TITLE: Effects of β-Mannanase in Corn-Soy Diets on Commercial Leghorns in Second Cycle Hens

ABSTRACT β-Mannanase (Hemicell®) is a unique enzyme-based feed ingredient, which can hydrolyze β-mannan, an anti-nutritional fiber in feed. Because soybean meal contains β-mannan and its derivatives, addition of β-mannanase may improve soybean-meal utilization. The purpose of this study was to evaluate the effect of β-mannanase on performance of commercial Leghorns fed corn-soybean meal based diets. In this experiment, three diets were formulated. The metabolizable energy content for diet 1 (high-energy diet) was 2951 kcal/kg, which was 120 kcal/kg higher than diet 2 (low-energy diet supplemented with β-mannanase) and diet 3 (low-energy diet without β-mannanase). Hy-Line W-36 hens (n = 720, 98 wk old) were randomly divided into three dietary treatments (16 replicates of 15 hens per treatment). The trial lasted for 12 weeks. Overall average feed conversion of hens fed the low-energy diet supplemented with β-mannanase was similar to that of hens fed the high-energy diet, and both were significantly lower than that of hens fed the low-energy diet without β-mannanase. There were no significant differences in overall average egg production and egg mass among three dietary treatments for the 12-wk period. However, the addition of β-mannanase significantly increased average egg production and egg mass of hens fed the low-energy diet from week 5 to 8. There were no significant differences in feed intake, egg specific gravity, egg weight, mortality, body weight, and body weight variability among three dietary treatments. β-mannanase supplementation improved energy utilization of corn-soybean layer diets, and has the potential to reduce the cost of practical laying hen diets containing β-mannan.

Key words: energy, β-mannanase, hens, energy utilization

INTRODUCTION

The addition of feed enzymes to improve dietary nutrient utilization has become popular during the last ten years. Phytase, which can improve availability of phosphorus in feed, is commonly used in commercial poultry diets today. There are growing interests in the potential of other enzyme products to improve performance of poultry provided with corn-soybean meal based diets.

Hemicell® is a fermentation product of *Bacillus lentus.* Its active ingredient is β-mannanase, which can hydrolyze β-mannan in feed. β-Mannan in ingredients such as guar, soybean meal, and sesame meal has been known as a powerful anti-nutritional factor. β-Mannans are linear polysaccharides composed of repeating D-mannose units with β-1, 4 bonds and D-galactose units. Daskiran et al. (2004) and Ray et al. (1982) reported that β-mannan significantly reduced growth, and increased feed:gain ratio in broilers. Some studies have been conducted to evaluate the effect of β-mannanase on nutrient utilization in several monogastric species. Daskiran et al. (2004) demonstrated that β-mannanase improved feed: gain ratio and reduced water: feed ratio and dry fecal output of broilers by degrading the β-mannans. McNaughton et al. (1998) reported that β-mannanase improved metabolizable energy, growth, and feed conversion in broilers. Petty et al. (1999) and Odetallah et al. (2002) indicated that β-mannanase also improved feed efficiency of swine and turkey respectively.

Corn-soybean meal based diets are the most popular for laying hens in US. Because soybean meal contains β-mannan and its derivatives such as β-galacto-mannan and β-gluco-mannan, addition of β-mannanase may improve soybean-meal utilization.

Patel and McGinnis (1985) found that β-mannan significantly decreased egg production, egg weight and feed intake in laying hens.

Little research has been conducted to investigate the effect of β-mannanase on performance of laying hens fed corn-soy diet (Jackson et al., 1999). The goal of this study was to evaluate the effect of β-mannanase on egg production, feed intake, feed conversion, egg weight, egg specific gravity, mortality, body weight and body weight variability in commercial Leghorns.

MATERIAL AND METHODS

Three diets were formulated for Hy-Line W-36 hens (Table 1). The metabolizable energy content of Diet 1 (high-energy diet) was 120 kcal/kg higher than that of Diet 2 (low-energy diet supplemented with β-mannanase) and Diet 3 (low-energy diet without β-mannanase) (Table 1).

In this experiment, 720 Hy-Line W-36 hens (molted at 66 wks) in the second cycle (98 wks old) were randomly divided into three treatments (16 replicates of 15 hens per treatment). Three hens were housed in a 40.6×45.7 cm cage and five adjoining cages consisted of a group. Replicates were equally distributed into upper and lower cage level to minimize cage level effect. All hens were housed in an environmentally controlled house with temperature maintained at approximately 25.6°C (21.1°C during the night and 28.9°C during the day). The house has controlled ventilation and lighting (16 hr/day), but no control on relative humidity. All hens were supplied with feed and water *ad libitum*. Feed consumption was recorded weekly, egg production was recorded daily, and egg weight and egg specific gravity were recorded bi-weekly. Egg weight and egg specific gravity were measured using all eggs produced during two consecutive days. Egg specific gravity was determined using 11 gradient saline solutions varying in specific gravity from 1.060 to 1.100 with 0.005-unit increments (Holder and Bradford, 1979). Mortality was determined daily and egg production and feed consumption were adjusted to a hen-day basis. Body weight was obtained by weighing three hens per replicate at the end of the experiment. Body weight was not determined at the beginning of the experiment in an effort to minimize stress on the hens prior to the test. Live weight uniformity was measured by body weight variability (CV), which was calculated as (sample standard deviation/mean) × 100. Egg mass (g egg/hen/d) and feed conversion (g feed/g egg) were calculated from egg production, egg weight and feed consumption. Feed samples were sent for β-mannanase enzyme activity analysis[1].

Data were subjected to one-way ANOVA by using general linear model procedure (PROC GLM) in SAS/STAT (2000). If differences in treatment means were detected by ANOVA, Duncan's Multiple Range Test was applied to separate means. Statements of statistical significance are based on a probability of ($P \leq 0.05$).

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[1] ChemGen Corp., Gaithersburg, MD.

RESULTS AND DISCUSSION

There were no significant differences in overall average egg production and egg mass among three dietary treatments for the 12-wk period (Table 2 and Table 3). However, average egg production and egg mass from week 5 to 8 of hens fed the low-energy diet supplemented with β-mannanase were similar to those of hens fed the high-energy diet, and both were significantly higher than those of hens fed the low-energy diet without β-mannanase (Table 2 and Table 3). These results are in agreement with those of Jackson et al. (1999) who observed a significant increase in egg production by adding β-mannanase to layer diets.

There were significant differences in overall average feed conversion (g feed/g egg) among three dietary treatments (Table 4). Overall average feed conversion of hens fed the low-energy diet supplemented with β-mannanase was similar to that of hens fed the high-energy diet, and both were significantly lower than that of hens fed the low-energy diet without β-mannanase. The addition of β-mannanase improved feed conversion of hens fed the low-energy diet approximate 4.2 %. This observation is consistent with those of Daskiran et al. (2004) and Jackson et al. (2004) who reported that β-mannanase improved feed/gain ratios in broilers. No significant differences in feed intake, egg weight, egg specific gravity, mortality, body weight, and body weight variability were observed among three dietary treatments (Tables 2-5). Mean values of mortality, body weight, and body weight variability for this experiment were 1.95%, 1.69 kg, and 15.05% respectively.

Based on the metabolizable energy content of diets, egg mass and feed intake, hens fed the low-energy diet supplemented with β-mannanase consumed 5.84 kcal ME to produce one gram egg daily, compared to 5.93 kcal ME and 6.07 kcal ME in the high and low energy diets respectively. Hens fed the low-energy diet supplemented with *β*-mannanase had better efficiency in utilizing dietary energy. This study demonstrated that degradation of *β*-mannans resulted in more energy available for production purposes in laying hens. Similarly, Radcliffe et al. (1999) observed increased apparent energy digestibility in swine with *β*-mannanase addition to corn-soybean meal based diets.

Significant effects of *β*-mannanase on performance of laying hens may not be explained by simply making *β*-mannan available as an energy source. The mode of action of *β*-mannanase is complex. An improvement in energy metabolism may be anticipated with an increase in *β*-mannan digestion. Experiments have demonstrated reductions in insulin secretion associated with *β*-mannan intake in swine (Leeds et al., 1980; Sambrook and Rainbird, 1985) and in humans (Morgan et al., 1985) and reduced glucose absorption in swine (Rainbird et al., 1984).

β-mannans are highly viscous and may have adverse effects on the digestive systems. Viscosity reduction has been suggested as a primary reason for improved performance with certain endolytic enzymes used in association with barley based high viscous cereals (Rotter et al., 1989, 1990). This may be a contributing factor in performance enhancement.

A third but important mode of action is a reduction in innate immune stimulation associated with a reduction in the *β*-mannan content of substrate entering the intestinal tract. *β*-mannans crossing the intestinal mucosa are potent stimulators of the innate immune system resulting in increased proliferation of macrophages and monocytes and resultant cytokine production. These result in exacerbated disease symptoms and reduced nutrient utilization. This has been observed using galactomannans derived from fungi (Ross et al., 2002). Improved performance of laying hens with enzyme addition to diets is likely a result of a combination of the three proposed modes of action.

The economic benefit of β-mannanase is dependent on enzyme price, feed ingredient prices, and the price of eggs. For example, if poultry oil price is high, β-mannanase may be a good alternative for poultry oil to reduce the cost of layer diets. This research demonstrated that the addition of β-mannanase improved energy utilization in typical corn-soy poultry diet. More research needs to be conducted to determine the optimum β-mannanase level in feed for the best performance and maximum profits of laying hens.

In conclusion, the addition of β-mannanase significantly improved overall average feed conversion of hens fed the low-energy diet. There were no significant differences in overall average egg production and egg mass among three dietary treatments for the 12-wk period. However, β-mannanase supplementation significantly increased average egg production and egg mass of hens fed the low-energy diet from week 5 to 8. β-Mannanase supplementation improved energy utilization of corn-soybean layer diets, and has the potential to reduce the cost of layer diets containing β-mannan.

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TABLE 1. Ingredient and nutrient content of the experimental diets

Ingredient (%)	Experimental diets		
	1	2	3
Corn	64.43	67.82	67.87
Soybean meal (48% protein)	21.18	20.40	20.40
CaCO$_3$	7.36	7.37	7.37
Hardshell[1]	2.00	2.00	2.00
Dicalcium phosphate	1.09	1.08	1.08
Poultry oil	3.00	0.35	0.35
NaCl	0.39	0.39	0.39
Vitamin Premix[2]	0.25	0.25	0.25
Mineral Premix[3]	0.25	0.25	0.25
DL-methionine	0.05	0.04	0.04
Hemicell®[4]	0.00	0.05	0.00
Calculated analysis			
Crude protein (%)	15.35	15.24	15.25
ME (Kcal/kg)	2951	2831	2831
Calcium (%)	4.00	4.00	4.00
aP[5] (%)	0.30	0.30	0.30
Methionine (%)	0.32	0.31	0.31
Methionine + cystine (%)	0.59	0.58	0.58
Lysine (%)	0.79	0.77	0.77
Analyzed value (MU[6]/ton of feed)			
β-Mannanase activity	16.08	125.04	15.62

[1] Hardshell = large particle (passing US mesh #4 and retained by US mesh #6) CaCO$_3$ supplied by Franklin Industrial Minerals, Lowell, Florida.

[2] Provided per kilogram of diet: vitamin A (as retinyl acetate), 8,000 IU; cholecalciferol, 2,200 ICU; vitamin E (as DL-α-tocopheryl acetate), 8 IU; vitamin B$_{12}$, 0.02 mg; riboflavin, 5.5 mg; D-calcium pantothenic acid, 13 mg; niacin, 36 mg; choline, 500 mg; folic acid, 0.5 mg; vitamin B$_1$ (thiamin mononitrate), 1 mg; pyridoxine, 2.2 mg; biotin, 0.05 mg; vitamin K (menadione sodium bisulfate complex), 2 mg.

[3] Provided per kilogram of diet: manganese, 65 mg; iodine, 1 mg; ferrous carbonate, 55 mg; copper oxide, 6 mg; zinc oxide, 55 mg; sodium selenium, 0.3 mg.

[4] ChemGen Corp., Gaithersburg, MD 20877, recommended addition rate = 0.05%.

[5] aP = available phosphorus.

[6] MU = 10^6 β-mannanase enzyme activity unit determined by ChemGen Corp.

TABLE 2. Effect of *β*-mannanase on egg production and feed intake

Dietary treatment		Egg production (%)				Feed intake (g feed/hen/d)			
ME level	Enzyme	1-4 wk	5-8 wk	9-12 wk	Overall	1-4 wk	5-8 wk	9-12 wk	Overall
High	-	73.68	72.31^{a}	70.45	72.14	100.19	97.76	92.86	96.94
Low	+	74.05	72.11^{a}	68.78	71.65	100.02	98.64	94.35	97.63
Low	-	73.23	68.36^{b}	66.73	69.44	101.22	99.55	95.57	98.78
SEM		1.22	1.01	1.28	1.06	0.76	0.83	0.96	0.78
Probability		0.8936	0.0197	0.1301	0.1728	0.6986	0.5662	0.3847	0.5028

$^{a-b}$ Values of the same column with no common superscripts are significantly different ($P \leq 0.05$).

TABLE 3. Effect of *β*-mannanase on egg weight and egg mass

Dietary treatment		Egg weight (g)				Egg mass (g egg/hen/d)			
ME level	Enzyme	1-4 wk	5-8 wk	9-12 wk	Overall	1-4 wk	5-8 wk	9-12 wk	Overall
High	-	66.97	66.76	66.90	66.88	49.35	48.29^{a}	47.14	48.26
Low	+	66.26	66.09	65.85	66.07	48.94	47.66^{a}	45.31	47.30
Low	-	66.71	66.32	66.31	66.45	48.82	45.32^{b}	44.20	46.11
SEM		0.34	0.32	0.31	0.30	0.88	0.76	0.85	0.74
Probability		0.3468	0.3265	0.0700	0.1736	0.9049	0.0198	0.0566	0.1313

$^{a\text{-}b}$ Values of the same column with no common superscripts are significantly different ($P \leq 0.05$).

TABLE 4. Effect of *β*-mannanase on feed conversion and egg specific gravity

Dietary treatment		Feed conversion (g feed/g egg)				Egg specific gravity (unit)			
ME level	Enzyme	1-4 wk	5-8 wk	9-12 wk	Overall	1-4 wk	5-8 wk	9-12 wk	Overall
High	-	2.04	2.03^{a}	1.98^{a}	2.01^{a}	1.0718^{a}	1.0702	1.0751	1.0724
Low	+	2.03	2.07^{a}	2.08^{b}	2.06^{a}	1.0699^{b}	1.0702	1.0750	1.0717
Low	-	2.08	2.20^{b}	2.17^{b}	2.15^{b}	1.0704^{b}	1.0694	1.0745	1.0715
SEM		0.020	0.016	0.022	0.016	0.0001	0.0001	0.0001	0.0001
Probability		0.4413	0.0001	0.0013	0.0015	0.0001	0.2007	0.5929	0.0868

$^{a-b}$ Values of the same column with no common superscripts are significantly different ($P \leq 0.05$).