



Universidad Popular Autónoma del Estado de Puebla
Centro Interdisciplinario de Posgrados e Investigación

Departamento de Negocios e Ingeniería

Maestría en Agronegocios

Efectos de la suplementación con *Yucca schidigera* Roetzl
ex Ortgies en el desempeño en el crecimiento en cerdos de
engorda

Tesina que para obtener el Grado de
Maestro en Agronegocios

Presenta:

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Puebla, Puebla, Junio de 2016.



UPAEP – Secretaría General

Dirección General de Apoyos Académicos

Dirección del Centro de Recursos para el Aprendizaje y la Investigación.

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Por este medio nos permitimos informar a Uds. la aprobación de la Tesina: “Efectos de la suplementación con *Yucca schidigera* Roezl ex Ortgies en el desempeño en el crecimiento en cerdos de engorda”, que presenta la alumna: Ishtar Silva Lara (Matrícula: 39500070, ID: 94175), como requisito para obtener el Grado de Maestría en este programa académico.

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Puebla, Puebla, Mayo 2016.



EFFECTS OF *Yucca schidigera* Roezl ex Ortgies
SUPPLEMENTATION ON GROWTH PERFORMANCE
OF FINISHING PIGS

By

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Master of Science in Animal Science

Oklahoma State University

Stillwater, Oklahoma

2015

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
July, 2015

EFFECTS OF *Yucca schidigera* Roezl ex Ortgies
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Title of Study:

EFFECTS OF *Yucca schidigera* Roezl ex Ortgies SUPPLEMENTATION ON
GROWTH PERFORMANCE OF FINISHING PIGS

Major Field: SWINE NUTRITION

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I. INTRODUCTION

In growing and finishing stage of production, the energy and protein (lysine) content of the diet takes special importance in achieving optimal growth performance. Improvement in growth performance respond to higher energy and protein (lysine) supplementation. However, when higher amounts of energy are fed, the higher the feed cost (Nitikanchana *et al.*, 2015).

There are different protein sources widely used in animal nutrition. These can be divided into animal or plant sources. The diverse features may vary among animals supplemented. Besides the protein content that the natural sources have, most of the resent research performed have had the thought of the existing and future restrictions regarding the use of antimicrobials in swine productions; therefore, an alternative to the use of antimicrobials is needed (Turner *et al.*, 2001).

In monogastric diets, the primary energy source is maize; but as this ingredient has been used by humans and other industries, feed cost has increased (Lokaewmanee *et al.*, 2011). Nowadays, due to the increased cost of energy ingredients, the swine industry is using high-fiber ingredients to reduce feed cost. Nevertheless, even though the diet cost is reduced after using high-fiber ingredients, the growth performance is reduced as well (Nitikanchana *et al.*, 2015).

The nutrient absorption is as important as the nutrient content of the diet. Therefore research have been done to determine different ways to improve this, leading to a better performance and growth rate. Probiotics and prebiotics have been widely used to improve gut health, however, the utilization on plant ingredients has been shown to improve animal performance. However, the mechanism and nutritional facts that this plant extracts have are not yet well understood.

The characteristics of naturals compounds and the way they function within the body are not well understood, but many characteristics from natural products such as improving growth

performance, effects on gut health as well as immune functions have been observed. Among the natural compounds, the ones that have been more investigated in swine production are probiotics, oligosaccharides and plant products (Turner *et al.*, 2001). Another such compound that has received attention in recent years for improving growth performance in many species is *Yucca schidigera*. Despite the fact that general understanding of the utilization and effects of the *Y. schidigera* extract exists, the primary concern of the recent research is swine supplementation. Although limited studies exist specifically for pigs, research with other livestock species can serve as a comparative reference for this purpose.

II. REVIEW OF LITERATURE

a. BIOLOGICAL ACTIONS OF SAPONINS IN NUTRITION

Saponins are compounds found in many plants, which in aqueous solutions can form stable, soap-like foams (Francis *et al.*, 2002). They are surface-active glycosides produced by plants. These compounds produce a health improving activity in the herbs (Hussain *et al.*, 2015).

There are two types of saponins, triterpenoid and steroid saponins. The most studied and most commercially common are *Quillaja saponaria* (triterpenoid) and *Yucca schidigera* (steroid). Even though the role of saponins in plants is not yet fully understood, it is considered as a defense system (Francis *et al.*, 2002).

Among the different pharmacological functions of the saponins, the ones of higher importance in animal nutrition are stimulation of the cell-mediated immune system, inhibition of growth cancer cells, antifungal and virucidal activity (Hussain *et al.*, 2015).

Some saponins can increase absorption and enhance intestinal mucosal cells permeability *in vitro*. However, with the higher intestinal permeability of the brush border, an increase in absorption of macromolecules has been observed. Despite the fact that the increase in intestinal permeability can be nutritionally useful, it can also permit allergens to pass through the membrane. Nevertheless, steroid saponins have not shown this effect when fed at the same level as triterpenoid saponins (Francis *et al.*, 2002).

Yucca extract supplementation has been shown to improve growth and feed efficiency, and health, yet the mechanisms for these responses are not well understood. However, in rats, a higher feed intake and appetite has been observed after supplementation. The rat's eating behavior (circadian rhythm) was changed into a 24 h eating behavior instead of eating just during the night (Francis *et al.*, 2002).

b. GUT HEALTH

Restricting the use of antibiotics in livestock animals have led to the need of finding an alternative to be able to maintain welfare and productivity of animals. Therefore, even though probiotics and prebiotics have been used specially for human health, its use have increased for animal nutrition due to improvement in gut's health and feed consumption after supplementation (Mace & Marshall, 2013), and optimized performance observed as well (Choct, 2009).

The effects of having a poor gut health will affect the animal as a whole. The most important functions of the gut are related to immunity (avoiding exogenous pathogens colonization), nutrient digestion and absorption, body energy expenditure (up to 20%), bacteria harbors (up to 640 species), and hormonal storage (over 20 different hormones) (Choct, 2009).

Bacterial species and microflora present in the gut may affect organ development, tissue growth, immune system maturation, hence a decreased on animal performance. The animal's microflora and gut development may vary among species due to dietary factors that change the ecosystem of the gut (composition, processing, digestibility and feeding method) (Choct, 2009). However, similar microflora and gut development are found within same animal species (Mace & Marshall, 2013).

c. *Yucca schidigera*

Yucca schidigera; from Agavaceae family and native from South-Western United States and Mexico, has been widely used in human health due to its chemicals components that help treat inflammatory disorders (Stochmal'ová *et al.*, 2015); such as headaches, arthritis, rheumatism and gonorrhea. On the other hand, in animal nutrition, reduced gastrointestinal ammonia, reduced fecal ammonia and reduced fecal odors are reported (Gordon *et al.*, 2014). In addition to those uses, improvements in growth rate, feed efficiency, health (Piacente *et al.*, 2005; Stochmal'ová *et al.*,

2015), digestion and absorption due to decrease ammonia concentrations are some of the effects reported on livestock (Gordon *et al.*, 2014). It is also used as a foaming agent, increasing the flavor in the food and beverage industries (Sahoo *et al.*, 2015), and stimulating nutrient absorption by its surface components (Gaber, 2006).

The active component of the *Y. schidigera* is excreted in the feces, after its excretion it will bind with the ammonia (produced by microbial action) and thus ammonia levels will be reduced (Hussain *et al.*, 1996). Added in the diet, slurry under slatted floors, or as filter bed of biofilters, are the most common supplementation forms (Whitney *et al.*, 2001).

According to Espinosa *et al.* (2008), ammonia emissions can be decreased by 12 to 30% after supplementation; however, Whitney *et al.* (2001) stated that the ammonia levels can be decreased as much as 69% depending on the time of supplementation (after 9 weeks), levels of supplementation (120 ppm), diet characteristics and environmental and housing conditions. The serum ammonia and urea levels are reduced as well as the environmental levels (Piacente *et al.*, 2005). The improvement in intestinal flora activity will decrease stress (Gordon *et al.*, 2014), and decrease urease activity in the pig intestines, leading to less nitrogen conversion into ammonia (Whitney *et al.*, 2001).

Steroidal saponins interact with cholesterol in cell membranes resulting in lysis and death of all the microorganisms but bacterias (Gordon *et al.*, 2014), hence research focus area is related to the anti-protozoal activity (McAllister *et al.*, 2001; Piacente *et al.*, 2005), anti-tumor activity, blood cholesterol levels reduction, reproductive processes improvement (Stochmal'ová *et al.*, 2015), and improvement in nonspecific immunity (Gurbuz *et al.*, 2011).

According to Holtshausen *et al.* (2009), after treating cattle with saponin supplementation, the reduction in protozoal activity observed *in vitro* was not always observed *in vivo*, this differences may be because of the basal diet, the dosage of saponins supplemented, and rumen

microflora adaptation in *in vivo* studies. On the other hand, McAllister *et al.* (2001), reduction of rumen protozoal population *in vivo* and *in vitro* were observed. This effect was transitory, showing a decrease in number of protozoa in the rumen by 60% after 4 days but returning to normal levels after 10 days. The return to normal levels is due to the capability to degrade Yucca component by bacterial population rather than protozoa developing resistance.

Turner *et al.* (2001) stated that saponins have the capability to alter rumen microflora *in vivo*, inhibit growth of *E. coli in vitro*, control ammonia production in the rumen; binding and retaining it in a non-volatile and non-toxic form (Whitney *et al.*, 2001), and as fecal aroma reducing on pets. Intestinal cells can also get modified after supplementation, getting healthier, leading to an increased nutrient absorption (Gurbuz *et al.*, 2011).

Furthermore, Piacente *et al.* (2005) found in recent research, that among the composition of the Yucca, the beneficial effects for livestock come from the saponin fraction as well as the non-saponin one. The saponin fraction; also known as the steroidal saponin fraction, is the one with surface active properties. On the other hand, the other active ingredient is the glycol-component fraction, it is the responsible for ammonia binding (Gurbuz *et al.*, 2011). Nonetheless, the compounds with the biological activity have not been identified and neither the mechanism of action of this compound.

There are two products available on market: Yucca powder and Yucca extract (with about 10% of dried material of saponin content) (Piacent *et al.*, 2005).

A different response is observed among different saponin preparations, dosage and supplemented species (Turnner *et al.*, 2001). Variability between researches is due to *Y. schidigera* processing, having different results if it is fed as powdered whole-plant product or liquid extract. This differences are because the whole-plant product contains more polyphenolics as compared to

the extract. On the other hand, best effect have been tested after direct administration into the rumen since it avoids the saliva degradation (Holtshausen *et al.*, 2009).

The antibacterial present in the diet, organic material in the manure and its pH and composition, and the temperature are some other factors that can affect the effects of the products (Thaler & Sulabo, 2006).

d. AMMONIA IMPORTANCE IN PORK PRODUCTION

Ammonia, carbon dioxide and hydrogen sulfide are the main gases produced by manure fermentation. Ammonia and carbon dioxide are produced by urea metabolism through urease.

Excessive ammonia exposure can be detrimental for animal and human health. This is specially observed in poor ventilated and high temperature facilities with poor air quality. Some of the ammonia exposure symptoms in humans are nausea, vomiting, severe pulmonary and gastrointestinal irritation, abdominal pain, laryngitis, pulmonary edema, dyspnea, lacrimation, bronchospasm, eye irritation, chest pain, coughing, severe burn of the cornea and upper airway. Moreover in animals, the damage can decrease growth performance, pig survival and sow reproduction. The symptoms are coughing, mucus irritation from the eye, mouth and nose, decreased feed intake and decreased growth performance at 50 ppm levels of ammonia for a three hour exposure (Colina *et al.*, 2000).

e. ANIMAL SUPPLEMENTATION

1. Rabbits

Yucca extract has been tested on different animals to know the action mechanism it has on different species and according to Hussain *et al.* (1996) rabbits fed with *Y. schidigera* extract showed improvement in feed efficiency and average daily gain as well as increased total cecal VFA productions in most cases.

Three different groups were tested to determine whether or not the Yucca supplementation has reproductive improvements in rabbits. In previous studies higher conception rate, increase in the number of liveborn, weaned, and decrease in stillborn have been reported. However, Stochmal'ová *et al.* (2015) only a better conception rate was obtained after supplementation. Even though there is not enough investigation to support this findings, the most possible explanation about yucca mechanism of action on the reproductive system is related to the influence on cholesterol and ammonium metabolism, antioxidant and platelet suppressing effects and its blood oxygenation effect.

2. Horses

Chelated minerals, direct-fed microbial (DFM), and *Yucca schidigera* extract were supplemented in horse diets to determine whether or not its supplementation decrease nutrient excretion in manure and improve animal performance, as it has been reported in the literature as well as in other livestock animals. No benefit in DM, ADF, or NDF digestibility was observed in the study. This results are associated with the effects of ammonia junction to saponins in the large intestine, decreasing ammonia resorption and recycling availability (Gordon *et al.*, 2014).

3. Poultry

In Gurbuz *et al.* (2011) experiment, one-d-old layer chicks were supplemented to determine if better growth performance, antibody titres, and intestinal histology was shown after its consumption. The results showed no difference on feed intake among treated groups, however, better growth performance, feed efficiency and final body weight was observed. On the other hand, it is suggested that Yucca extract has the ability to enhance antibody production as well as to modulate some immune system cells. In addition, a better villus height-crypt depth ratio was shown in the jejunum and higher villus height in the ileum was also reported in the recent study, leading to increase intestinal absorption.

4. Cattle

Most research have been made on ruminants due to the important methane production they have. Methane is negatively correlated with energy utilization, *Y. schidigera* supplementation decrease methane production without adverse effects in productivity (Holtshausen *et al.*, 2009).

Holtshausen *et al.* (2009) stated that on dairy and beef cattle the saponins can inhibit rumen ciliate protozoa leading to decrease methane production in the rumen due to association of protozoa and ruminal methanogens.

On the other hand, Espinosa *et al.* (2008) stated that ammonia emission can be decreased by 12 to 30% after Yucca extract supplementation. The decrease of methane production have benefits for the animal production and environment because the cow will increase energy efficiency and because it is a potent greenhouse gas (Holtshausen *et al.*, 2009).

Holtshausen *et al.* (2009) observed that the saponin supplementation decrease methane production, but little have been found about the side effects that feeding this can have because in order to reduce the methane production there is a decrease in feed digestibility and ruminal

fermentation, but rumen microflora can get adapted to some plant extract leading the microbial fermentation to be transient and not of permanent effects.

Research of Holtshausen *et al.* (2009) stated that the liquid extract decreased rumen protozoa and changed VFA production, leading to change acetate:propionate ratio, propionate and ammonia-N concentrations as well. On the other hand McAllister *et al.* (2001) found that the steroidal saponins of the Yucca powder extracted with butanol showed hemolytic, anti-protozoal and anti-bacterial effects and when extracted by ethyl ether no effect have been proved against Giardia trophozoites. Cellulolytic bacteria population is decreased when fed Yucca extract, meanwhile this effect is not shown with amynolytic bacterias (Francis *et al.*, 2002).

5. Swine

Espinosa *et al.* (2008), McAllister *et al.* (2001), and Colina *et al.* (2001) stated that the reduction of ammonia emissions and odor are the common usage of *Y. schidigera* extracts in swine production. Ammonia emission can be decreased by 12 to 30% after Yucca extract supplementation. The ammonia concentration is a public concern due to the health problems that can produce to the animals, workers and people living close to swine farms (Colina *et al.*, 2001).

Turner *et al.* (2001) explained that even though positive influence have been shown on ruminal fermentation, the inclusion of *Y. schidigera* on weanling pigs diets have little benefit to growth performance.

Ammonia emission by nursery pigs is important due to its high amino acid concentration diets and the low room ventilation to conserve an ideal temperature during cold weather. Five trials were performed to determine if there was a difference between Yucca supplementation (125 ppm) and control diets in nursery pigs related with ADG, ADFI, F:G and ammonia emission. No differences were observed in ADG, ADFI and F:G. On the other hand, ammonia concentration were higher in the room of pigs fed the control diet (Colina *et al.*, 2001). At a rate of 125 ppm aerial

ammonia levels were reduced (Whitney *et al.*, 2001), and at a rate of 125 ppm of feed the ammonia emissions were suppressed by 55.5% (Casey *et al.*, 2006). However, the decrease of ammonia excretion can be more modified by less protein consumption than by additives supplementation (Panetta *et al.*, 2005).

Increase of 5-10% in growth rate was reported at a rate of 62-125 ppm; however, no improvement was seen at a rate of 250 ppm. On the other hand, when supplemented to growing pigs from 60-190 lbs at a rate of 120 ppm, an increase of 0.11 lb/d was observed (Whitney *et al.*, 2001).

Yucca has phytoestrogens that influence steroidogenesis in porcine ovarian granulosa cells (not seen in other species), indicating that yucca can affect functions such as fecundity. After Yucca extract supplementation in sows, less appearance of pigs born dead and preweaning mortality was observed, specially due to improved oxygen supply (Stochmal'ová *et al.*, 2015).

Saponnins are used to bind ammonia, nevertheless yucca extract is not the product with better responses as compared to zeolite or peat moss (Ndegwa *et al.*, 2008).

f. MICRO-AID FEED GRADE CONCENTRATE ®

The supplemented product for this research was MICRO-AID® from DPI GLOBAL. It is a dry, granular and natural product of *Yucca schidigera* extract, primarily used as an environmentally safe odor-eliminating product but it has also been proven to reduce ammonia and gasses, such as sulfides and phenols, and serves as an aid in waste management.

Better air quality can increase the animal performance, as well as health improvement and well-being of the livestock and workers. MICRO-AID® is proven effective on a wide variety of species, including cattle, equine, poultry, shrimp, swine (Table 1), domestic pets and more.

Table 1. Micro-Aid® Feed Grade Concentrate

Swine	Ounces (oz)/Ton	Grams (g)/Metric Tonne
Starter 4 oz 125 g	4 oz	125 g
Grower/Finisher 2 oz 62.5 g	2 oz	62.5 g
Sows – Gestation 2 oz 62.5 g	2 oz	62.5 g
Sows – Lactation 4 oz 125 g	4 oz	125 g

DPI Global product usage sheet

The current experiment was conducted to evaluate the growth performance as well as to determine the ME equivalency of Micro-aid (*Yucca schidigera* extract) in corn-soybean meal diets for finishing pigs.

II. METHODOLOGY

a. MATERIALS AND METHODS

Use of the animals indicated in this study was reviewed and approved by the Oklahoma State University and performed at the Swine Research and Education Center of the University.

b. ANIMALS AND HOUSING

Seventy crossbred (Danbred x (Landrace x Yorkshire)) gilts and barrows (126 d of age; mean BW = 68 kg) were randomly allocated to 7 experimental groups with 10 replications. Throughout this study, subjects were individually housed to allow for individual measurement of feed intake. The pigs were housed in indoor stalls in individual metal pens (27 x 39 x 67 in) on an experimental farm in a controlled environment. Facilities allowed each animal visual, olfactory, auditory, and limited tactile contact with others within treatment group. Each pen contained a nipple waterer and a feeder with a hinged lid that opens toward the front. Feed and water were provided *ad libitum*.

All animals were acclimated to feeders and waterers before the study to facilitate feed and water consumption during the trial. The experimental period lasted 39 d. Individual BW was recorded using a digital load bar scale during the transition, acclimatization, and collection periods. Pigs were weighed on d 0, 8, 17, 22, 32, and 39 to determine average daily weight gain (ADG), feed intake (ADFI), and feed efficiency, expressed as feed:gain (F:G).

c. DIETS AND FEEDING

The pigs were fed a complete diet that was specially formulated to meet their metabolizable energy (ME) requirements, 2879 kcal/d maintenance ME; the diet was unchanged throughout the experimental period. A corn-soybean meal diet served as the positive control (ME = 3350 kcal/kg). The composition of the diets are shown in Table 2. The standard curve utilized 4 dietary energy

concentrations (3350, 3250, 3150 and 3050 kcal/kg). Corn was used to meet energy requirements of the diet. However, sand was used to replace corn for energy concentration reduction. Therefore, energy concentration varied depending on corn and sand amount used in the standard curve. The treatments with the 3050 kcal/kg ME content (diet 4, 5, 6, and 7) were supplemented with 0.0, 0.0625, 0.125 and 0.25 ppm Micro-aid (*Yucca schidigera* extract). Any improvements in growth performance with the addition of Micro-Aid to the low energy diet were plotted against the standard curve to estimate the energy equivalency. The feed was weighed daily and the pigs were fed in the morning.

Table 2. Composition of diets

Item	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7
ME – kcal/kg	3350	3250	3150	3050	3050	3050	3050
MicroAid	-	-	-	-	+	++	+++
Ingredient, %							
Corn, yellow dent	74.87	71.91	68.99	66.00	66.00	66.00	66.00
Soybean meal (47.5% CP)	22.51	22.51	22.51	22.51	22.51	22.51	22.51
Dicalcium phosphate	0.99	1.00	1.00	1.01	1.01	1.01	1.01
Limestone	0.76	0.75	0.75	0.75	0.75	0.75	0.75
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25
L-lysine HCl	0.30	0.31	0.32	0.32	0.32	0.32	0.32
DL-methionine	0.08	0.09	0.10	0.11	0.11	0.11	0.11
L-threonine	0.10	0.11	0.11	0.12	0.12	0.12	0.12
Trace mineral premix	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Vitamin premix	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sel-Plex	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Sand	0.00	2.94	5.84	8.80	8.74	8.68	8.55
MicroAid	0.00	0.00	0.00	0.00	0.0625	0.125	0.25
Nutrient composition							
Dry matter, %	89.46	89.64	89.82	90	90	90	90
Crude protein, %	17.29	17.09	16.86	16.63	16.63	16.63	16.63
ME – kcal/kg	3350	3250	3150	3050	3050	3050	3050
Lysine, %	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Calcium, %	0.60	0.59	0.59	0.59	0.59	0.59	0.59
Phosphorus total, %	0.55	0.54	0.53	0.53	0.53	0.53	0.53

d. EXPERIMENTAL DESIGN AND SAMPLE COLLECTION

The experimental period lasted 39 d. A randomized complete block design was used with each of the diets. Pigs were blocked by weight and sex and randomly allotted to seven dietary treatments. There were 10 replication per treatment. Pigs were fed 5 days of initial diet for acclimatization period. Once assigned to a treatment, animals were randomly assigned locations within the pen-treatment group. Total daily diet quantities were adjusted weekly based on feed intake ad libitum.

e. STATISTICAL ANALYSES

Data were analyzed as a randomized complete block. The model included the effects of treatment, replication, and treatment x replication served as the error term. All data were analyzed with the GLM procedure of SAS. Linear, quadratic, and cubic effects were tested for the standard curve (3,350, 3,250, 3,150, and 3,050). The negative control was compared to the average of the dietary treatments containing Micro-aid. Within the 3 Micro-aid treatments, linear and quadratic effects were tested for the increasing Micro-aid supplementation. Least squares mean estimates with standard errors of the estimates were produced.

III. RESULTS AND DISCUSSION

Data for the 39 d evaluation period are present in Table 3. Average daily feed intake was similar across all dietary treatments; thus, daily ME intake decreased with decreasing ME on the standard curve. Daily weight gain decreased (linear, $P < 0.001$) with decreasing dietary ME. There was no difference ($P > 0.05$) in daily weight gain for the average of the 3 Micro-aid treatments vs the negative control. However, a slight increase in daily gain (linear, $P < 0.10$) was noted with increasing Micro-Aid added to the negative control diet. Feed:gain responded in a similar fashion.

Table 3. Effect of adding *Yucca schidigera* extract to finishing pig diets on growth performance^a

Item	ME, kcal/kg							SE
	3350	3250	3150	3050	3050	3050	3050	
	Micro-Aid, ppm							
					0.063	0.125	0.25	
ADFI, kg/d	2.467	2.440	2.431	2.472	2.454	2.449	2.463	0.03
ADG, kg/d ^{bc}	1.029	1.002	0.975	0.925	0.930	0.939	0.961	0.05
F:G ^b	2.42	2.47	2.57	2.68	2.64	2.61	2.57	0.06

^aLeast squares means for 10 pigs/treatment.

^bLinear effect within standard curve, $P < 0.01$

^cLinear effect within Micro-Aid treatments, $P < 0.10$

To determine the ME equivalency of Micro-aid, ADG and F:G for pigs fed the 4 levels of dietary ME were plotted against dietary ME and a prediction equations was developed. The prediction equations for both ADG and F:G fit well ($R^2 > 0.97$). Average daily gain and F:G for pigs fed the varying levels of Micro-Aid were used in the prediction equation to predict dietary ME. This value was then used to estimate the increase in ME for each level of Micro-Aid. Figure 1 shows the ME equivalency of Micro-Aid based on ADG. Note that as ME level increased, ADG increased (standard curve). The ME equivalency was 0, 20, and 87 kcal/kg for the three levels of Micro-Aid, respectively. Similarly, F:G responded the same as ADG (Figure 2). The ME equivalency for the three levels of Micro-Aid was 12, 42, and 98 kcal/kg, respectively. Averaged together the overall ME equivalency for the three Micro-aid levels was 6, 31, and 94 kcal/kg.

Figure 1. ME equivalency of Micro-Aid based on ADG of the standard curve.

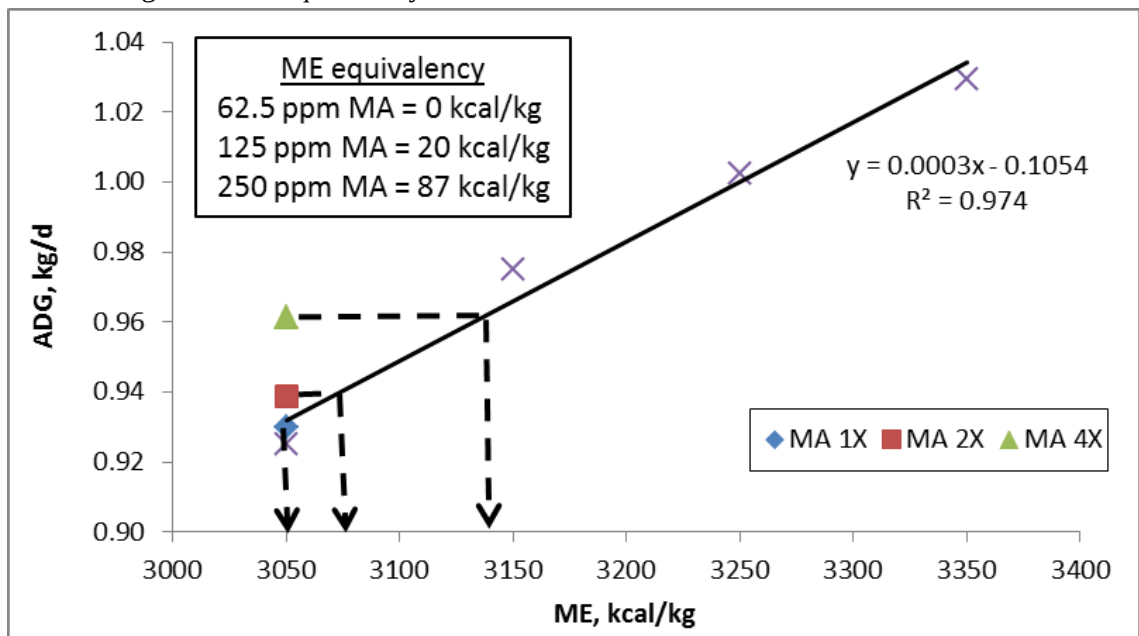
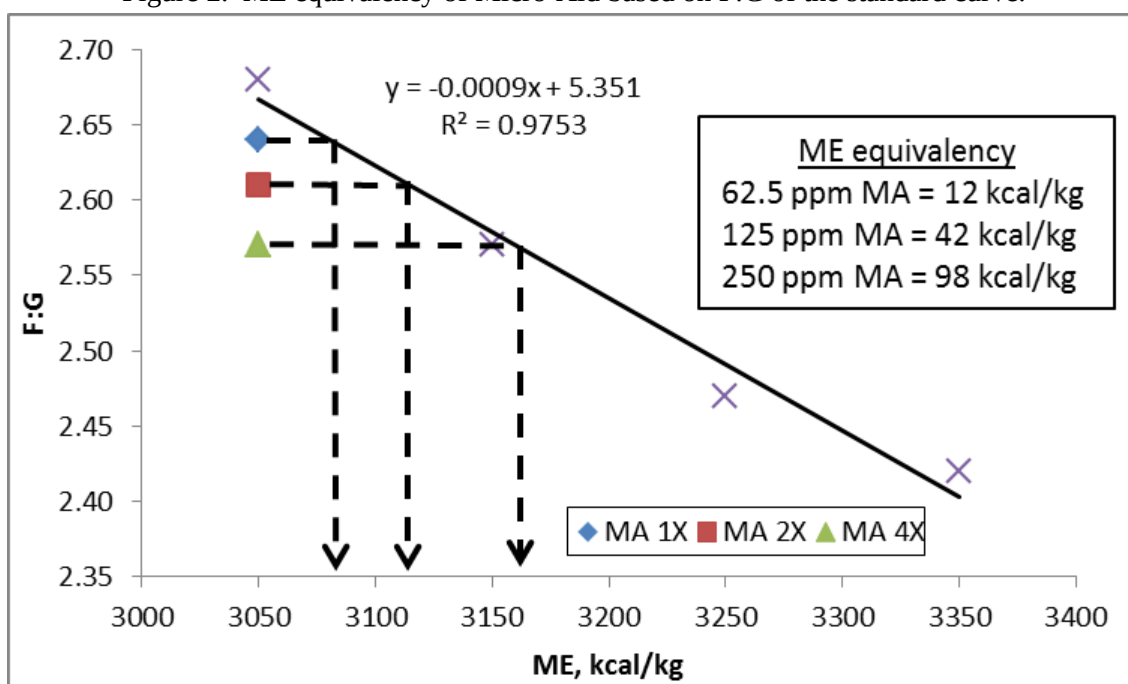


Figure 2. ME equivalency of Micro-Aid based on F:G of the standard curve.



IV. CONCLUSION

The improvement on growth performance was the main objective in this trial, therefore the importance to determine the ADG and F:G after Micro-Aid supplementation. The results indicate that under the conditions of this study, the addition of Micro-Aid as an additive in finishing pig diets at a rate up to 250 ppm is effective in improving the growth rate of the pigs.

ADG and F:G improved as the level of Micro-Aid increased. Based on the results of the experiment, an equivalency value for energy can be assigned to Micro-Aid. Averaged the ADG and F:G the ME equivalency for the three levels of Micro-Aid supplementation were 6, 31 and 94 kcal/kg for the inclusion rate of 62.5, 125 and 250 ppm respectively.

An ME equivalence for the *Yucca schidigera* extract has not been reported by other author. Nevertheless, an improvement in growth performance has been reported before. According to Whitney et al. (2001) an improvement in growth performance was reported, unlike the reported results of 5, 10 and 0% of growth improvement at a rate of 62, 125 and 250 ppm respectively, in this trial a 0.05, 1.5 and 4% of improvement was reported. There are differences among the values from the different studies, which it is the result of differences in the techniques used and characteristics of the study.

Even though there was a linear statistical trend in this experiment, further research should be done with higher *Yucca schidigera* extract amount in order to determine inclusion rate with best growth performance, and to evaluate its effect at different production stages.

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