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Effect of a liquid extract of *Moringa oleifera* on body weight gain and overall body weight of weaning pigs

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Weaning piglets were continuously delivered a fermented extract of *Moringa oleifera* at a dilution of 1/250 in the drinking water beginning at 21 or 28 days of age. Weekly body weight and weight gain were measured for 5 consecutive weeks in the fermented extract treated and the control group. There was no significant difference between those groups ($P<0.05$), except the body weight gain in the period 21-28 days ($P<0.05$), as fermented extract treated piglets were heavier (1.16 kg) than the control group (0.61 kg). The data indicate that *M. oleifera* extract has a positive growth promoting effect on the animals.

Key words: *Moringa oleifera,* additive, weight gain, weaning, piglets.

INTRODUCTION

Antibiotics have been successfully used to control bacterial infections and as growth promoters in domesticated animals. In modern meat production, especially in pigs, the use of antibiotics improved the efficiency of feed conversion, resulting in faster weight gain and economic benefits (Niewold, 2007). Nevertheless, the abuse and misuse of antibiotic agents in meat production has led to antibiotic resistance of zoonotic bacteria including *Salmonella enterica, Escherichia coli, Campylobacter jejuni* and *Clostridium perfringens* in pig and poultry populations (Sridevi Dhanarani et al., 2009; Furtula et al., 2010).

The continuous use of antimicrobial agents may lead to a weakening of the immune system and to an imbalance of the intestinal microbiota. For example, a decrease in the IgM and IgA concentration was observed when macrolide, cycline and β-lactam antibiotics were added to the feed of weaning pigs (Bosi et al., 2011). Furthermore, an animal with a weakened immune system is susceptible to infection by pathogenic microorganisms including bacteria and viruses, which can reduce production performance. In order to maintain and enhance animal body weight, the scientific community and the industry are continuously searching for reliable and appropriate alternatives to antibiotics, for both growth promotion and therapeutic applications (Hume, 2009). Alternatives to antibiotics include natural herbal extracts known as essential oils from different plants such as citrus fruits, oregano, pepper, onion, thyme, eucalyptus and *Moringa oleifera* to stimulate the immune system and develop the gastrointestinal tract to improve the overall production performance (Hume, 2009; Amad et al.,

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Table 1. Chemical Composition of the *Moringa oleifera* liquid extract supplied in the experiments.

Element	Units	Results
Organic matter	%	+/- 6.0
Crude protein	%	+/-3.5
Ashes	%	+/-0.2
Fats	%	+/-0.3
Nitrogen	%	+/-0.06
Organic carbon	%	+/-3.4
Potassium	%	+/-0.12
Calcium	%	+/-0.35
Magnesium	%	+/-0.03
Density	kg/m³	1.025
pH		Between 4.2-5.4
EC	Mmhos/cm	97
Color		Yellowish brown
Smell		Characteristic

EC = Electric conductivity. Source: Nutritional Laboratory of Junta Agroempresarial Dominicana (JAD), Santo Domingo, Dominican Republic.

2011; Jamroz and Kamel, 2002; Hernandez et al., 2004).

M. oleifera is used to supplement the feed of ruminants, especially in tropical regions and leads to a positive performance enhancing effect (Sanchez et al., 2006; Mendieta-Araica et al., 2010). But *M. oleifera* is also well known as an immune stimulating and performance enhancing natural product, both in humans and in animals (Fahey, 2005; Garima et al., 2011). Further, studies were done showing the growth enhancing effects of a liquid extract on plants (Foidl et al., 2001); It is typically used as a dried leave powder or as a methanol leaf extract added as a supplement to the animal feed and has demonstrated positive effects (Foidl et al., 2001; Ly et al., 2001; Sudha et al., 2010). However, to the best of our knowledge, there are few scientific reports regarding the direct effect of liquid fermented extracts of *M. oleifera* added to the drinking water of weaning pigs. For these reasons, we conducted a field study to evaluate the performance of weaning pigs consuming drinking water treated with a liquid and fermented extract of *M. oleifera.*

MATERIALS AND METHODS

Location

The study was conducted in a commercial pig farm in the city of Moca, Espaillat Province, Dominican Republic. The Geo-climatic conditions were subtropical with an average temperature of 24°C, and 70% of humidity. The water supplied for the experiment came from a farm-owned well treated with chloride and softened with a filter to reduce the salts and heavy metals content.

Liquid extraction procedure

A commercial liquid extract of *M. oleifera* was used in this study, which is produced from 250 kg of mashed leaves and twigs in 1100 L of water (Immunobiol, produced by Green Miracle, Moca, Espalliat province. The characteristic chemical and physical values of the extract were measured and are stated in Table 1.

Experimental animals

A total of 400 pigs were used in two replicated experiments, two hundred per experiment. A total of ten floor cages housed 20 pigs each per experiment. Out of these ten cages, five received drinking water enriched with a fermented extract made from *M. Oleifera* and 5 were considered as control groups. From each one of the five treated and the five non-treated cages, three pigs were matched having the same sex and the same weight and were identified with earmarks.

The same procedure was conducted in each experiment. These three selected marked pigs per box were weighed individually weekly. The test boxes had an individual water supply separated from the control group so that the water for the test group could be handled separately. The extract was added for the duration of the experiment to the drinking water of the pigs in the test group at a concentration of 1 gallon to 250 gallons of drinking water. The pigs of the first experiment (five *M. oleifera* groups and five control groups) started receiving the extract at 21 and 28 days of age and in the first and second experiment, respectively.

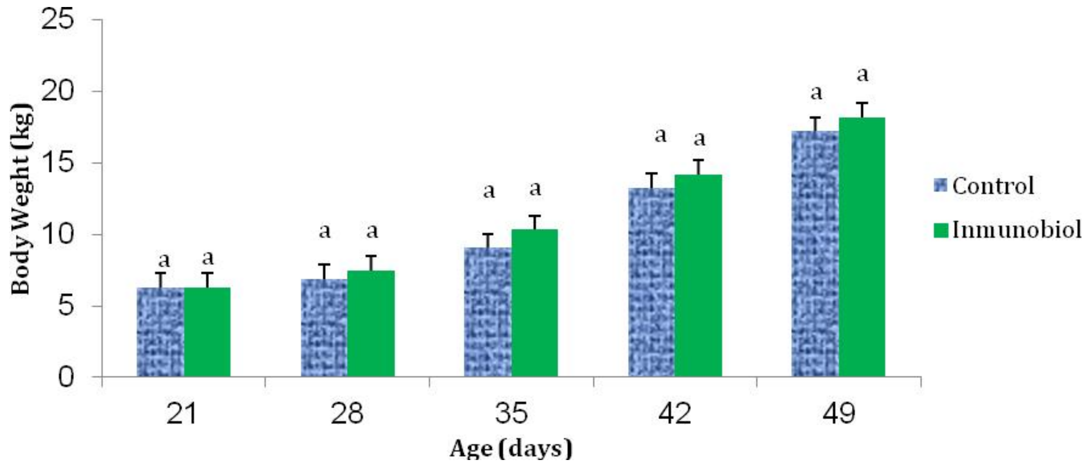
The feed supply and consumption throughout the study was continuous and the feed was formulated with corn, soybean, digestible protein sources such as spray dried plasma, potato meal, fish meal and dry whey powder, which meet or exceeded the National Research Council (NRC, 2012). The exact feed consumption and the feed conversion could not be measured in this experiment due to local performance technical issues.

The weekly weight was measured for five weeks in pigs. All piglets received the same treatment and feed formulation with the exception of the extract treated delivered in the drinking water. The variables evaluated were the body weight and body weight gain. The body weight was measured by weighing the piglets in a scale graduated in grams and the body weight gain was calculated by subtracting the initial from the final weight per period.

Statistical analysis

The statistical analysis was conducted using the General Lineal Model (GLM) of the Statistical Analysis System (SAS, 2002) with a

Panel A.



Panel B.

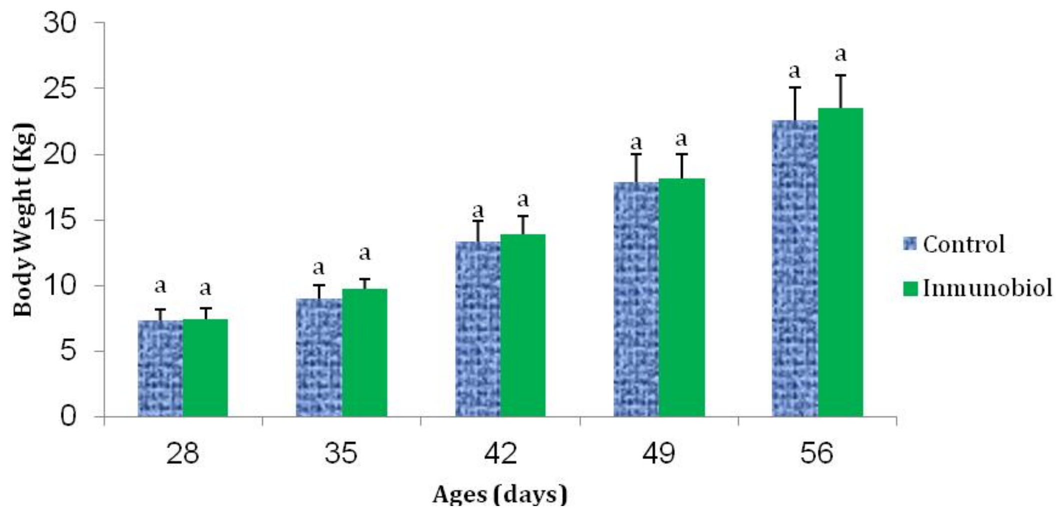


Figure 1. Body weight measured weekly for 5 consecutive weeks in piglets consuming drinking water or the same water treated with fermented *Moringa oleifera* extracts beginning at 21 (Panel A) or 28 (Panel B) days of age.

probability of 95%. The mean separation was done with Duncan of SAS with a probability of error not more than 5%.

RESULTS

In the first and second week, body weight gain was significantly increased in the group of pigs receiving the *M. oleifera* supplement (P<0.05; Figure 1A; Table 2). For the remaining time points in the experiment, body weight was not significantly different between the treatment and control groups in any other of the time periods evaluated. However, pigs receiving the extract of *M. oleifera* in the drinking water did have a higher body numerical body weight throughout all periods of the experiment.

At the beginning of the study on Day 21, the piglets in the control and treatment groups weighed an average of 6.28 and 6.32 kg, respectively. On Day 28, the control and treated pigs averaged 6.89 and 7.48 kg, respectively, which was significantly different between the two groups (P<0.05). On day 35, 42 and 49, the average body weights of the pigs treated with *M. oleifera* were always higher than the average body weights of the control groups, but not statistically significant (P>0.05). The final average body weight gain of the *M. oleifera* group was 11.85 kg, while the control group only gained 10.92 kg.

At the beginning of Experiment 2, there was no significant difference in the average body weight of the *M. oleifera* treated piglets (7.4 kg) and control group (7.38 kg) (Figure 1B). However, after 1 week of treatment at Day 35, *M. oleifera* treated piglets averaged 9.70 kg which was 0.68 kg more than the control animals with

Table 2. Body weight gain measured weekly for 5 consecutive weeks in piglets consuming drinking water or the same water treated with fermented *M. oleifera* extracts beginning at 21 (Panel A) or 28 (Panel B) days of age*.

Periods (days)	21-28	29-35	36-42	43-49	21-49
Group 1					
Control**	0.61±0.27[a]	2.17±0.80[a]	4.17±0.51[a]	3.97±0.49[a]	10.92±1.93[a]
Inmunobiol**	1.16±0.41[b]	2.84±0.34[a]	3.86±0.38[a]	3.99±0.52[a]	11.85±0.77[a]
Group 2					
Control*	1.63±0.37[a]	4.35±0.81[a]	4.55±0.59[a]	4.69±0.62[a]	15.22±1.65[a]
Inmunobiol**	2.30±0.42[a]	4.24±0.89[a]	4.25±0.67[a]	5.30±1.35[a]	16.09±1.94[a]

*Data represent the Means±SEM of 15 pigs per treatment. **Means±SEM in the same column with similar letters no differ statistically (P>0.05).

9.02 kg. The same trend was observed at 42, 49, and 56 days of age, where the piglets fed with the *M. oleifera* extract were heavier than the piglets of the control group. At the termination of the experiment, the piglets consuming water containing the *M. oleifera* extract, gained an average of 0.89 kg (3.9%) more than the piglets of the control group. Furthermore, the overall averaged body weight of the *M. oleifera* fed group was 16.09 kg, whereas the control group only gained 15.22 kg.

DISCUSSION

M. oleifera is a hardy tree that can grow in nutrient poor soil and is well adapted to drought conditions. In recent studies, the effects of supplementing proteins and fatty acids with *M. oleifera* dried leave flour was shown in pigs (Mukumbo et al., 2014). Moringa leaves have also been reported to provide a suitable protein source for ruminant and monogastric livestock (Soliva et al., 2005).

Extracts from the leaves and pods have been reported to have numerous health benefits and seed extracts have been shown to be antimicrobial (Atawodi et al., 2010). Raw Moringa components may contain certain amounts of antinutritional factors including tannins and saponins that could interfere with nutritional beneifts, although the concentrations are quite low (Foidl et al., 2001). Further, it has been demonstrated that fermentation of *M. oleifera* leaf extract by *Lactobacillus plantarum* increases protein content, pepsic digestibility of protein and availability of iron in the extract which can be considered as a prebiotic enhancement of its effectively (Thierry et al., 2013).

Olufunsho Awodele et al. (2011) reported decreased food consumption and no toxic effects in rats consuming *M. oleifera* extract. Further, treated rats had the same weight as rats that did not consume the extract, which provides some evidence of improved feed conversion. Like the rat study, the author did not observe any evidence of toxicity using a 0.4% final concentration. However, it was not possible to measure feed conversion in these experiments.

Supplementation of the piglet diet with these fermented compounds may have supplied some nutrient benefits. However, given the low dosage that the piglets received, the weight gain seen in these experiments was probably not due to the nutrient content of the extracts, but more likely due to the performance enhancing effects of a number of detected phyto-components in the plant (Garima Mishra et al., 2011).

The data presented here indicate that the piglets consuming water treated with *M. oleifera* extract showed an increased weight gain, and this weight gain was more noticeable in the first experiment where piglets started the treatment at an earlier age. This might indicate that the effect of the liquid extract of *M. oleifera* is more effective at a younger age. Previous studies indicate that other antibiotic alternatives (feed additives, botanicals, probiotics) are also more effective in young animals with a naïve immune system and under developed gastrointestinal tract (Uni et al., 1999; Uni et al., 2003; Solis de los Santos et al., 2003). It appears that some prebiotics and plant extracts can impact the developing gastrointestinal morphology and the associated immune system in a positive manner (Uni and Ferket, 2004). Solis de los Santos et al. (2005) reported that the villus height and the intestinal surface area were significantly increased in chicks fed a prebiotic supplement. Similarly, phytogenic feed additives have also been demonstrated to alter intestinal villi structure which impacts weight gain (Namkung et al., 2004; Nofrarias et al., 2006; Oetting et al., 2006). Accordingly, the piglet weight gain observed in these experiments may be partly explained by taller villi as a result of the *M. oleifera,* which would result in a larger surface for nutrient absorption (Gartner and Hiatt, 2001). However, no intestinal samples were obtained, and thus, this hypothesis remains to be validated.

In conclusion, the results presented here indicate that fermented extracts of *M. oleifera* are promising growth promoter alternatives for use in swine production. The extracts of these trees are available and can be made at a relatively low cost which also facilitates their use. The data collected here indicate that efficacy is related to age, which may be related to development of immature immune and gastrointestinal systems. Further research should be conducted to understand how this extract impacts the immune system and gastrointestinal tract architecture in order to optimize the use of *M. oleifera* extracts.

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