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# Effect of Beta-Mannanase Supplementation on Growth Performance, Fecal Consistency, and Carcass Characteristics of Weanling Pigs

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**ABSTRACT**

The study aimed to investigate the effect of beta-mannanase supplementation on growth performance, fecal consistency, and carcass characteristics of weanling pigs. A total of 100 weaned piglets (initial body weight = 7 ± 0.5 kg) were divided into 2 dietary treatments of (T1) control diet; and (T2) beta-mannanase supplemented diet. Each treatment was replicated 5 times with a pen of 10 piglets each following a completely randomized design. Feed and water were supplied ad libitum during the 30-day feeding trial. Fecal scores per pen were determined every morning on a daily basis; 1 pig per replicate was randomly selected for carcass evaluation. The results showed that there were no significant differences (P>0.05) in feed conversion ratio, fecal consistency scores, dressing percentage, and loin eye area between T1 and T2. Treatment T1 produced a greater body weight and gained weight faster compared to T2. In conclusion, beta-mannanase supplementation did not improve growth performance, fecal consistency, and carcass characteristics in weanling pigs. The amount of beta-mannanase was not enough to degrade the non-starch polysaccharides of the soybean meal.

Keywords: Beta-mannanase, Carcass characteristics, Fecal consistency, Growth performance, Weanling pigs

## Introduction

Soybean meal (SBM) is usually used as a protein source to ensure adequate essential amino acids in pig diets. Newly weaned piglets correlated with reduced growth, reduced nutrient intake, and greater sensitivity to diarrhea (Walsh *et al.*, 2013). Newly weaned piglets have trouble digesting soybean meal (SBM) due to anti-nutritional factors such as antigenic protein and non-starch polysaccharides (NSP) up to 22.7% on a dry matter basis (Lenehan *et al.*, 2003). The beta-mannan accounts for 150 to 370 g/kg of total NSP content of the pig diets (Centraal Veevoeder Bureau Veevoedertalel, 1998). Galactomannans in soybean meal are chemically composed of a d-mannose backbone attached in chains by β-1 to -4 linkages, with attached d-galactose molecules attached as side chains by α-1 to -6 linkages (Carr *et al.*, 2014). This anti-nutrient may cause diarrhea and limit the growth of piglets, due to a lack of essential enzymes to degrade it (Cromwell, 2000). Galactomannans also cause interferes the microbial growth in the gut and weaken the immune system due to the high viscosity (Arellano et al, 2022).

In order to prevent poor performance post-weaning and diarrhea, enzyme supplementation is a strategy that can be used to increase the use of SBM in pig diets without reducing growth performance. The enzyme was a nutritional additive that recently gained popularity in the pig industry (Fouhse *et al.*, 2019; Upadhaya *et al.*, 2016). It has been recognized to improve nutrient digestibility by targeting specific anti-nutritional factors in feed ingredients to allow pigs to digest and absorb more nutrients from the feed (Bedford and Partridge, 2010).

The beta-mannanase was an enzyme necessary to digest mannans, an NSP present in SBM by breaking down the β-1, 4 linkages between mannose units in mannans making mannose available for mannose absorption (Shimizu *et al.*, 2015). The use of beta-mannanase in diets containing feedstuffs high in NSP is expected to reduce harmful reactions to NSP in weanling pigs through digestion of the NSP portion of the feed. This study was conducted to investigate the effect of beta-mannanase supplementation on growth performance, fecal consistency, and carcass characteristics of weanling pigs.

## Materials and Methods

All pig handling and processing procedures in this study were approved by the Institutional Animal Care and Use Committee (IACUC) of the College of Veterinary Medicine, University of the Philippines Los Baños (UPLB). The experiment was conducted using 100 piglets of mixed sexes with similar weaning weights (body weight: 7 kg ± 0.50 kg) coming from a pool of weanling pigs at the International Training Center on Pig Husbandry (ITCPH) farm in Lipa City. The experiment used a Completely Randomized Design (CRD) with two treatment groups and 5 replicates (pen) each treatment with 10 piglets per replicate. The dietary treatment groups are treatment 1 (T1) as the control diet and treatment 2 (T2) as the basal diet supplemented with 400 ppm beta-mannanase (commercial enzyme: Hemicell® from Elanco Animal Health, Greenfield, Indiana). Feed and water were given ad libitum. There was a 1-week period of adjustment to the basal diet before the 30-day feeding trial.

A commercial pre-starter pig feed ration, which is the basal feed used on the farm, was used as the basis for the formulation of feeds used in the trial. The formulation of the basal diet was adjusted such that soybean meal content was increased and milk was decreased. For the experimental diets, the basal diet formulation was constant for the treatment groups. The experimental feeds were prepared from a commercial feed mill supplemented with 400 ppm beta-mannanase. Diets were formulated to contain 13.82 MJ/kg of ME and 8.5 g/kg lysine. All the diets met the nutrient requirement for grower pigs (NRC, 1998).

The initial body weight (BW) of each piglet was measured at the beginning of the experiment and the final BW at the end of the feeding trial. The difference between the initial and final BW was measured to get the body weight gain value. The amount of feed consumed was recorded daily by measuring the difference between the amount of feed offered and the feed refused.

The average daily gain (ADG) = $\frac{total\ weight\ gain}{number\ of\ feeding\ days}$

Feed conversion ratio (FCR) = $\frac{total\ feed\ consumed}{total\ weight\ gain}$

Mortality rate = $\frac{Number\ of\ dead\ pigs}{initial\ number\ of\ pigs}$

Fecal scores based on the study of Flohr *et al.* (2014) were determined every morning daily for individual pens and the average fecal score value per pen was recorded. The following fecal scoring system was used: 1 hard, dry pellet; 2 firms, formed stool; 3 soft, moist stool that retains shape; 4 soft, unformed stools; 5 watery liquid that can be poured.

At the end of the experiment, one animal per replicate was randomly selected and slaughtered for carcass characteristics. The visceral organs were removed, and each carcass was weighed.

The dressing percentage =$\frac{carcass\ weight}{live\ weight} \times 100$

The loin eye area ($cm^2$) measured at the 10th rib was determined using a plastic grid for quick measurement of the loin eye. The income over feed and pig cost for each treatment was determined using the prevailing prices of feeds and starter pigs. Data collected were analyzed using SPSS software (IBM Analytics, USA). An Independent T-test was used for equality of means. The statistically significant was used P<0.05.

## Results and Discussion

### Growth performance

The result of the growth performance of weanling pigs fed with T1 and T2 is presented in Table 1. The average final body weight of T1 was numerically higher compared to T2 and the value were not statistically different (P>0.05). However, the average body weight gain and ADG of T2 were significantly lower (P<0.05) than T1. Statistical analysis showed that there was no significant difference in the feeds consumed and FCR among T1 and T2 (P>0.05). One pig died from each treatment group and the mortality rate of T1 and T2 were both 2%. Deaths were due to respiratory problems and the observed lesions upon necropsy were suggestive of pneumonia.

Table 1. Effect of beta -mannanase supplementation on growth performance of weanling pigs

| Parameter | Treatment | |
|---|---|---|
| | T1 | T2 |
| Average initial weight (kg)$^{ns}$ | 7.13 | 7.05 |
| Average final weight (kg)$^{ns}$ | 18.03 | 16.65 |
| Average body weight gain (kg)$^{s}$ | 10.90 | 9.60 |
| Average daily gain (g/head/day)$^{s}$ | 363.27 | 319.83 |
| Average Feed consumed (kg)$^{ns}$ | 479.65 | 433.27 |
| Average feed conversion ratio $^{ns}$ | 2.29 | 2.23 |
| Mortality rate (%) $^{ns}$ | 2 | 2 |

$^{s}$ Significant difference (P<0.05).
$^{ns}$ No significant difference (P>0.05).

Based on the study, the inclusion of beta-mannanase in the diet of weanling pigs did not affect the growth performance of weanling pigs. The result is similar with Jang *et al.* (2020), in which the beta-mannanase did not affect feed intake, ADG, and the gain-to-feed ratio (F/G) of weanling pigs. Enzyme beta-mannanase treated at 21 days of age piglets gained 10 g/day less than the control piglets (Vangroenweghe *et al.*, 2021). The observations of the present study coincide with the data reported by Vonderohe *et al.* (2014) and Carr *et al.* (2014), whereas there was no effect of beta-mannanase supplementation in nursery pig diets on growth, feed efficiency, or feed intake. The inclusion of beta-mannanase enzyme in maize-soybean meal-based diets containing distiller's dried grains with solubles did not improve the growth performance of nursery pigs (Jones *et al.*, 2010). Lenehan *et al.* (2003) reported that the addition of beta-mannanase to the diets did not lead to an improvement in average daily feed intake (ADFI), ADG, or F/G in late nursery pigs.

The results did not also conform to the work of Frank *et al.* (2009) and Pettey *et al.* (2002) who reported that nursery pigs fed with diets supplemented with beta-mannanase had increased ADG and improved feed conversion (F/G) compared to pigs fed with the control diet. Nonetheless, the study of Kim *et al.* (2017) in growing pigs, the overall ADG, final BW and blood gucose were greater for pigs fed with beta-mannanase compared negative control diet. A trial evaluated by EFSA FEEDAP Panel (2017) on weaned piglets on maize-soybean meal-based diets showed results the diets containing beta-mannanase had significantly higher final body weight and resulted in significantly higher daily feed intake and improved feed-to-gain ratio compared to the control diet.

According to Carr *et al.* (2014), several studies showed that dietary enzymes improve body weight, feed efficiency, and immunity in poultry. However, feed enzymes affect differently in poultry than swine, in which more variable results in pigs are evident compared to poultry. The use of beta-mannanase on feed efficiency reported random results. The supplementation of beta-mannanase has inconsistent effects on growth performance in weanling pigs. A possible reason for this inconsistent effect might be the various amount of soluble NSP and insoluble NSP in the diet as cell walls encapsulating nutrients (Jang *et al.*, 2020). The differences in the response to enzyme supplementation in the experiments could be due to differences in enzyme purity, level of supplementation, thermostability, types of enzymes used, the pH optimum, and the composition of diets of the various products used (Lv *et al.*, 2013).

The concentration or type of enzymes included in the present experiment may be not suitable or insufficient to elicit a favorable response (Bedford and Inborr, 1993). However, the efficacy of enzymes is sometimes found to be low if the level is above an optimum enzyme concentration (Officer, 1995). So, in this experiment, the reduced efficacy of the beta-mannanase may be due to either too low or too high enzyme concentration. Lower exogenous enzyme activity in the gastrointestinal tract may also be an issue for the lack of beneficial effect (Kim *et al.*, 2004). It is possible that the enzyme may not have had sufficient time yet to establish itself in the gut.

Non-starch polysaccharides (NSPs) are one of the main anti-nutritional factors (ANFs) that have negative effects on the nutrient utilization and digestibility of non-ruminant diets (Choct *et al.*, 2010). Beta-mannan is an NSP that is broken down by beta-mannanase and then fermented in the hindgut. Beta-mannanase does not simply act on the 1.3% beta-mannans found in SBM and break down the polymer to its constituent monosaccharides; the magnitude of the improvements in digestibility can range from approximately 3 to over 10 percentage units and the increase in digestibility coefficients must be due to other mechanisms (Lv *et al.*, 2013).

According to Anderson and Hsiao (2009) beta-mannanase rapidly reduces the molecular weight of soluble beta-galactomannan and decreases the immune response associated with mannans. They speculated that gut inflammation alters the microbiota composition and its normal ability to provide colonization resistance against pathogens. Lv *et al.* (2013) concluded in their experiment that beta-mannanase increases digestibility by reducing digesta viscosity. Moreover, the viscosity of digesta is reduced, there can be more interaction between digestive enzymes and substrate hence increasing nutrient digestibility (O'Connell *et al.*, 2005; Passos *et al.*, 2015). A study in broilers revealed that beta-mannanase increased amylase and trypsin activity in the digesta (Li *et al.*, 2010).

In addition, to improve growth performance using enzyme supplements, a negative effect of ADG was also observed. Treatment T1 tended to have better ADG compared to T2, in which the feed consumption of T2 was not significantly different from T1 but still was numerically lower compared to the T1. The reduced feed intake most probably caused the lower ADG. Comparatively, Pettey *et al.* (2002) reported that pigs fed diets with a beta-mannanase slight decrease in feed intake compared to the pigs fed the control diet but still maintained the numerically highest ADG of all treatment groups. The impaired feed intake of this study was possible due to the addition of beta-mannanase to the diet may have resulted in the reduction of feed palatability.

**Fecal consistency**

Table 2 shows the weekly average fecal scores of T1 and T2. The fecal consistency scores of T1 and T2 were not statistically different from each other (P>0.05). Numerically, pigs fed with T2 had a lower overall average fecal score which tended to be on the less watery side or less diarrheic. It could be possibly adduced that beta-mannanase has a potential effect of causing less diarrhea, but since statistically there is no significant difference, there is still insufficient evidence to suggest that beta-mannanase supplementation affects fecal consistency. The results of this experiment did not refer to the observation of Zuo *et al.* (2015), in which supplementing enzymes can reduce diarrhea in weaned pigs. High levels of NSP in pig diets can cause an increase of digesta viscosity and reduce nutrient digestibility due to the interaction between substrate and digestive enzymes (Passos *et al.*, 2015). Zuo *et al.* (2015) noted that the reduction of diarrhea is probably due to increased digestive enzyme activities, improved intestinal development, and increased nutrient digestibility.

Table 2. Effect of beta-mannanase supplementation on average fecal consistency scores[a] of weanling pigs

| Week | Treatment | |
|---|---|---|
| | T1 | T2 |
| 1 | 3.19 | 3.19 |
| 2 | 3.32 | 3.00 |
| 3 | 3.88 | 3.46 |
| 4 | 3.25 | 3.01 |
| Overall score | 3.41 | 3.17 |

No significant difference (P>0.05) was observed for all means.
[a]The scale used for assessing fecal consistency was based on a numerical scale of 1 to 5, where 1 hard, dry pellet; 2 firms, formed stool; 3 soft, moist stool that retains shape; 4 soft, unformed stool; 5 watery liquid that can be poured.

### Carcass characteristics

The average carcass characteristics of the treatment groups are presented in Table 3. Dressing percentage and loin eye area were not statistically different among treatment groups (P>0.05). Numerically, T1 had a larger dressing percentage and loin eye area compared to T2. With a larger body weight, consequently, T1 had a higher dressing percentage.

Table 3. Effect of beta-mannanase supplementation on carcass characteristics of weanling pig

| Parameter | Treatment | |
|---|---|---|
| | T1 | T2 |
| Live weight (kg) | 18.25 | 16.502 |
| Carcass weight (kg) | 13.44 | 11.88 |
| Dressing percentage (%) | 73.64 | 71.99 |
| Loin eye area (sq. cm) | 21.10 | 18.19 |

No significant difference (P>0.05) was observed for all means.

On the other hand, the result of Pettey *et al.* (2002) reported that beta-mannanase addition to the typical corn-SBM diet for growing-finishing pigs resulted in increased carcass lean tissue and lean gain of pigs but did not influence the longissimus muscle area; in which this observation was in line with the findings in the present study. Results by Hahn *et al.* (1995) revealed trends in gilts-fed maize-soy bean meal-based diets with beta-mannanase increased lean gain and feed efficiency in barrows.

Pettey *et al.* (2002), believe that the presence of unhydrolyzed mannans inhibits the release of the gastric inhibitory polypeptide (GIP) and glucagon-like peptide (GLP-I) thus also inhibiting the secretion of insulin. They note that insulin promotes protein tissue synthesis by stimulating glucose uptake by muscle cells and inhibiting protein catabolism. The suppression of insulin secretion can decrease the intestinal absorption of glucose in peripheral tissues such as striated muscle by monogastric animals (Torki and Chegeni, 2007). Therefore, a deposit of lean tissue will be also optimal, when the insulin level is returned.

### Income over feed and pig cost (IOFPC)

Table 4 shows the average income over feed and pig cost of T1 versus T2. T1 had an average IOFPC of 511 PHP (Philippine Peso). Supplementation of beta-mannanase in the diet decreased the IOFPC by 21.14% to a level lower than the control. The results indicate that supplementation of beta-mannanase in the diet decreased the IOFPC to a level lower than the control. The decrease in IOFPC could be attributed to the lower ADG of pigs fed with beta-mannanase supplemented diet compared to pigs fed with the control diet.

Table 4. Average income over feed and pig cost of treatment groups

| Parameter | Treatment | |
|---|---|---|
| | T1 | T2 |
| Average body weight gain (kg) | 10.90 | 9.60 |
| Average feed consumed per pig (kg) | 479.65 | 433.27 |
| Average feed cost per pig (PHP) | 1,669 | 1,517 |
| Average sales per pig (PHP) | 2,180 | 1,920 |
| Income over feed and pig cost (PHP) | 511 | 403 |

*Price of starter pigs at 200PHP per kg.
*Price of beta-mannanase at 550PHP/kg.

## Conclusions

In conclusion, beta-mannanase supplementation had no significant effect on growth performance, fecal consistency, and carcass characteristics of weanling pigs. The concentration and type of enzymes are critical to the direction or size (positive or negative) of an animal's response to enzyme supplementation. The amount of enzymes (400 ppm) added was not enough to degrade the non-starch polysaccharides of the soybean meal.

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