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Full Length Research Paper

Effect of β-Mannanase on Broiler's Performance

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The β-mannans are highly viscous, water soluble and heat resistant non-starch polysaccharides found in leguminous plant cell walls. These are most prevalent in variety of poultry feed ingredients including soybean meal, palm meal, kernel meal, copra meal, sesame meal, guar meal. The β-mannans present in feed depress growth and feed conversion and increase nitrogen and fecal output, decreasing metabolizeable energy. The feed induced immune response diverts energy away from productive performance, consuming about 3% metabolizeable energy. Its presence up to 2 to 4% in feed severely retards growth and decreases feed efficiency in broilers. The β-mannan in broiler chicken diets increases digesta viscosity and decreases nutrient digestibility. The most pronounced adverse effects of β-mannan are being observed for lipids then for proteins, and the lowest for starch. Presence of β-mannan in the monogastric animals reduces glucose absorption and insulin secretion. The β-mannans also increase the viscosity of digesta reducing the utilization of feed, which ultimately reduces the performance of broiler birds in terms of growth performance. The β-mannanase is an endohydrolyase enzyme that is a fermentation product of Basillus lentus. It contains high amounts of β-mannanases, which degrades the β-mannans in broiler feeds. By acting on the β-mannans contents of the feed, β-mannanase minimizes the negative effects of β-mannans. It improves body weight in several monogastric species. Better feed:gain ratio and reduced water:feed ratio and dry fecal output was also observed in broilers. It also results in better immunity of broiler chickens. In conclusion, addition of β-mannanase in broiler diets rich in β-mannan contents improves the growth performance and immunity of broiler chickens.

Key words: Non-starch polysaccharides, mannanase, broiler, performance.

INTRODUCTION

Mannans are non-starch polysaccharides (NSPs) occur in the form of Glucomannan, galactomannan, gluco-galactomannan and glucronomannan in plants. Mannans and heteromannans are constituents of hemicellulose in leguminous plant cell walls (Reid, 1985). Hemicelluloses are those cell wall non-starch polysaccharides which are not solubilized by water or chelating agents but are solubilized by aqueous alkali (Selvenderan and O'Neill, 1985). According to this definition, hemicellulose includes mannan, xylan, galactan, aribanin. β-mannan also referred as linear polysaccharide with repeating units of β-1-4 mannose with β-1-6 glucose or galactose attached to the β-mannan backbone (Carpita and McCan, 2000). The β-mannans are highly viscous, water soluble and heat-resistant compounds (Dale, 1997).

The β-mannans are most prevalent in variety of animal feed ingredients including soybean meal, palm meal, kernel meal, copra meal, sesame meal, guar meal. Soybean meal is a major protein source in poultry feed which has remarkably high levels of β-mannans. Other poultry feed ingredients like distiller's dried grains and canola meal also contribute to the β-mannan contents of poultry diets. The β-mannan contents of a large number of soybean meal samples taken from various parts of the world have been reported to be reasonably consistent (Hsiao et al., 2006) (Table 1).

Several studies have demonstrated the negative effects of β-mannans (Furuse and Mabayo, 1996; Lee et al., 2003; Daskiran et al., 2004) in broiler feed. The inclusion level of 2 to 4% in feed severely retards growth and decrease feed efficiency in broilers. The β-mannans present in feed depress growth and feed conversion and

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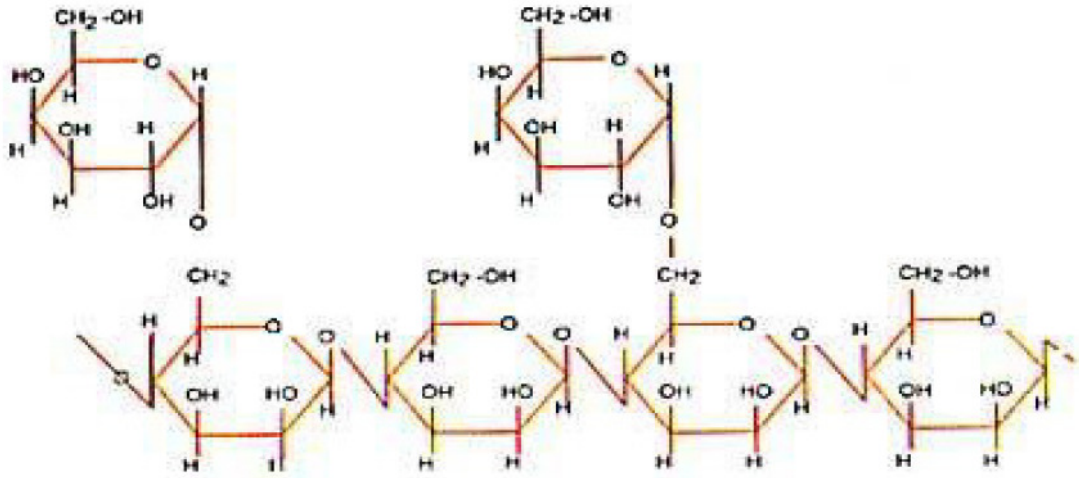
Table 1: β -mannanase content of various feed ingredients

Ingredient	β-mannan content (%)
Palm kernel meal	30-35
Copra meal	25-30
Soybean hulls	8.0
Guar meal[a]	3-9
Sesame meal	3.2
Soybean meal (non-dehulled)[a]	1.61
Soybean meal (dehulled)[a]	1.26
Sunflower meal (33%)[a]	1.20
Rye	0.69
Peanut meal	0.51
Canola meal	0.49
Barley	0.49
Lupinseed meal	0.42
Cotton seed meal	0.36
Rice bran	0.32
Oats	0.30
Wheat midlings	0.15
Wheat	0.10
Bakery meal	0.10
Maize	0.09
Sorghum	0.09
Wheat bran	0.07

(Dierick, 1989; [a]Hsiao et al., 2006).

Figure 1: Structure of β-1-4-galactomannan.



increase nitrogen and fecal output, decreasing metabolizeable energy as well (Daskiran et al., 2004; Lee et al., 2003). It riggers an innate immune response that can consume up to 3% of total metabolizeable energy (Deskiran et al., 2004) making it unavailable for growth. It decreases feed intake, weight gain and feed to gain ratio (Ray et al., 1982; Furuse and Mabayo, 1996). The β-mannans in broiler chicken diets increases digesta viscosity and decreases nutrient digestibility, with most pronounced effects being observed for lipids then for proteins, and lowest for starch (Maisonnier et al., 2003). It also reduces glucose absorption, insulin secretion (Leeds et al., 1980) and increasing viscosity (Lee et al., 2003). The β-mannanase is an endohydrolyase enzyme that is a fermentation product of Basillus lentus which degrades β-mannan in broiler feeds. The enzyme cleaves randomly 1-4, β-D-mannan main chain of galactomannan, galactogluco-mannan and mannan as illustrated in figure 2.

In several recent studies, β-mannanse addition to broilers diet at the recommended level (100 million units per ton MU/ton) has been demonstrated to improve the

Figure 2: Structure of soy β-1, 4-galacto-mannan and its hydrolysis by Hemicell.

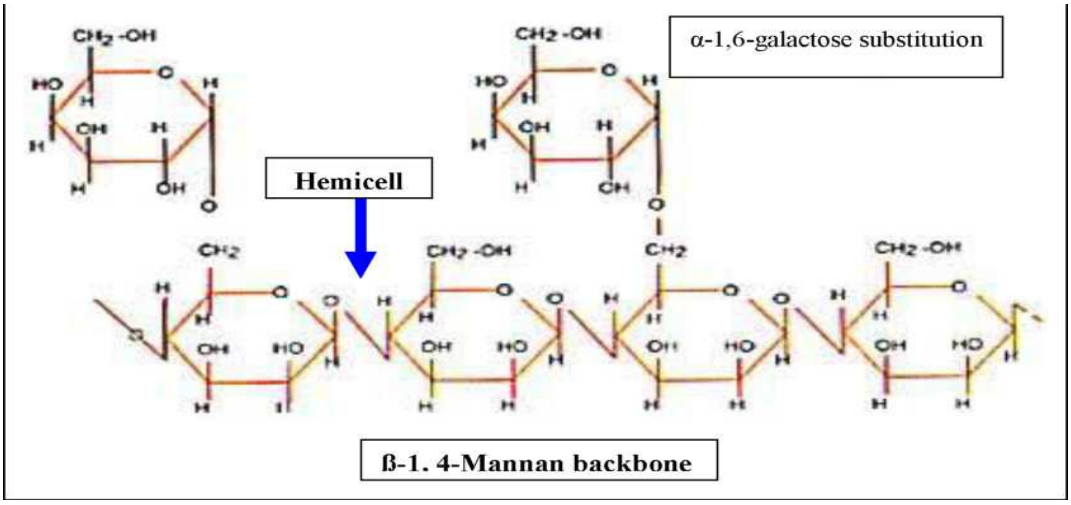


Table 2: Effect of varying levels of β-mannanase on 0-42 day broiler performance

Parameter	β-mannanase addition rate (MU ton^{-1})			
	0	50	80	110
Weight gain (g)	2547	2529	2651	2660
FCR (g/g)	1.970	1.965	1.924	1.899

general performance. The addition of β-mannanse to broiler diets containing 2% guar gum has been shown to significantly reverse the growth depression due to β-mannan content of guar gum in broiler feed (Daskiran and Teeter, 2001). Using corn-SBM based diets have revealed that β-mannanase improved both growth and feed efficiency by about 3% (McNaughton et al., 1998). β-mannanse improves body weight uniformity in several monogastric species (Anderson et al., 2001). It results in better feed:gain ratio and reduced water:feed ratio and dry fecal output of broilers by degrading β- mannans (Daskiran et al., 2004). The inclusion of β-mannanse at 80 million units per ton improved broiler gains and feed conversion ratio (Jackson et al., 2004a). It improved feed conversion by approximately 4.2% in chickens fed a low energy diet supplemented with 0.05% enzyme (Wu et al., 2005).

During last decades there has been an escalating usage of β-mannanase in commercial broiler diets. The main focus herein is to review the available literature on the effect of β-mannanase on the performance of broiler chickens.

Weight gain and Feed conversion

Jackson et al. (2004b) performed an experiment to check the effect of varying levels of β-mannanase on 0-42 day broiler performance. Graded levels of β-mannanase were added to corn-soyabean meal-based diets in a 42 day broiler pan trail, with the results shown in table 2.

Results showed improved growth and feed conversion ratio (FCR) at 80-110 MU ton^{-1} inclusion level. In addition to growth and FCR, results revealed benefit with regard to mortality at highest inclusion level. B-mannanase supplementation at 110 MU ton $^{-1}$ has improved growth and FCR by 4.4 and 3.7%, respectively. This can compared with the larger response to the enzyme (7% in growth and 6% in FCR) reported in a 42 day broiler trail using low energy corn-soya diets containing 4-12% wheat bran (Torki and Chegeni, 2007).

Guar gum has high levels of β-mannans (Vohra and Kratzer, 1964; Couch et al., 1967) that depress growth in chicks (Ray et al., 1982). The β-mannan in guar has galactose:mannose ratio of 1:1.7 which is virtually identical to that of soybean meal 1:1.8 (Whistler and Smart, 1953; Whistler and Saarnio, 1957). This is a useful tool for assessing the effect of β-mannanse in various diets. Daskiran et al. (2004) performed two experiments to check the effect of β-mannanase on broiler bird performance of 14 days of age at various levels of β-mannan content using guar gum based diets. In the absence of guar gum, β-mannanse improved FCR by 2.9%, with no effect on weight gain. With the addition of 2% guar gum, performance was clearly depressed compared with the controlled, and by adding β-mannanse in 2% guar gum diet improved body weight gain and FCR by 5.5 and 6 %, respectively (Table 3).

The β-mannanse enzyme supplementation improved

Table 3: The effect of β-mannanse on broiler chick performance to 21 days in diets varying the guar gum contents

Guar gum (MU ton^{-1})	Enzyme[a]	BW (g)	FCR (g g^{-1})
0	absent	394.8	1.82
0	present	390.20	1.149
2	absent	335.7	1.417
2	present	354	1.337

(Daskiran et al., 2004)
BW: body weight; FCR: feed conversion ratio
[a]β-mannanase enzyme at 100 million unit per ton to the feed

Table 4: The effect of β-mannanse at graded levels on broiler chick performance to 21 days in diets containing 1% guar gum.

β-mannanase (MU ton^{-1})[a]	BW (g)	FCR
0	346.5	1.336
100	346.9	1.304
200	348.1	1.291
300	345.5	1.286

(Daskiran et al., 2004)
BW: body weight; FCR: feed conversion ratio
[a]MU = 10^6 enzyme activity units

Table 5: The effect of experimental treatments on body weight gain and feed conversion ratio.

Guar Meal Level	Body Weight Gain (g)	Feed Conversion Ratio (g/g)
Control	2358.25	1.74
Low	2229	1.81
Intermediate	2208	1.83
High	2105	1.88
Intermediate + β-mannanase	2282	1.80
High + β-mannanase	2167	1.83

(Mohayayee and karimi, 2012)

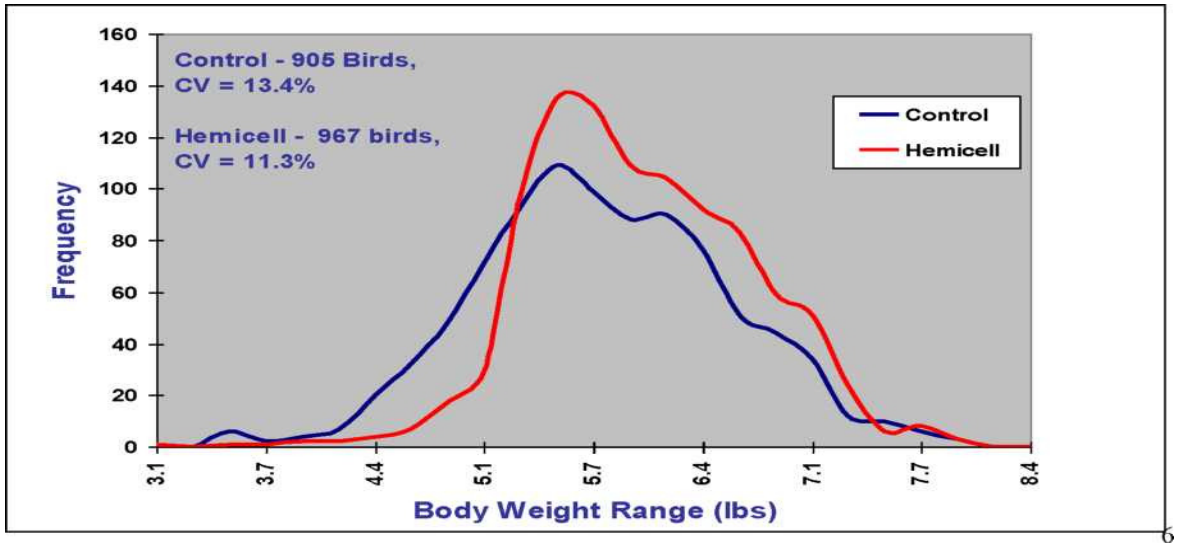
the performance of broiler fed corn-soyabean meal based diets but its effect was increased with the increase in β-mannan contents of diet. These results were supported by an experiment conducted with diets devoid of soybean meal, containing sunflower meal and canola meal as protein sources (Magpool et al., 2010). B-mannanse improved feed efficiency and weight gain when guar meal was included in the diet at 5-7%. Daskiran et al. (2004) checked the effect of graded level β-mannanase enzyme on weight gain and feed conversion ratio of diet with high β-mannan contents. There was non-significant response of weight gain but feed efficiency tended to improve as level of β-mannanase enzyme was increased in the diet (Table 4). These observations were in agreement Jackson et al. (2004b) for feed conversion, but differ in the body weight gain, which may be due to younger age of birds.

Mohayayee and karimi (2012) checked the effect of guar gum and β-mannanase enzyme supplementation on the weight gain and feed conversion ratio. Experimental groups included: control diet without guar meal, low level of guar meal (2, 4 and 6% in starter, grower and finisher diets, respectively), intermediate level of guar meal (4, 6 and 8% in starter, grower and finisher diets respectively), intermediate guar meal + β-mannanase enzyme, high levels of guar meal (6, 9 and 12% in starter, grower and finisher diets respectively) and high guar meal + β-mannanase enzyme. There were 7 and 11% reduction in weight gain with intermediate and high guar meal diet, respectively. With the supplementation of β-mannanase, reduction of 7% in weight gain due to intermediate guar meal diet was removed but there was non-significant effect on reduced weight gain with high guar meal diet supplemented with β-mannanase. The feed conversion ratio was improved significantly with the supplementation of β-mannanase to the intermediate guar meal diets but non-significant effect was observed with high guar meal diets having enzyme supplementation (Table 5).

Live weight Uniformity

Live weight uniformity in broiler bird flocks is very impor-

Figure 3: Effect of β-mannanase on body weight uniformity of broilers



Anderson et al., 2001

Table 6: Effect of β-mannanase enzyme on protein and dry matter digestibility.

	Protein Digestibility (%)		Dry Matter Digestibility (%)
Enzyme[a]	**In vitro**	**Illeal**	**In vitro**
Present	68.30	61.80	62.49
Absent	71.31	62.48	64.96

(Saki et al., 2005)
[a]β-mannnanase at a rate of 100 million units ton^{-1}.

-tant factor affecting the profitability. The uniformity in live weights during grow out phase translates the ultimate consistency of final products. Efficiency of modern processing operations is affected by the variability of live weights, because the automatic equipment's are typically adjusted with the average body weight. In addition, the consistency of carcass or parts can result in a higher value in the market place. Variability in live weight exists in any population of broilers due to many factors such as genetic variation, management conditions inherent stresses and climatic conditions etc., but reduction in live weight variability can improve the efficiency of modern day processing operations.

In order to statistically evaluate live weight uniformity, all birds in pens were individually weighed and coefficient of variation (CV) is determined in pen trails by weighing all birds at various ages. Several broiler pen trails have evaluated the effect of β-mannanase on the uniformity of live weights. Anderson et al. (2001) have determined the effect of β-mannanase 100 MU on body weight uniformity at different ages with 2240 broilers. The birds were individually weighed at 21, 35 and 49 days of age. The average live weight CV was significantly lower at 21, 35 and 49 days of age. The CV of 49-day body weight was 13.31% for controlled and 11.02% for birds with enzyme supplementation (Figure 3). Piao et al. (2003) reported that β-mannanse significantly decreased CV from 11.58% to 9.17%, representing a 26% reduction. In agreement with these results, Jackson et al. (2005) reported 19% decrease in CV with 42 day old male broilers. In a pen trail (Jackson et al., 2004b) determined the effect of β-mannanase on live weight uniformity. They determined the individual live weights at different ages and reported a decrease of 20 and 21% in CV at 21 and 49 days of age, respectively. In each of these reports, the improved uniformity was caused by smaller percentage of underweight birds provided with β-mannanase.

Intestinal function and morphology

The effect of β-mannanase on digestion has been examined in several experiments. In a broiler trail using corn-soybean based diet containing approximately 8% wheat, Saki et al. (2005) reported significant increase in protein and dry matter digestibility and reduced uric acid content in litter with the addition of β-mannanase in corn-soybean based diet (table 6).

Azarfar (2013) studied the effect of β-mannanse on the illeal digestibility of crude protein and crude fat in broiler chickens fed corn-soybean based diets. Enzyme was

Table 7. Effects of β-mannanase enzyme on illeal digestibility of crude fat, crude protein and dry matter in broiler chicken

Parameter	Enzyme (g/kg)		
	0	0.5	1
Crude fat (%)	63.49	65.31	77.54
Crude protein (%)	68.51	74.29	79.27
Dry matter (%)	76.32	82.59	79.63

(Azarfar, 2013)

added at the rate of 0, 0.5 and 1 g/kg in experimental diets. The results of this experiment revealed that dietary supplementation of β-mannanase significantly improved illeal digestibility of crude protein. These findings were in agreement with the results of other researchers who found that dietary supplementation with exogenous enzymes improves illeal digestibility of dietary proteins (Delang et al., 1998; Gdala et al., 1997; Papadopoulos, 1998; Wright, 1995; Yaser, 2002; Saki et al., 2005). However illeal digestibility of crude fat was only improved when diet was supplemented with β-mannanase at the level of 1g/kg (table 7).

Mussini et al. (2011) also reported the significantly improved crude protein digestibility in broilers fed corn-soybean based diet with the inclusion of β-mannanase at the level of 0.01 and 0.1%. Similar results were reported in the diets containing guar gum supplemented with β-mannanase (Daskiran et al., 2005).

Some studies have been conducted to check effect of β-mannanase on intestinal morphology. Abidmoradi and Mehri (2007) examined several components of gut morphology in 42-day-old broilers provided with four levels of β-mannanase (0, 100, 140, 180 MU ton^{-1}) in corn-soybean meal-based diets. Increasing β-mannanase dosage showed improvement in several criteria, with increase in duodenal villus height and crypt depth, and decreased epithelial thickness and goblet cell numbers with the enzyme supplementation at 140 $MUton^{-1}$. Crypt depth increased and goblet cell numbers in illeal villi were reduced at this level of inclusion. A linear decrease in illeal viscosity was also observed with increasing level of enzyme addition. The authors commented that reduced goblet cells number may be expected to lower mucin production, and endogenous nitrogen losses and decreased epithelial thickness may benefit the absorption of nutrients. Ouhida et al. (2002) reported decrease in concentration of purine bases in the ileum at 21 and 42 days with the supplementation of β-mannanase. This may be attributed to reduced microflora in the ilium and caeca caused by reduced undigested polysaccharide escaping from gut digestion. Lee et al. (2003) checked the effect of β-mannanase supplementation on intestinal viscosity fed diets having guar germ and hull fractions. Two experiments were designed to study the effect of β-mannanase (at 0, 1x and 4x; 1x= 1.09 X 10^5 units/kg) with two guar meal fractions at three levels, germ (0, 5.0 and 7.5 %) and hull (0, 2.5 and 5%). Results showed that Supplementation of β-mannanase in feeds containing either fraction of guar meal reduced intestinal viscosity and alleviated the deleterious effects associated with guar meal feeding. Abidmoradi and Mehri (2007) reported the significant decrease in digesta viscosity with β-mannanase supplementation, which was in the agreement with the Lee et al. 2003.

Disease challenge

Necrotic enteritis is a common disease observed in poultry on worldwide basis. At the subclinical level, reduced feed efficiency in infected birds is most important as economic point of view (Stutz and Lawton, 1984). Causal agent of necrotic enteritis is the anaerobe, gram-positive and spore forming bacterium Clostridium perfringens (Van Immerseel et al., 2004). The use of C. perfringens inhibitory antibiotics is a common method of inhibition of necrotic enteritis (George et al., 1984; Ficken and wages, 1997). Coccidiosis is caused by protozoan parasites of Emeria species (Williams, 2005). Anticoccidial vaccines have been available since 1952 (Williams, 2002). However, coccidia have developed a resistance to all of the available anticoccidial drugs (Chapman, 1997). Due to emergence of drug resistant species of Emeria and C. perfringens, the concern about the use of alternative means of optimizing broiler production under commercial conditions has arisen. Several experimental enzymes have been tested as to their ability to reduce the degree of infection in chicks exposed to Eimeria species and C perfringens. Jackson et al. (2003) has conducted two experiments to check the effect of β-mannanase on broiler chick performance under disease stress. In the first experiment, poor performance was shown by the birds as expected with infection, but the β-mannanase supplementation significantly improved gain and FCR by 14% and 11%, respectively for disease challenged birds (Table 8). Medication, significantly improved performance to a larger extent as compared to β-mannanase.

In the second experiment, an antibiotic and coccidiostat were examined separately with and without β-mannanase (Table 9). The β-mannanase significantly increased weight gain and reduced upper and lower coccidial lesion scores in infected birds. A significant decrease in lesion score in the lower intestine was also observed with the enzyme. There was no further improvement in perform-

Table 8: Effect of infection[a], β-mannanase enzyme[b], and medication[c] on broiler chick performance from 8-21 days of age.

Infection	Enzyme	Medication	Gain (g)	FCR (g g^{-1})	Mortality (%)	Lesion Score (day 14)[d]	
						Upper	Lower
-	-	+	540	1.446	0.00	0.00	0.00
-	+	+	548	1.424	1.78	0.00	0.00
+	-	-	429	1.704	9.78	1.38	1.56
+	+	-	490	1.536	3.75	1.16	1.44
+	-	+	522	1.447	0.89	1.03	0.88

(Jackson et al., 2003)
FCR, Feed conversion rate.

Table 9: Effect of infection[a], β-mannanase enzyme[b], and medication[c] on broiler chick performance from 8-21 days of age.

Treatment	Enzyme	Gain (g)	FCR (g g^{-1})	Mortality (%)	Upper	Lower Non-infected
1 Non-medicated	-	427	1.695	1.25	0.00	0.00
2 Medicated	-	437	1.656	2.50	0.00	0.00
Infected, non-medicated						
3	-	296	1.909	1.25	2.44	2.31
4	+	338	1.849	3.75	1.94	1.34
Infected, BMD						
5	-	352	1.770	5.00	2.25	1.94
6	+	348	1.772	5.00	2.09	1.34
Infected, SAL						
7	-	368	1.720	3.75	1.00	1.09
8	+	397	1.688	3.75	0.97	1.09
Infected, BMD + SAL						
9	-	397	1.671	5.00	1.59	1.63
10	+	390	1.666	5.00	0.78	1.16

(Jackson et al., 2003)
FCR, Feed conversion rate.

Table 10: Effect of β-mannanse on the concentration of serum immunoglobulin of broilers Immunoglobulin.

(g/L)	β-mannanse (%)			
	0.00	0.025	0.05	0.075
3 w				
IgA	0.313	30.312	0.314	0.314
IgG	0.365	0.364	0.367	0.365
IgM	0.244	0.286	0.260	0.266
6 wk				
IgA	0.312	0.315	0.315	0.314
IgG	0.365	0.366	0.367	0.365
IgM	0.217	0.219	0.257	0.229

(Zou et al., 2006)

-ance when both antibiotic and coccidiostats were present. These results demonstrate that β-mannanase is highly effective in birds exposed to disease stress.

Immunity

The β-mannans (β-galactomannans) are non-starch polysaccharides found in the leguminous feed ingredients of poultry feeds. B-mannans have similar molecular pattern to some pathogens, so animal's innate immune system perceives β-mannans as a Pathogen Associated Molecular Pattern (PAMP) and initiate a protective action (Stahl and Ezekowitz, 1998; Didierlaurent et al., 2005; Ausubel, 2005). The β-mannans have been shown to increase the proliferation of monocytes and macrophages resulting in secretion of cytokines (Peng et al., 1991; Ross et al., 2002). The monitoring of specific acute-phase proteins can provide a measure of the stimulation of the innate immune system. Acute-phase proteins are an aspect of the innate immune system, and are known

Table 11: Effect of β-mannanse on relative immune organ weights of broilers.

Relative organ weight (g/ 1000g)	β-mannanse (%)			
	0.00	0.025	0.05	0.075
3 w				
Thymus	3.37	3.53	3.86	3.33
Spleen	0.52	0.73	0.58	0.55
Bursa	2.59	2.90	2.89	2.94
6 wk				
Thymus	1.90	2.33	2.44	2.26
Spleen	0.63	0.78	1.11	1.04
Bursa	1.26	0.86	1.08	1.69

(Zou et al., 2006)

Table 12: Effect of β-mannanase on feed intake of broiler birds fed corn-soybean based diets at low and high metabolizeable energy (ME) levels.

Diet	FI[a] (g)
Low ME and no mannanase	3586.5
High ME and no mannanase	3111
Low ME with mannanase	3694.5
High ME with mannanase	3458

(Karimi et al., 2004)
[a]FI: Feed intake, 0-6 weeks of age.

to accumulate in blood at high levels in response to various forms of stress. One acute-phase protein, known as α-1-acid glycoprotein (AGP), was monitored in a series of cage and pen trials with poultry (Anderson et al., 2006). These experiments revealed that, by the exclusion of antibiotics from the diet, the AGP level was significantly increased in birds. The addition of β-mannanase to the diet have significantly decreased the blood AGP level, which describes that addition of β-mannanase to the diet has significantly reduced mannan contents of feed by breaking the β-mannans chains. A reduction in stimulation of innate immune system may result in a reduced expenditure of energy in non-productive functions. Zou et al. (2006) checked the effect of β-mannanse on the serum immunoglobulin concentration, T-lymphocyte proliferation and relative weight of immune organ. There were four treatment groups having β-mannanse at the levels of 0, 0.025, 0.05, 0.075%, respectively. Results showed that the enzyme significantly increased the serum IgM concentration in 3- and 6-wk-old broilers, proliferation of T-lymphocytes in 6-wk-old broilers for the 0.05% group was also improved significantly (Table 10), and supplemental hemicell was also improved relative immune organ weight (Table 11).

Gharaei et al. (2012) performed an experiment to check the effect of guar meal with and without β-mannanse on the immune response of broiler chicks. Addition of β-mannanase enzyme to the diet significantly improved immune response, which were in agreement with zou et al. (2006) for β-mannanse in improving immune response of broiler chickens.

Feed intake

The β-mannan contents in broiler feed decrease feed intake (Ray et al., 1982; Furuse and Mabayo, 1996). Several experiments have been conducted to check the effect of β-mannanase supplementation to the diets having β-mannan contents on feed intake in broiler chicks. The β-mannanase supplementation to the guar meal based diets have significantly improved feed intake (Lee et al., 2005). Karimi et al. (2004) observed significantly improved feed intake with the corn-soybean based diets at high metabolize able energy levels on the broiler birds (table 12). However, non-significant results were observed for diets having low metabolizeable energy.

An experiment was performed to investigate the effect of replacement of soybean-meal with canola meal in broiler diets supplemented with β-mannanase on the intake of growing broiler chicks (Torki and Chegnai, 2007). There were three hundred and sixty un-sexed one day old chicks randomly allocated to four treatments, each of which had 9 pens of 10 birds. Experimental groups were: control group (corn-soybean meal), corn-soybean meal with and without enzyme, corn-soybean meal-canola meal with and without enzyme. Results showed that there was non-significant increase in feed intake with and without enzyme supplementation. (table 13).

In agreement with these results, Abidmoradi and Mehri, (2007) reported the non-significant increase in the feed intake of broilers fed diet supplemented by β-mannanase.

Table 13. Evaluation of dietary replacement of soybean meal by canola meal supplemented by β-mannnanase on the feed intake of broiler chicks.

Diet	Enzyme	Feed Intake (g/day/bird)
Corn-[a]SBM	No enzyme	109.8
Corn-SBM-[b]CM	No enzyme	102.6
Corn-SBM	Hemicell	111.0
Corn-SBM-CM	Hemicell	111.0

(Torki and Chegnai, 2007)
[a]SBM: Soybean meal
[b]CN: Canola meal

Jackson et al. (2004) also reported the similar results for the dose response study of the β-mannanase on broiler chicks fed corn-soybean based diets. Zou et al. (2006) performed an experiment to check the effect of the β-mannanase on feed intake of broiler chicks. The chicks were fed same corn-soybean based diets with four different levels of hemicell 0, 0.025, 0.05, and 0.075%, respectively. There were non-significant differences in feed intake among the treatments from 0-6 years of age. Ouhida et al. (2002) reported no effect on feed intake of broiler chicks by β-mannase addition. Azarfar (2013) also reported non-significant difference in feed intake.

CONCLUSION

Presence of β-mannan contents in the feed of broiler birds negatively affects the productive performance. Addition of β-mannanase at the level of 100 million units per ton to the broiler diets high in β-mannan contents improved the productive performance and immunity of broiler chickens.

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