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Full Length Research Paper

The effect of guar meal (germ fraction) and β-mannanase enzyme on growth performance and plasma lipids in broiler chickens

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A completely randomized design experiment was conducted to assess the effect of β-mannanase enzyme on a commercial broiler chickens strain fed with different levels of guar meal germ fraction (GM) Each treatment was assigned to 4 replicate for a total of 24 pens, consisting of 15 chicks per pen, in randomized complete block design. Experimental groups include: control diet without GM, low level of GM (2, 4 and 6% in starter, grower and finisher diets respectively), intermediate level of GM (4, 6 and 8% in starter, grower and finisher diets respectively), intermediate GM+β-mannanase enzyme, high levels of GM (6, 9 and 12% in starter, grower and finisher diets respectively) and high GM+β-mannanase enzyme. Body weight gain (BWG), feed intake (FI) and feed:gain ratio (F:G) were measured weekly. At the end of the experiment (42 day of age), blood samples were collected for the determination of plasma triglycerides, total cholesterol, high density lipoprotein (HDL), low density lipoprotein (LDL) and then the chicks were killed for carcass dressing. BWG, FI, F:G ratio and plasma lipids were affected by experimental groups (P<0.05). Experimental groups had no significant effects on relative weight of carcass and relative weight of giblets except for abdominal fat (P>0.05). In the control, low GM and intermediate GM+β-mannanase groups, BWG, FI, F:G ratio, relative weight of carcass and giblets and plasma lipids were better than other treatments. High GM in broilers diet deleteriously affected growth performance, FI, F:G ratio and plasma lipids. Result indicates that optimal levels of guar meal are low level without β-mannanase and intermediate level with β-mannanase without adverse effects on growth performance or plasma lipids of broiler chickens.

Key words: Guar meal, β-mananase, plasma lipid, performance, broiler chicken.

INTRODUCTION

Guar plant (*Cyamopsis tetragonoloba*) is a drought-tolerant legume that can be grown in unsuitable conditions. The guar bean is used as a vegetable for humans in Asia. Guar was used primarily as a thickening agent because of the high content of galactomannan gum found in their seeds (Chenault et al., 2002). Guar gum is a highly viscous galactomannan polysaccharide (Lee et al., 2003) and is used as a stiffener in soft ice cream, a stabilizer for cheeses, instant puddings and whipped cream substitutes. Burnett (1966) and Lee et al. (2003a, b) found that the guar gum residues in the meal can increase the viscosity of digester, thereby reduce the growth and feed efficiency. Gum residue increases intestinal viscosity, which decreases the nutrient absorption in the gastrointestinal tract (Rainbird et al., 1984). The increase in viscosity can reduce glucose absorption up to 35% and water absorption up to 40% (Rainbird et

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Abbreviations: GM, Guar meal; **BWG,** body weight gain; **FI,** feed intake; **HDL,** high density lipoprotein; **LDL,** low density lipoprotein.

al., 1984). Poor growth observed after guar meal feeding is attributed to the residual gum contained in guar meal. Although, feeding high levels of non digestible polysaccharide has been associated with decrease in nutrient utilization, numerous investigations has shown some useful physiological functions of galactomannans, such as those found in guar beans. These functions include decrease in plasma cholesterol (Frias and Sgarbieri, 1998; Favier et al., 1998; Yamamoto et al., 2000; Maisonnier et al., 2001), postprandial plasma glucose (Fairchild et al., 1996; Ou et al., 2001), post-prandial hypotension in type 2 diabetes patients (Groop et al., 1993; Russo et al., 2003), inhibition of colonization of pathogenic gastrointestinal bacteria (Bengmark, 1998), and enhance macrophage activity (Duncan et al., 2002). Guar meal is a relative inexpensive high protein meal and has two parts; germ fraction with high protein content and hull fraction with low protein content. Germ and hull fractions of guar meal contain different concentrations of residual gum that remain after gum extraction from the guar bean. Protein contents of American guar meal are varying from 33 to 45% depending on fraction type (Van Etten et al., 1961; Couch et al., 1967; Nagpal et al., 1971; Conner, 2002). Verma and McNab (1984) reported that approximately 88% of the nitrogen content in guar meal was true protein, with an arginine content approximately twice as soybean meal, although the methionine and lysine contents have been reported to be inadequate for optimal rat growth (VanEtten et al., 1961). The use of guar meal in poultry feed has been limited because of reported adverse effects, which include diarrhea, growth rate suppressing and mortality increase, when fed at relatively high levels (Sathe and Bose, 1962; Couch et al., 1967; Verma and McNab, 1982; Patel and McGinnis, 1985). Since that guar meals germ fraction's energy, protein, methionine and phosphorus is higher than in soybean meal, addition of guar meal as a partial replacement for soybean meal in poultry diets may be a useful economic strategy for decreasing feed costs while maintaining production levels, but some of the anti-nutritional agents in guar meal limit the usage of high levels of this meal in broiler diets. Guar gum, tripsin inhibitor, saponins, poliphenols and hemagelotenins are some of the anti-nutritional agents in guar meal (Verma and Mcnab, 1982; Conner, 2002; Lee et al., 2003a). High content of galactomannan gum in guar meal can increase intestinal viscosity, suppress growth and reduce feed efficiency (Gutierrez et al., 2007; Burnet, 1966; Lee et al., 2003a, b). Hemicell is a fermentative product of *Bacillus lentus*. The most active ingredient is β-mannanase enzyme, which hydrolyzes β-mannan (Zou et al., 2006). Supplementation of the broiler's diet with β-mannanase enzyme decreased intestinal viscosity and increased growth and feed efficiency (Lee et al., 2003b). Patel and McGinnis (1985) also showed that autoclaving or adding hemicellulase enzyme improved growth performance of chickens fed guar meal. Verma and McNab (1982) found negative effects of guar meal which were more prominent in younger birds than older birds and found that the inclusion of enzymes such as hemicellulase or β-mannanase improved feed utilization. Toasting the meal, steam pelleting of the diets and supplementations with no methionine improved the performance.

Therefore, the objectives of this study were to evaluate the ppossibility of replacing soybean meal with guar meal by-product (germ fraction) in traditional corn-soy diets with or without of β-mannanase enzyme inclusion and measuring growth performance, carcass characteristics and plasma lipids of broiler chickens.

MATERIALS AND METHODS

Birds, housing and cares

Three hundred and sixty (360) one-day-old male broiler chicks of commercial strain (Ross 308) were randomly assigned to 6 dietary treatments with 4 replicate pens of 15 chicks each. Each pen was one square meter and covered with wood shaving. The house temperature was initially maintained at 32°C and reduced gradually 2.8°C every week to reach a constant temperature of 20 to 22°C at 28 day of age. A continuous lighting was used for the first 3 days and a 23:1 h light:dark cycle was applied for the rest of the experimental period. Birds were allowed free access to the feed and fresh water throughout the experiment. Performance parameter such as BWG, FI and FI:BWG (F:G) ratio were measured weekly.

Diets characteristics

Diets were formulated according to the recommended nutrient by Ross 308 manual for broiler chicks and were offered in mash form. The compositions of the basal diet and experimental diet are shown in Table 1. Habituate diet to guar meal 2% fed to boilers from day 1 to 7 because some of guar meal's limitations, especially high content of galactomannan gum. The starter, grower and finisher diets were provided similar nutrient and fed *ad libitum* from 1 to 10, 11 to 28 and 29 to 42 days of age, respectively.

Sampling and measurements

Two birds close to the average pen weight of chicks were randomly selected and 2 ml of blood was withdrawn by bronchial vein puncture into heparinised syringes at 42 day of age. Plasma was separated by centrifugation and stored at -20°C, then transported to Laboratory for assay. Afterwards the chickens were slaughtered for dressing parameters and thereafter relative weight of carcass, breast, thigh, heart, pancreas, spleen, liver, abdominal fat, gizzard and bursa of fabricious were determined. Triglycerides (TG), total-cholesterol (TC), high density lipoprotein-cholesterol (HDL) and low density lipoprotein-cholesterol (LDL) concentrations (expressed as mg/dl plasma) were estimated in plasma samples by using enzymatic kits (Biocin, Germany).

Experimental variables

Experimental variables included (1) performance parameters such as BWG, FI and F:G ratio (2) Blood parameters such as triglycerides, total cholesterol, HDL-cholesterol and LDL-cholesterol and (3) dressing parameters such as relative weight of carcass, breast, thigh, heart, pancreas, spleen, liver, abdominal fat, gizzard

Table1. Compositions of experimental diets by low, intermediate, high or no levels of guar meal.

Composition (g.kg^{-1})	Starter					Grower				Finisher			
	Habituate	Control	Low	Intermediate	High	Control	Low	Intermediate	High	Control	Low	Intermediate	High
Corn	560	577.4	591.5	603	615	577.4	591.5	603	615	631	678	695	725
Soybean meal	340	347	320	299	280	347	320	299	280	296	205	175	115
Guar meal	20	0	20	40	60	0	40	60	80	0	60	90	120
Fish meal	40	20	17	10	0	20	17	10	0	0	0	0	0
Plant oil	0	15	10	5	0	15	10	5	0	33	17	10	0
Shell	15.5	14.9	15.5	15.81	16.6	14.1	14.7	15	15.8	12.95	13.2	13.28	13.58
Di Calcium phosphate	14	14.5	14.5	15.2	16	14.5	14.5	15.2	16	15.5	14.6	14.3	13.56
Lysine	1.2	1.4	1.82	2.4	2.9	1.4	1.82	2.4	2.9	1.1	2.2	2.57	3.31
Methionine	1.3	1.8	1.68	1.59	1.5	1.8	1.68	1.60	1.5	1.65	1.2	1.05	0.75
Common Salt	2	2	2	2	2	2	2	2	2	2	2	2	2
Sodium bicarbonate	1	1	1	1	1	1	1	1	1	1	1	1	1
Minerals + vitamins	5	5	5	5	5	5	5	5	5	5	5	5	5
Coccidiuasetate	0	0	0	0	0	0.5	0.5	0.5	0.5	0.5	0.5	0.1	0.5
Antibiotic(Lincomysin)	0	0	0	0	0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Hemicell(β-mannanase source)	-	-	-	-/+	-/+	-	-	-/+	-/+	-	-	-/+	-/+
Calculated analysis													
ME (Kcal.Kg)	2836.2	2950	2950	2950	2950	3015	3015	3015	3015	3100	3100	3100	3100
Crude protein (%)	22.07	21	21	21	21	20.1	20.1	20.1	20.1	18.3	18.3	18.3	18.3
Calcium (%)	1	0.92	0.92	0.92	0.92	0.86	0.86	0.86	0.86	0.85	0.85	0.85	0.85
Available phosphor (%)	0.5	0.46	0.46	0.46	0.46	0.43	0.43	0.43	0.43	0.42	0.42	0.42	0.42
Metionine (%)	0.54	0.54	0.54	0.54	0.54	0.5	0.5	0.5	0.5	0.47	0.47	0.47	0.47
Metionine + Cystein (%)	0.9	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6
Lysine (%)	1.38	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.05	1.05	1.05	1.05

Habituate diet used for all chicks at first week of age. Starter, grower and overall phase included the 1 to 24, 25 to 49 and 1 to 42 days of broiler's rearing period.
ME, Metabolizable energy.

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Statistical analysis

A completely randomized design was used to investigate the effects of the treatments. Analysis of variance was calculated with the general linear model procedure (GLM) of the Statistical Analysis Systems Institute Inc. (SPSS, 2005). Differences between measurements were compared by the Duncan's multiple range tests (Duncan, 1955) following ANOVA, and values were considered statistically different at P<0.05. The homogeneity of variance was checked.

RESULTS

Performance

Results of BWG can be seen in Table 2 at starter, grower and overall phases of this experiment. At the starter phase, the treatments have no significant effects on BWG (P>0.05). At the grower phase, low GM diet and High GM (±enzyme) diets reduced BWG compared to the control group by 7 and 13% respectively but both intermediate GM (±enzyme) diets did not reduce BWG.

At overall phase, low GM diets did not reduce BWG compared to the control group but enzyme-less intermediate GM diet and both high GM(±enzyme) diets reduced BWG compared to the control group (P<0.01). In this case, enzyme-less intermediate GM diet reduced BWG by 7% but this reduction was removed when this diet was supplemented with β-mannanase enzyme. Enzyme-less high GM diet reduced BWG by 11%, however, this reduction has not been removed when this diet was supplemented with β-mannanase enzyme.

Table 2 shows the effects of dietary treatments on the averages of FI in starter, grower and overall phases of rearing period. FI was not affected by experimental groups at starter phase. There was a significant effect of dietary GM on the broiler chicks FI at grower phase (P<0.01), whenever the birds were fed on high GM (±enzyme) diets, they have lower FI (5 and 6% in ±enzyme diets respectively) rather than control diet. There was a significant effect of dietary GM on the FI of broiler chicks at overall phase too (P<0.05); whenever the birds were fed on high GM (±enzyme) diets, they have lower FI (by 4%) rather than the control diet. However, this reduction continued (by 3%) when this diet was supplemented with β-mannanase enzyme. There were no significant differences between other dietary groups, rather than the control group at overall phase.

Results of F:G ratio averages are shown in Table 2 in starter, grower and overall phases of rearing period. There were significant effects of GM on F:G ratio during starter (P<0.05), grower (P<0.01) and overall phases (P<0.05). During starter phase, F: G ratio in the enzyme-less intermediate and high GM diets were higher than the control diet, however, F:G ratios returned and became similar to the control diets when these diets were supplemented with β–mannanase enzyme. At grower phase, the highest F:G ratios was seen in high GM (±enzyme) diets so that enzyme supplementation could

not improved this ratio. At overall phase, F:G ratio in enzyme-less intermediate GM diet was higher than the control group but it was improved when this diet was supplemented with β–mannanase. In the enzyme-less high GM diet, F:G ratio was higher than other groups and β–mannanase enzyme addition could not improved this ratio, too.

Carcass dressing

Results of broilers carcass dressing in 42 day old broiler chickens are shown in Table 3. Experimental treatments had no significant effect on relative weight of carcass and relative weight of giblets except for abdominal fat (P>0.05). Abdominal fat in high GM (±enzyme) diets was higher than the control and low GM diets by 22 and 16% on average, respectively.

Blood parameters

Results of blood parameters in 42 day old chicks are shown in Table 4. Intermediate and high GM (±enzyme) diets increased plasma triglycerides by 7% on average compared to the control group. Plasma cholesterol concentrations in enzyme-less intermediate and high GM diets were higher than the control group, however, it became similar to the control group when the were birds fed on these diets supplemented with β–mannanase enzyme. There was a tendency (p=0.05) for LDL to be affected by experimental groups. Plasma HDL was higher than the control group in the birds fed on the enzyme-less diet and contained high levels of GM but when β–mannanase enzyme was added to this diet, the mentioned parameter reduced and reached to the control groups.

DISCUSSION

In the present study, we found that adding of 2, 4 and 6% GM (in starter, grower and finisher, respectively) to the enzyme-less diets or 4, 6 and 8% GM (in starter, grower and finisher, respectively) only to the enzyme supplemented diets of broilers had no adverse effects on BWG of broilers at overall phase. However, enzyme-less diets that contained 4, 6 and 8% GM (in starter, grower and finisher, respectively) such as high GM diets without or with enzyme can decrease the BWG in overall phase. In brief, it concluded that from a WG point of view, there were some limitations for addition of intermediate or high levels of GM in the broilers diets and it can be possible to

Table 2. The effect of experimental treatments on body weight gain (g), feed intake(g) and F:G ratio in experimental periods.

Guar meal level	Body weight gain (gr.day)			Feed intake (gr.day)			F:G ratio		
	24-Jan	25-42	Jan-42	24-Jan	25-42	Jan-42	24-Jan	25-42	Jan-42
Control[a]	803.75	1554.75[a]	2358.25[a]	1233.25	2882[ab]	4115.25[a]	1.53[b]	1.85[c]	1.74[c]
Low	779.25	1450[bc]	2229[abc]	1230.50	2801[bc]	4031.50[ab]	1.57[ab]	1.93[abc]	1.81[abc]
Medium	751	1457.25[abc]	2208.25[bc]	1207.50	2848.50[ab]	4056[ab]	1.61[a]	1.95[abc]	1.83[ab]
Medium+ Enzyme[b]	763.25	1519.50[ab]	2282.75[ab]	1204	2911[a]	4115[a]	1.57[ab]	1.91[bc]	1.80[bc]
High	759.5	1346.25[d]	2105.50[c]	1223	2740[dc]	3963[b]	1.61[a]	2.03[a]	1.88[a]
High+ Enzyme	807.5	1359.75[dc]	2167.25[bc]	1272.25	2708.75[d]	3981[b]	1.57[ab]	1.99[ab]	1.83[ab]
SEM	4.91	5.98	8.01	5.86	5.01	7.36	0.03	0.05	0.04
P Value	0.2	0.001	0.004	0.3	0.001	0.042	0.02	0.008	0.015

Different superscripts within a column indicate a significant difference ($P < 0.05$). a: Control diet without guar meal; b: β-mannanase SEM: standard error of the means.

Table 3. The effect of experimental treatments on relative weight of carcass dressing(g/100g body weight).

Guar Meal level	Body weight gain			Feed intake			F:G ratio		
	Starter	Grower	Overall	Starter	Grower	Overall	Starter	Grower	Overall
Control[a]	803.75	1554.75[a]	2358.25[a]	1233.25	2882[ab]	4115.25[a]	1.53[b]	1.85[c]	1.74[c]
Low	779.25	1450[bc]	2229[abc]	1230.50	2801[bc]	4031.50[ab]	1.57[ab]	1.93[abc]	1.81[abc]
Intermediate	751	1457.25[abc]	2208.25[bc]	1207.50	2848.50[ab]	4056[ab]	1.61[a]	1.95[abc]	1.83[ab]
Intermediate + Enzyme[b]	763.25	1519.50[ab]	2282.75[ab]	1204	2911[a]	4115[a]	1.57[ab]	1.91[bc]	1.80[bc]
High	759.50	1346.25[d]	2105.50[c]	1223	2740[dc]	3963[b]	1.61[a]	2.03[a]	1.88[a]
High + Enzyme	807.50	1359.75[dc]	2167.25[bc]	1272.25	2708.75[d]	3981[b]	1.57[ab]	1.99[ab]	1.83[ab]
SEM	4.91	5.98	8.01	5.86	5.01	7.36	0.03	0.05	0.04
P Value	0.2	0.001	0.004	0.3	0.001	0.042	0.02	0.008	0.015

Different superscripts within a column indicate a significant difference ($P < 0.05$). a: Control diet without guar meal; b: β- mannanase; SEM: standard eror of the means.

Table 4. The effect of experimental treatments on plasma lipids.

Guar meal level	Triglyceride	Cholesterol	LDL	HDL
Control a	99.07b	110.06b	53.57	33.60b
Low	102.99ab	114.86ab	55.87	36.43ab
Intermediate	105.108a	117.40a	58.27	37.08ab
Intermediate+ Enzyme b	104.83a	114.13ab	58.01	34.82ab
High	107.84a	119.31a	57.29	38.74a
High+ Enzyme	106.69a	115.76ab	56.50	35.48ab
SEM	0.30	0.37	0.27	0.24
P Value	0.001	0.006	0.05	0.02

Different superscripts within a column indicate a significant difference ($P < 0.05$).a: Control diet has no guar meal; b: β-mannanase SEM: standard error of the means. HDL, High density lipoprotein; LDL, low density lipoprotein

overcome these problems by use of a proper enzyme but only in intermediate GM diets and not in high GM diets. These results are similar to the findings of Gutierrez et al. (2007) which reported that addition of 5% guar by product to hen diets did not have adverse effects on the growth performance. Lee et al. (2005) showed that addition of β-mannanase in diet with intermediate levels of guar meal improved growth performance and BWG that was similar with the result of this research.

Feeding of high levels of guar meal germ fraction in broilers diet because of high content of galactomannan gum cause increased intestinal viscosity and decreased FI that was similar to the research of Lee et al. (2003a), this that indicated the use of high levels of guar meal (germ or hull) in feeding broiler chickens deleteriously affected FI. Use of high levels of guar meal germ fraction

in broilers diet because of high content of galactomannan gum resulted in intestinal viscosity enhancement, reduction of FI and finally rise of feed conversion ratio, and these contradicted the results of Lee et al (2003a) that found feeding with high levels of guar meal germ fraction had no significant effect on feed conversion ratio between experimental treatments. Mehri et al. (2010) found that inclusion of 500 or 700 g/ton β-glucanase enzyme had no any effects on FI but 900 g/ton reduced FI in broilers fed corn-soybean based diets. They did not evaluate the effects of guar meal but in the present study, we found that enzyme addition did not reduce FI in intermediate or high GM diets.

The increase of FI in the broilers fed high guar treatments indicated that there were some unfavorable characteristics in guar by-products and these characteristics were not enough for reduction of FI in broilers when added at low levels, which is supported by previous data (Gutierrez et al., 2007). Feed conversion ratios for broilers fed high GM (with or without β-mananase) or intermediate GM without β-mananase were significantly higher than for the control group, although, no significant differences were detected among other guar treatments and the control.

In carcass dressing, only abdominal fat were significantly affected by experimental treatments that probably it can be due to energy and protein balance deficiency. Lee et al. (2005) reported that use of low levels of guar meal germ fraction in broiler's feeding resulted in higher carcass weight, breast weight and breast efficiency than broilers fed with higher levels of this meal that were similar with the results of present research (Table 3).

Of blood parameters, triglycerides, cholesterol and HDL were significantly affected by experimental treatments, these probably were because of the eating of high levels of guar meal germ fraction. NSPs like guar gum destroy the intestinal micro-flora and this effect on amino acid intestinal-hepatogenic cycle maybe caused to increase HDL.

Results indicate that optimal levels of guar meal are low level without β-mananase and intermediate level with β-mananase without adverse effects on growth performance or blood parameters of broiler chickens. The addition of guar by-products as a partial replacement for soybean meal in poultry diets may be a useful economic strategy for decreasing feed costs while maintaining production levels. The results of this study suggest that guar meal can be fed to broilers at low levels up to 5% of the diet or intermediate levels supplemented with mannanase- which proposed in the present study-without unfavorable effects on performance, FI, dressing characteristics and blood parameters.

Conclusion

In this study, we conclude that high GM diets have some adverse effects on broilers performance, abdominal fat and blood parameters as like as intermediate GM diets and some of these problems can be overcome by the use of an appropriate enzyme but only in intermediate GM diets and not in high GM diets.

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