	75. 0
Electricity	JD	1	30	30. 0
Veterinary expenses	JD	1	33.3	33. 3
Disinfectants	JD	1	30	30. 0
Labor cost	JD	1	183	183. 0
Interest on operating capital (9% yearly, 0.75% *2 months *JD 1468 total variable costs)				21. 1
B .Total variable costs	JD			1426. 7
Fixed costs				
Rent of building	JD			60. 0
Interest on fixed capital (9% yearly, 0.75% *2 months *JD 60 total fixed costs)				0. 9
C. Total fixed costs	JD			60. 9
D. Total costs (b+c)	JD			1487. 6
E. Gross margin (a-b)	JD			94. 8
F. Net profit (a-d)	JD			33. 9

numerically consumed more grams than control (Table 2). Consistent with our results, previous research with xylanase (Ravidran *et al.,* 1999; Cafe *et al.,* 2002; Cowieson and Adeola, 2005) cited no effects on FI of broilers when supplemented to cereal-based diets (corn, wheat, or barely). Saki *et al.* (2005) and Zou *et al.* (2006) reported no significant differences in average FC at 21 and 42 days in broilers fed diets supplemented with $-mannanase at 0.05% of the diet. Both experiments were conducted with corn-soybean based diets similar to those used in our trial.

Feed conversion ratio was significantly (P<0.05) affected by enzyme supplementation at 42 days (Table 2). Bergazym-supplemented group exhibited FCR at a level comparable with Con group, and significantly lower than Hemi group. Broilers fed Hemi diet were significantly less efficient in converting feed to gain in contrast to Con and Berg groups by 0.24 units. Xylanase supplementation has been shown to produce a 2.2% reduction in FCR when supplemented in an enzyme mixture to broilers fed regular corn-soy diets (Zanella *et al.,* 1999). More recent work (Mathlouthi *et al.,* 2002; Wu and Ravindran, 2004) with other cereal grains (rye and wheat) has shown that xylanase supplementation greatly reduced feed/gain or FCR in broiler chickens. In disagreement with our findings with Hemi, Zou *et al.*

[1]Berg and Schmidt, An der Alster 81, D-20099 Hamburg, Germany.
2ChemGen Corporation, 211 Perry Parkway, Gaithersburg, MD 20877-2144, USA.

Table 4: Input-output data and gross margin for broiler enterprise [Unit of 900 broilers per one cycle (42 days)] - Hemi Diet

	Unit	Quantity	Price Per unit	Value JD
Broilers : (900 - 16 (mortality) = 884 sold birds@1.76kg)	Kg	1555.84	0.88	1369. 1
Manure :	JD	1	11	11.0
A. Gross revenue				1380.1
Variable costs				
Purchase of day old chicks:	Chick	900	0.2	180.0
Feed mixture	Kg	2700	0.25	675.0
Bed preparation	Sack	27	1.55	41.9
Gas (Liquid propane)	Jar	45	3.5	157.5
Water	Cubic meter	15	5	75.0
Electricity	JD	1	30	30.0
Veterinary expenses	JD	1	33.3	33.3
Disinfectants	JD	1	30	30.0
Labor cost	JD	1	183	183.0
Hemi enzyme	Kg	0.45	4	1.8
Interest on operating capital (9% yearly, 0.75% *2 months *JD 1407.5 total variable costs)				21.1
B. Total variable costs	JD			1428.5
Fixed costs				
Rent of building	JD			60.0
Interest on fixed capital(9% yearly, 0.75% *2 months *JD 60 total fixed costs)				0.9
C. Total fixed costs	JD			60.9
D. Total costs (b+c)	JD			1489.4
E. Gross margin (a-b)	JD			-48.4
F. Net profit (a-d)	JD			-109.3

(2006) found that Hemicell greatly improved FCR when supplemented to regular corn-soybean diets at an inclusion rate of 0.05% of the diet. Jackson *et al.* (2004) reported inclusion of $-mannanase at 80 million U/ton improved FCR at 42 days, while Daskiran *et al.* (2004) cited reduced FCR to values or better than control at 0.5, 1.0 and 1.5% inclusion rates at 42 days in broiler diets. Trials conducted with swine have shown lowered insulin secretion due to $-mannan contained in soybean meal and (Leeds *et al.,* 1980; Sambrook and Rainbird, 1985) and a reduction in glucose absorption (Rainbird *et al.,* 1984). It has been therefore, postulated that addition of Hemicell may ameliorate insulin secretion and glucose absorption by hydrolyzing $-mannan (Zou *et al.,* 2006), and improve energy metabolism. In this experiment, addition of 0.05% Hemicell failed to elicit any response even though 0.05% is within the range of the manufacturer's recommendations. There is no explanation for this finding previously reported by Saki *et al.* (2005) at similar inclusion rates.

There were no significant differences in BW 21 and/or 42 days due to enzyme supplementation (Table 2). However, weights of broilers fed Con and Berg diets were numerically greater than those in the Hemi group with a difference of 168 and 156 g/bird, respectively, in final BW. A similar trend was observed with regard to BWG, with birds in the Con and Berg groups exhibiting BWG at 21 and/or 42 days in contrast to birds supplemented with Hemi, even though differences were not significant (Table 2). Cafe *et al.* (2002) reported significant improvement in final BW at 49 days in broilers fed xylanase-supplemented diets in contrast to a control corn-based diet. Contrary to our results, response to xylanase supplementation has been reported with regard to BWG in broilers. Studies by Zanella *et al.* (1999), Mathlouthi *et al.* (2002) and Wu and Ravindran (2004) in broilers and Adeola and Bedford (2004) in ducks have all cited increased weight gains in birds fed cereal-based diets supplemented with xylanase. In this experiment, Hemi did not improve BW 21 and/or 42 days. The results are inconsistent with findings of Saki *et al.* (2005) who reported that Hemi increased 42 day BW of broilers by 60 g/bird when added at 0.05%. In contrast to our results, previous experiments (McNaughton *et al.,* 1998; Jackson *et al.,* 2004; Saki *et al.,* 2005; Zou *et al.,* 2006) all reported improved weight gains in broilers due to Hemi supplementation at 42 days. As indicated earlier, this is potentially related to an improvement in energy utilization, anticipated with reduced $-mannan intake.

In this experiment, supplementation of xylanase and $-mannanase to broiler diets only resulted in a significant effect on FCR. No significant effects and/or improvements were observed on FI, BW and BWG. The beneficial effects of xylanase are more evident in diets based on barley, wheat, and rye which contain higher NSP content than corn (Cowieson, 2005) which has less than 1 g/kg (Choct, 1997). We have indicated earlier in the discussion of improved performance in broilers fed on corn/soybean based diets when supplemented with xylanase. However, in these trials xylanase was

Table 5: Input-output data and gross margin for broiler enterprise [Unit of 900 broilers per one cycle (42 days)] - Berg Diet

	Unit	Quantity	Price Per unit	Value JD
Broilers: (900- 13 (mortality) = 887 sold birds@ 1.916 kg)	Kg	1699.492	0.88	1495. 6
Manure:	JD	1	11	11. 0
A. Gross revenue				1506. 6
Variable costs				
Purchase of day old chicks:	Chick	900	0.2	180. 0
Feed mixture	Kg	2700	0.25	675. 0
Bed preparation	Sack	27	1.55	41. 9
Gas (Liquid Propane)	Jar	45	3.5	157. 5
Water	Cubic meter	15	5	75. 0
Electricity	JD	1	30	30. 0
Veterinary expenses	JD	1	33.3	33. 3
Disinfectants	JD	1	30	30. 0
Labor cost	JD	1	183	183. 0
Berg enzyme	Kg	0.225	5	1. 1
Interest on operating capital(9% yearly , 0.75% *2 months *JD 1406.8 total variable costs)				21. 1
B. Total variable costs	JD			1427. 9
Fixed costs				
Rent of building	JD			60. 0
Interest on fixed capital (9% yearly, 0.75% *2 months *JD 60 total fixed costs)				0. 9
C. Total fixed costs	JD			60. 9
D. Total costs (b+c)	JD			1488. 8
E. Gross margin (a-b)	JD			78. 7
F. Net profit (a-d)	JD			17. 8

supplemented in combination with other exogenous enzymes such as protease, amylase or phytase in contrast to individual use which is the case in our trial. The independent use of xylanase is unlikely to yield the value or consistency of response that a multiple of enzyme activities is capable of providing (Cowieson, 2005).

Supplementation of $-mannanase did not improve performance of broilers and even the FCR was significantly lower than xylanase and control diet. It has been shown that the large effects of $-mannanase on performance cannot be explained simply in terms making $-mannan available as an energy source (Jackson *et al.,* 2004). The $-mannan content of soybean meal is only about 1.1 to 1.3% (Dierick, 1989) and in complete diets 0.4 to 0.7% (Jackson *et al.,* 2004). The mode of action of this enzyme is complex. $-mannans are highly viscous and have adverse effects on digestive system and are associated with feedstuffs such as barely, wheat and rye. Enhanced performance may occur due to use of this enzyme in combination with other enzymes in broilers fed diets based on viscous cereals (Jackson *et al.,* 2004). In our trial, $-mannanase was used individually and for broilers fed corn based diets.

As indicated above, the results show that there is no significant difference in the broilers' weights in the control group and the two groups fed diets supplemented with the two tested enzymes. On the contrary, the addition of the enzymes reduced the body weights of the broilers. This reduction in body weight in addition to the cost of adding the enzymes has resulted in economic losses to the producer. Table 3 shows the enterprise budget for producing 300 Hubard broilers under control conditions. While Tables 4 and 5 include the enterprise budgets for producing 300 broilers using diets with added Hemi and Berg enzymes, respectively. The calculations in Tables 3 through 5 demonstrate that gross margins per the 300 broilers decreased from JD 94.8 (US$ 134) (the control diet) to JD -48.4 (US$ -69) when the Hemi enzyme was added to the diet. However, when Berg enzyme was added the gross margins per the 300 broilers decreased to JD 78.7 (US$ 111) compared to the control diet.

The estimated benefit-cost ratio using the three budgets shows that at the Con diet the ratio was 1.07 while when the Hemi and Berg enzymes were added to the diets, the ratio dropped to 0.97 and 1.05, respectively.

Conclusions: It is obvious from the results of the above analysis that both Berg and Hemi when supplemented individually did not improve performance except with FCR which was similar for Berg and Con diets, whilst Hemi-supplemented birds were less efficient. It is likely that a better response could be obtained if both enzymes were supplemented together and or in combination with other enzymes such as phytases or proteases. It is also important to note that we used a corn-based diet, as corn is the predominant cereal grain imported and used by poultry producers in Jordan. Further research is needed on utilizing these enzymes simultaneously and in combination with other exogenous enzymes and also an investigation of their effects on morphology and viscosity of the digestive tract.

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