EFFECTS OF YEAST-BASED NON-NUTRITIONAL ENHANCERS ON THE PERFORMANCE OF WEANLING PIGS

Angela B. Bael and Domingo B. Roxas

ABSTRACT

The study was conducted to determine the effects of yeast-based non-nutritional enhancers (mannoproteins, betaglucans and nucleotides) (YNE) on the growth performance of weanling pigs. Eighty crossbred weanling pigs (40 males and 40 females) with 7-8 kg initial weight were placed in groups of five pigs per pen and randomly distributed to four dietary treatments: 1) basal diet (BD) + 0% YNE; 2) BD+ 0.05% YNE; 3) BD + 0.15% YNE; and 4) BD + 0.30% YNE. The treatments were arranged following a randomized complete block design with sex of the animals as the blocking factor. The weanling pigs were fed with booster diet for five days and pre-starter diet for 25 days. Results showed that feed intake increased (P<0.05) only at 0.30% YNE inclusion rate. The average daily gain increased (P<0.05%) at 0.15% and 0.30% YNE inclusion rates. However, feed conversion efficiency did not differ (P>0.05) among the treatments. Higher inclusion rate of YNE in the diet reduced the scouring incidence and increased the livability rate of weanling pigs. The addition of 0.30% YNE in the basal diet was the most practical to use among treatments.

Keywords: betaglucans, mannoproteins, nucleotides, weanling pigs, yeast-based non-nutritional enhancer

INTRODUCTION

The intestinal microflora of newborn and pre-weanling piglets is in a continual state of flux. The piglet's gut rapidly changes in size, has high protein turnover rates, undergoes rapid changes in microflora, and quickly alters its digestive and immune functions (De Lange *et al*., 2000). Ideally, the ratio of beneficial to pathogenic bacteria should be 9:1. Due to these conditions, weaning and succeeding nursery phases represent a period of gastrointestinal and immune instability since the gastrointestinal tract of weanling pig undergoes morphological, histological and microbial dysfunctions. Therefore, piglets are very sensitive to dietary changes. Commercial farming conditions also place various stressors on the GIT of the animal. These can cause adverse reactions, resulting in poorer performance manifested by low weight gain, digestive disturbances and nutrient

Animal and Dairy Sciences Cluster, College of Agriculture, University of the Philippines Los Baños, Laguna, Philippines (email: angela_bael@yahoo.com).

malabsorption, often manifested as a scouring type problem, and in worst cases, death (Walsh *et al*., 2007). Optimizing gut health is a key to improving animal performance.

Nowadays, feed additives are commonly used to influence the gut health of swine. These are non-nutritive substances that, when added to diets will improve the response of pig to feeds and subsequently increase swine production efficiency. Some of the commonly used feed additives include organic acids, enzymes, prebiotics, probiotics and immunomodulators. Brewer's yeast *(Saccharomyces cerevisiae)* is an example of a material wherein enzymes, prebiotics and immunomodulator can be derived from (Roxas, 2006).

Yeast-based non-nutritional enhancers (YNE) are one of the most promising feed additives that commercial farmers in the Philippines may use. It contains mannoproteins and betaglucans from yeast cell wall and nucleotides from yeast extract. Adding YNE to diets in the critical phases of swine production such as the weaning period wherein immunity of the animal is low, will improve the immune status of the animal and stabilize intestinal microflora (Carlson *et al*., 2004).

For many years, brewer's dried yeast (*Saccharomyces cerevisiae)* products, which are often by-products of beer manufacturing, have been added to animal feeds for their nutritional content, as they contain high levels of protein and B vitamins. More recently, brewer's yeast has been used as a rich source of cell wall particles, such as mannoproteins and betaglucans that can be used as antibiotic-replacement products for animal production. Whole yeast products or yeast cell wall components have been used to affect the physiology, morphology and microbiology of the intestinal tract of swine in improving its growth (Sauerwein *et al*., 2006).

Mannoproteins are mainly N- and O- glycosilate proteins with a highly polymerized and branched glucosilade fraction, with around 150 and 200 mannose residues (Posadas *et al*., 2010). Dietary supplementation with mannoproteins is beneficial to swine by acting as a general intestinal immune modulant. It works by adversely affecting *Clostridia* that reside near the intestinal wall and serve as a binding site for certain pathogenic bacteria (*e.g*., *Escherichia coli* and *Salmonella* with type 1 fimbrae and mannose-seeking lectins). Mannose residues exposed on glycoproteins present at the gut epithelial cell surface form important attachment sites for several unfavorable organisms. Mannose, itself, is relatively inefficient, but yeast cell wall-derived mannoproteins are potentially very effective at blocking type 1 fimbrae docking sites. Mannoproteins have been shown to improve nutrient utilization through stimulation of specific microbial populations in the gastrointestinal tract (Kocher *et al*., 2004). It has recently been demonstrated that feed supplementation with mannoprotein inhibits gut colonization by *Salmonella* and other gut bacteria in animals, thus, improving gut morphology. The use of feeds rich in mannose as carbohydrate in the diet could have prebiotic or bio-protective effect against intestinal infection caused by enterobacteria.

Betaglucans are polysaccharides of D-glucose monomers linked by β-glycosidic bonds. The β-(1,3) glucans are a naturally-occurring class of polysaccharides found in the cell wall in many species of yeast (including brewer's yeast or *S. cerevisiae*), mushrooms, cereal grains and some bacterial lichen and algal species. Betaglucans are known as "biological response modifiers" because of

their ability to activate the immune system particularly by activating the immune cells known as macrophages. Yeast-derived particulate betaglucan activate dendritic cells and macrophages via C-type lectin receptor dectin-1 pathway. Betaglucans enhance defense against bacterial challenges and improve growth performance in pigs (Babineau *et al*., 1994).

Nucleotides are low-molecular-weight intracellular compounds that are involved in many biochemical processes, *e.g*. as monomeric units of nucleic acids, in transferring chemical energy, in biosynthetic pathways, as biological regulators and as coenzyme-components (Andrés-Elias *et al*., 2007). Although nucleotides are endogenously produced by the body, dietary nucleotides may affect the gastrointestinal tract by promoting the ultrastructure (Uauy *et al*., 1990), modulating the intestinal microbiota, and activating immune-enhancing cells (Lee *et al*., 2007). Some studies have revealed the effects of added commercial products containing nucleotides or nucleotides-enriched diets not only on the intestinal ultimate structure by promoting beneficial bacteria including bifidobacteria (Martinez-Puig *et al*., 2005), but also on intestinal enzyme activities (Sauer *et al*., 2009), and on recovery of scouring (Arnaud *et al*., 2003). Likewise, villous height reduction was less pronounced and the affinity to scouring infections was reduced (Martinez-Puig *et al*., 2007).

This study was conducted to determine the effects of YNE on the performance of weanling pigs. Specifically, it aimed to evaluate the effects of YNE on the performance of weanling pigs in terms of feed intake, live weight gain, feed conversion efficiency, feed cost efficiency and livability rate; and to determine the possible effects of the said non-nutritional enhancer on the occurrence of scouring in piglets.

MATERIALS AND METHODS

Site and duration of the study

The feeding trial was conducted from April 18, 2012 to May 19, 2012 at a swine farm in Siniloan, Laguna. The farm has an area of 2.2 ha with a 450-sow level and a farrow-to-finish type of production. A certain section of the farm's nursery area was renovated by the management to accommodate the design of the feeding trial. The feeds used in the trial were mixed at the farm's subsidiary feed mill, SIFECO (Siniloan Feeds Corporation, Laguna).

Dietary treatments

The experiment used a yeast-based non-nutritional enhancer product (Progut^{TM}) containing both mannoproteins and betaglucans (cell wall particles) and internal cell nucleotides (extract) of brewer's yeast, *S. cerevisiae.* It was mixed with the formulated booster and pre-starter diets at rates specified by test material manufacturer.

The dietary treatments were prepared using formulated booster and pre-starter feeds (formulated by the farm) as the basal diets to which the YNE was added in the case of the treated diets. The treatments were: 1) basal diet (BD) + 0%

YNE; 2) BD+ 0.05% YNE; 3) BD + 0.15% YNE and 4) BD + 0.30% YNE.

The minimum nutrient requirements (low density) of weanling pigs were: 3150 kcal/kg metabolizable energy, 19.7% crude protein, 0.95% calcium, 0.65% total phosphorus, 1.35% lysine and 0.74% methionine + cystine (PHILSAN, 2003).

Experimental animals and feeding system

Eighty crossbred (Duroc x Large White x Landrace) weanling pigs composed of 40 males and 40 females of the same age with an average live weight of 7-8 kg were used. Five pigs (of the same sex) were housed per pen, with four replications per treatment. The treatments were randomly assigned to the pens. Randomized complete block design (RCBD) was followed, with sex of the animals as the blocking factor.

The weanling pigs were fed with booster diet for five days and pre-starter diet for 25 days. The feeds were prepared in mash form to facilitate mixing of the YNE with the diet. The weanling pigs were provided with drinking water at all times.

Chemical analysis of the diets

Samples of booster and pre-starter diets were collected and properly labelled for analysis. The samples were analyzed for their proximate composition (crude ash, moisture, crude protein, crude fiber, ether extract and nitrogen-free extract). Samples of booster and pre-starter diets were also analyzed for calcium and total phosphorus content following the Association of Official Analytical Chemists (AOAC, 1995) procedures, at the Animal Nutrition Analytical Service Laboratory, Animal and Dairy Sciences Cluster, College of Agriculture, University of the Philippines Los Baños, Laguna.

Parameters measured

The parameters measured in this study were as follows: initial and final weights, average daily feed intake (ADFI), average daily gain (ADG), feed conversion efficiency (FCE), frequency, persistence and degree of scouring, livability rate and feed cost efficiency.

Statistical analysis

To determine the significant differences between treatments, one-way analysis of variance (ANOVA) procedure using Statistical Analysis System following a randomized complete block design was used. Treatment means of parameters were compared using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Chemical composition of the diets

The proximate analyses of the feed diets used in the study are presented in Table 1. Most of the values obtained from the analysis closely conformed to the calculated minimum nutrient requirements of a weanling pig.

The analyzed values for crude protein, crude fiber, crude fat and calcium were close to the expected amount of nutrients in the diets with low nutrient density.

Table 1. Proximate composition, calcium and phosphorus content of booster and pre -starter feeds (as fed basis).

Nutrient	Diet	
	Booster	Pre-starter
Dry matter, %	88.58	89.35
Ash, %	5.96	7.17
Crude protein, %	18.92	17.28
Crude fiber, %	3.05	2.12
Crude fat, %	3.05	3.02
Nitrogen-free extract, %	57.60	59.76
Calcium, %	1.09	0.99
Total phosphorus, %	0.23	0.35

Results are based on the average of the three replicates.

On the other hand, total phosphorus content obtained from the analysis was lower than the expected nutrient value. Despite minor differences, the obtained values were able to meet the minimum nutrient requirements of the animal for its normal growth and development.

Growth performance parameters

The effects of YNE added at different inclusion rates on the performance of weanling pigs are presented in Table 2.

Live weight change

The initial live weight of the weanling pigs did not differ significantly among the treatments. The coefficient of variation was low (4.01%), which indicated that the experimental animals had uniform weights at the start of the experiment.

The average daily gain of weanling pigs increased ($P<0.05$) at 0.15% and 0.30% YNE inclusion rates. Higher inclusion rates of YNE in the diets resulted to higher average daily gain of weanling pigs. Sims *et al*., (2004) stated that YNE (mainly mannoproteins) acts on increasing the villi height, its uniformity and integrity for beneficial effects on small intestine's growth and development. Increase in villi height enhances the efficiency of digestion and nutrient absorption processes inside the animal's body. Long villi are correlated with improved gut health. Therefore, weanling pigs with improved gut health are also expected to have improved growth and body development. Hiss and Sauerwein (2003) showed that continuous supplementation of postweaning feed diets with 0.15% and 0.30% yeast products resulted in a numerical increase in average daily gain. Spring and Privulescu (1998) also attained a 7.4% improvement in daily gain in their study on the logical role of yeast products in piglets.

Table 2. Effect of yeast-based non-nutritional enhancer (mannoproteins, betaglucans and nucleotides) on growth performance, scouring frequency, scouring index (SI), livability rate and feed cost efficiency of weanling pigs.

Parameter	Treatment				CV, %
	1 Basal diet	2 Basal diet + 0.05% YNE	3 Basal diet + 0.15% YNE	4 Basal diet + 0.30% YNE	
No. of animals	20	20	20	20	
Feeding period, days	30	30	30	30	
Initial weight^{ns}, kg	8.00	7.13	7.31	7.52	4.01
Final weight, kg	17.63	16.59	17.98	19.73	
Avg. daily feed intake, kg	0.54^{b}	0.56^{b}	0.62^{b}	0.69^{a}	4.48
Avg. daily gain, kg	0.32^{c}	0.32^{c}	0.36^{b}	0.42^{a}	2.48
Feed conversion efficiency^{ns}, FI/LWG	1.71	1.72	1.70	1.67	2.60
No. of scouring piglets	17	16	13	10	
Average no. of days scoured	3.25	3	2.5	2	
No. of piglets with SI of 2	12	12	12	10	
No. of piglets with SI of 3	5	4	1	0	
% Livability	80	90	95	100	
Price/kg feed, PhP					
Booster	28.65	28.91	29.43	30.21	
Pre-starter	26.10	26.36	26.88	27.66	
ADFI, kg					
Booster	0.12	0.16	0.13	0.13	
Pre-starter	0.63	0.63	0.72	0.81	
Daily feed cost, PhP	19.88	21.23	23.18	26.33	
ADG, kg	0.32	0.32	0.36	0.42	
Cost efficiency, PhP/LWG	62.13	66.34	64.39	62.69	

YNE- yeast-based non-nutritional enhancer; CV- coefficient of variation.
^{ns}not significant; ^{a,b,c}row means with different superscripts differ (P<0.05).
Scouring index: 3-severe scouring by watery feces and persistent (more than 3 days); 2-mild scouring characterized by semi-solid feces and not persistent (3 days or less); 1-normal, solid feces.
Feed prices: non-commercial booster feed-PhP 28.65/kg; non-commercial pre-starter feed-PhP 26.10/kg; YNE (Progut^{TM})-PhP 520.00/kg.

Feed intake

Average daily feed intake increased (P<0.05%) only at the highest inclusion rate of YNE (0.30%). YNE contains biological response modifiers (mannoproteins, betaglucans and nucleotides) for controlling pathogenic microorganisms and mitigating the deleterious effects of production stressors. It serves as immunomodulator by enhancing the resistance of weanling pigs to stress and diseases (Stone, 1998). Yeast-based mannoproteins attract pathogenic bacteria to attach to these dietary particles rather than to the intestinal cells; the bacteria then pass out of the gut with the digesta, thus, causing no harm to the host animal. In addition, betaglucans and nucleotides activate the immune system of the animal. Therefore, a healthy weanling pig tends to have a good appetite, thereby increasing its feed intake. Similar results were obtained by Carlson *et al*. (2004) in their study on the effect of supplemental yeast extract on the performance and intestinal morphology of postweaning pigs. Pigs fed with nursery diet containing yeast extract had higher average feed intake than pigs fed with control diet.

Feed conversion efficiency

The feed conversion efficiency of the weanling pigs did not differ significantly among the treatments (P>0.05). Although the average daily gain and average daily feed intake were significantly better than the control, the resulting feed conversion efficiency did not differ significantly. Results of this study were similar to the research conducted by Brummer *et al*. (2010), who found numerical but non-significant differences on the feed conversion efficiency of young animals fed with or without *S. cerevisiae* cell wall products. Furthermore, Yang *et al*. (2003) observed that feed conversion efficiency of young animals was unaffected by yeast product supplementation.

Feed conversion efficiency of the young animal is of lesser significance compared to feed intake and average daily gain at the weanling stage. At early stages, farmers are more concerned with higher feed intake and live weight gain of the animals to boost its potential to grow and develop resistance to diseases. Improved feed intake usually translates to higher live weight gains in the animal. Feed conversion efficiency is an important parameter when used in experiments with longer growth periods (grower to finisher stages) and when the animals are older since in these stages, animals require more feed and higher live weight is due to more effective conversion of feeds.

Scouring incidence and livability rate of weanling pigs

The different levels of YNE showed positive influence on the number of weanling pigs that exhibited scouring problem. Scouring persistence of shorter periods was observed in weanling pigs fed with treated diets compared to the animals fed with basal diet. Similarly, weanling pigs with scouring index of 2 decreased and animals fed with diet containing 0.30% YNE did not exhibit scouring index of 3.

According to Vondruskova *et al*. (2010), yeast products exert beneficial effects on the microflora composition in the gut by supporting the growth and/or activities of probiotic microorganisms in the gastrointestinal tract. The predominance of beneficial species of microorganisms over pathogens is essential for stability of

the immune system of the intestines, to prevent scouring incidences and consequently, to improve the condition of the entire body. In addition, Maribo and Spring (2003) observed that pigs with pathogenic *E. coli* infection fed with diet supplemented with yeast extract as a source of nucleotides have reduced scouring compared to pigs fed with control diet.

No deaths occurred in animals fed with 0.30% YNE while those animals fed with control and diets with lower level of YNE had mortalities. Addition of YNE on the diet could have influenced the capability of weanling pigs to resist environmental stresses and certain diseases. YNE, being an immunomodulator, enhances the immune system of young animals making them more resistant to health challenges.

One factor that has possibly affected the performance of animals in this study was the effect of high environmental temperature coupled with high humidity at the time (April-May 2012) the study was conducted. Environmental temperature has a marked effect on feeding patterns of weanling pigs.

Performance of pigs is greatly reduced during periods of heat stress (above comfort zone). According to Myer *et al.* (1998), pigs that feel too hot will lie apart and exhibit rapid breathing (panting) to increase heat dissipation. To further dissipate heat from the body, weanling pigs tend to eat less because eating, digestion and nutrient absorption generate heat. Likewise, high relative humidity has a negative effect on feed consumption and feed conversion due to difficulties in thermoregulation. Unfortunately, reduction in feed intake results in reduced growth and substandard performance of the animal.

Feed cost efficiency

The data on feed cost efficiency showed that the increasing level of YNE in the diet led to higher daily feed cost due to addition of YNE and subsequent increase in feed intake. Feed cost efficiency of animals fed with diets containing 0.05% and 0.15% YNE were lower compared to the control, which means that the corresponding increases in live weight gain were not high enough to compensate for the additional cost of supplemental YNE in the diets. On the other hand, diet with the highest inclusion rate (0.30% YNE) was the most practical since the goal in weanling stage is to boost animal's growth potential. What is more important is not the price of feeds because price of feeds are transient in nature. The concern is the important benefits derived from YNE in improving the growth and health performance of weanling pigs.

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