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Growth Performance of Grower Pigs (*Sus scrofa domesticus* L.), Nutritional and Microbial Contents of Wet and Fermented Commercial Hog Ration with Different Levels of Wood Vinegar

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ABSTRACT

Background: Swine is a very important commodity that contributed to the country's food security by providing about 60% of the total animal meat consumption of the Filipinos. Feeds comprise a major expense in swine production and searching for possibly better and cheaper alternatives is urgent to have high quality but economical animal feeding.

Methods: The study aimed to evaluate the growth performance of grower pigs (*Sus scrofa domesticus* L.), nutritional and microbial contents of wet and fermented commercial ration with different levels of wood vinegar as follows: T_0: 0% wood vinegar (WV) per liter Plain water (PW) (3000 mL PW) (control), T_1: 2% WV per liter PW (60 mL WV: 2940 mL PW), T_2: 5% WV per liter PW (150 mL WV: 2850 mL PW). Data gathered were analyzed using ANOVA and LSD to compare treatment means by STAR version 2.0.1.

Result: A significantly higher (p<0.05) bi-weekly cumulative feed intake (BWCFI) and bi-weekly cumulative body weight gain (BWCBWG) were noted on grower pigs given wet and fermented commercial hog ration with different levels of WV during week 4 and no significant differences during weeks 2, 6 and 8. No significant differences were noted on ADG and FCR throughout the study. A significantly higher profit was noted on grower-pigs given wet and fermented commercial hog ration 5% WV inclusion. Moreover, no differences in microbial and nutritional contents were noted on fermented feeds. Regardless of treatments, the wet and fermented commercial hog ration revealed the same microbial content present to enumerate as follows: *Yeast, Lactobacillus* and *Streptococcus*.

Key words: Grower pigs, Growth performance, Nutritional and microbial contents, Profit, Wet and fermented commercial ration, Wood vinegar.

INTRODUCTION

Swine is a very important commodity that contributed to the country's food security by providing about 60% of the total animal meat consumption of the Filipinos. Currently, hog production in the Philippines is a multibillion-peso industry and the country's largest livestock enterprise that ranks eighth in the world. It provides additional income to backyard raisers that supplement their basic needs and resulting in to increase in demand because the majority purchase and utilize pork and pork-related products (Velasco, 2015). Feeds comprise a major expense in swine production if to give the pigs high quality feeds (Linneen *et al*., 2016). Due to the advent of organic animal farming, both farmers and researchers tried to find ways in searching for available raw materials that can be used as feed or supplement that give beneficial effects to the animals without compromising the health concerns of consumers. The discovery of natural or organic feed supplements, probiotics and prebiotics became a fad in the market and research arena. Recently, wood vinegar has been added to the feeds and drinking water of livestock and poultry to enhance proper digestion for easy nutrient absorption and to remove pigpen odour (Sarian, 2017). Further, regarded as a breakthrough in animal feeding, fermentation has been reported to nutritionally enrich the feeds through improved flavor, aroma, texture, appearance, palatability and digestibility of feeds and feedstuff (Food and Agriculture Organization FAO, 1998 and Battcock, 1992).

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Previous studies have been revealed that wood vinegar supplementation in the diets significantly improves the growth of pigs. Pigs fed 0.1, 0.2 and 0.3% wood vinegar diets resulted in a significantly higher average daily gain (ADG) and ADFI than those without wood vinegar supplementation (Choi *et al*., 2009). In another study (Yan *et al*., 2012), bamboo vinegar diets exhibited a significantly higher ADG and gain: feed (G: F) ratio in pigs, as compared to a control group from 0 to 3 weeks and 0 to 6 weeks. Besides, in their study, the fecal *E. coli* numbers were reduced by increasing wood vinegar supplementation. Although the use of WV in swine raising has been cited by several researchers in weaning pigs (Choi *et al*., 2009) and

growing pigs (Rodjan *et al*., 2018). Searching for possibly better and cheaper alternatives is urgent to have high-quality but economical animal feeding. The use of wood vinegar as feed fermenters, growth promoters and profitability of using wood vinegar in swine raising has not yet fully been documented. Therefore, this study aimed to assess the growth performance of crossbreed grower-pigs given wet and fermented commercial hog ration with different levels of wood vinegar; determined the nutritional and microbial contents of wet and fermented commercial hog ration; and assessed the profitability of wood vinegar in swine feeding.

MATERIALS AND METHODS

Pig management and experimental design

A total of nine newly-weaned (30 days old) Landrace x Large White piglets with an average of 10 kilograms each (three females and six castrated males) were used and were randomly and equally distributed to three treatments replicated three times with one pig per replication laid out in a completely randomized design (CRD). Upon arrival at the experimental area, a multi-vitamin/mineral supplement was given to prevent transport stress. The experimental piglets were given the usual commercial pre-starter feeds given at the farm and were gradually shifted to the experimental diet after five days of feeding.

Preparation of experimental diets and treatments

The wood vinegar (WV) was incorporated into the Plain Water (PW) at different levels based on the treatments as follows: T_0: 0% WV per liter Plain water (3000 mL PW) (control), T_1: 2% WV per liter PW (60 mL WV: 2940 mL PW), T_2: 5% WV per liter PW (150 mL WV: 2850 mL PW). This specific amount of WV to PW was then mixed and used to submerge and ferment the commercial feeds eight hours before feeding. The daily experimental ration was based on the requirement of the animal and then shifted gradually according to physiological requirements. The preparation of experimental diet was prepared in the morning for the afternoon feeding (3:00 PM) and preparation in the afternoon was given for the next morning (8:00 AM) to prevent rancidity. The gradual shifting of feeds was practiced throughout the study. The daily feed consumption of pigs for each replicate was recorded. The bi-weekly cumulative feed intake (BCFI) and bi-weekly cumulative body weight gain (BWCBWG) were recorded. The body weight gain (BWG), average daily gain (ADG) feed conversion ratio (FCR) and the profit was then calculated.

Analysis for microbial population and proximate analysis of fermented feeds

Three samples of wood vinegar placed inside closed bottles and three samples at 100 grams each of wet and fermented feeds from each treatment were taken and brought to the Microbiology Laboratory of the College of Veterinary Medicine, VSU. Three samplings were done at a regular interval within the duration of the feeding trial. The microbial assay was carried out by the procedure suggested by Torrallardona *et al*. (2003). The microbial groups analyzed were total anaerobic bacteria (Tryptic soy agar), *Bifidobacterium* spp. (MRS agar), *Lactobacillus* spp. (MRS agar) and Coliform bacteria (Violet red bile agar). Duplicate plates were inoculated with a 0.1 ml sample and incubated. The anaerobic conditions were generated using an anaerobic jar with a gas generator envelope (GasPak Plus, disposable H_2 and CO_2 generating system with palladium catalyst). Proximate analysis of fermented feeds was carried out in the nutrition Laboratory, Department of Animal Sciences, VSU. The dry matter, crude protein of the experimental diets samples were determined according to the methods of AOAC (2000).

Data gathered

Growth performance

Bi-weekly Cumulative Feed Intake (kg) - the total amount of feeds consumed every two weeks was obtained by weighing the feeds given minus the feed refuse. Data on feed intake were recorded on daily basis.

1. **Bi-weekly cumulative body weight gain** - measures the amount of weight gain at a two-week interval.

BWCBWG (kg) = Current Body Weight - Previous Body Weight at Bi-weekly interval

2. **Average daily gain**- Average daily gain is the bodyweight gained per day.

$$\text{ADG (kg)} = \frac{\text{Final weight - Initial weight}}{\text{Feeding days}}$$

3. **Feed conversion ratio**- measures the amount of feed required to produce kilogram live weight.

$$\text{FCR} = \frac{\text{Feed consumed kg}}{\text{Weight gain kg}}$$

4. Profit = (Final LW × Price/kg of LW) – (Voluntary Feed Intake × Cost of feeds) + wood vinegar) + (Price/piglet)

Data analysis

Data were analyzed using One-way Analysis of Variance (ANOVA) and treatment means were compared using the Least Significant Difference Test (LSD) of the Statistical Tool for Agricultural Research (STAR) software.

RESULTS AND DISCUSSION

Feed intake

Table 1 shows that grower pigs were given wet and fermented commercial hog ration with different levels of wood vinegar (WV) significantly higher (p=0.025) the bi-weekly cumulative feed intake at week 4, but not significant at weeks 2, 6 and 8 (p>0.05). The results from this study might be due to the fermentation of feeds that improves the flavor, texture and appearance of food well as making food more palatable (Food and Agriculture Organization, FAO, 2002; Battcock, 1992). In line with our findings, the present study is in agreement with the results of Choi *et al*. (2009)

that pigs fed 0.1, 0.2 and 0.3% wood vinegar diets resulted in significantly higher average daily feed intake (ADFI) than those pigs fed the control diet.

Gain in weight

Results showed that grower pigs given wet and fermented commercial hog ration with different levels of WV was significantly higher (p=0.048) the bi-weekly cumulative body weight gain at week 4 and showed insignificant result (p>0.05) during weeks 2, 6 and 8 (Table 2). The significant result might be attributed due to the higher feed intake of pigs (Table 1) that was converted into body weight gain. This result aligns with Choi *et al*. (2009) and Missotten *et al*. (2010) that wood vinegar could enhance the performance of weanling pigs by improving nutrient digestibility and reducing harmful intestinal coliforms. The present study revealed that the grower pigs with 5% WV in the diet had better BCWG during week 4 than the grower pigs without wood vinegar supplementation. Increasing organic acids leads to acidification which lowers gastric pH that promotes pepsin activity optimization in the gut that helps in protein digestion that might influence the digestibility of crude protein and thereby the more nutrient available for absorption that may be attributed to growth and feed efficiency parameters (Schutt, 2011). Besides, these positive effects may be attributed to the characteristics of the organic compound, such as improvement of the gastrointestinal tract, enhancement of nutrient digestibility and the competitive elimination of pathogenic bacteria (Khan and Iqbal, 2016).

Average daily gain

The bi-weekly average daily gain (ADG) on grower-pigs given wet and fermented commercial hog ration with different levels of wood vinegar was not significant (p>0.05) (Table 3). The result was contradicted with the findings of Choi *et al*., (2009) that pigs fed 0.1, 0.2 and 0.3% wood vinegar diets was significantly higher (p<0.05) the overall daily gain than pigs fed diets without wood vinegar supplementation. The results from this study may suggest that ADG may not have a significant difference daily. It should be noted that only week 4 showed significant results (Table 2) throughout the study. Although the results were insignificant, the ADG is correlated with the BWG (Table 1) that was higher on 5% WV among treatments.

Feed conversion ratio

Feed conversion ratio (FCR) or feed conversion rate is a ratio or rate measuring the efficiency with which the bodies of livestock convert animal feed into the desired output. The FCR of grower-pigs given wet and fermented commercial hog ration with different levels of wood vinegar was not significantly different (p>0.05) (Table 4). Despite the insignificant result, the overall FCR of grower-pigs with 5% WV displayed an FCR value of 0.63 (Table 4). It should be noted that the FCR of grower-pigs on 5% WV was attributed to higher mean cumulative body weight gain (Table 2). The FCR value of 0.63 was a good indicator in determining the profitability of a swine project (Edwards *et al*., 1989) as the cost of feed can account for 75% of the variable costs associated with production (Johnson *et al*., 1999).

Table 1: Bi-weekly cumulative feed intake (kg) of grower-pigs (*Sus scrofa domesticus* L.) given wet and fermented commercial hog ration with different levels of wood vinegar.

Treatment	Week 2	Week 4	Week 6	Week 8	Mean
T_0 - 0% WV	2.64	4.32^b	5.65	10.70	5.83
T_1 - 2% WV	2.42	4.30^b	5.49	10.64	5.71
T_2 - 5% WV	2.59	4.50^a	5.67	10.86	5.91
p - value	0.258	0.025*	0.147	0.096	0.996

*Column means with no common superscripts are significantly different (P<0.05).

Table 2: The bi-weekly gain in weight (kg) of grower-pigs (*Sus scrofa domesticus* L.) given wet and fermented commercial hog ration with different levels of wood vinegar.

Treatment	Week 2	Week 4	Week 6	Week 8	Mean
T_0 - 0% WV	4.25	4.77^b	8.25	12.90	7.54
T_1 - 2% WV	5.57	6.65^b	8.67	11.68	8.14
T_2 - 5% WV	5.25	8.13^a	8.75	14.20	9.08
p - value	0.462	0.048*	0.580	0.482	0.826

* Column means with no common superscripts are significantly different (P<0.05).

Table 3: Bi-weekly average daily gain (kg) of grower-pigs (*Sus scrofa domesticus* L.) given wet and fermented commercial hog ration with different levels of wood vinegar.

Treatment	Week 2	Week 4	Week 6	Week 8	Mean
T_0 - 0% WV	0.30	0.34	0.59	0.92	0.54
T_1 - 2% WV	0.40	0.48	0.62	0.83	0.58
T_2 - 5% WV	0.38	0.58	0.63	1.01	0.65
p - value	0.250	0.072	0.592	0.495	0.817

Table 4: A bi-weekly cumulative feed conversion ratio of grower-pigs (*Sus scrofa domesticus* L.) given wet and fermented commercial hog ration with different levels of wood vinegar.

Treatment	Week 2	Week 4	Week 6	Week 8	Mean
T_0 - 0% WV	0.65	0.53	1.22	0.84	0.81
T_1 - 2% WV	0.45	0.50	0.89	0.94	0.69
T_2 - 5% WV	0.52	0.51	0.70	0.78	0.63
p - value	0.250	0.592	0.072	0.495	0.576

Profit

Results disclosed a significantly highest (p=0.047) profit of 3, 187.44 Philippine Peso (PHP) in 5% WV among treatments (Table 5). This significant difference was attributed to high body weight gain (BWG) and generally better feed conversion ratio (FCR) of grower-pigs on 5% WV among treatments. Similarly, a significantly higher profit on grower-pigs given wet and fermented commercial hog ration with wood vinegar is an amazing indication of the profitability of wood vinegar for swine raising especially in the commercial level of operations.

Total late count (TPC) and differential identification on fermented feeds and proximate analysis

Total microbial plate count, differential identification and proximate analysis on wet and fermented feeds are not significantly different (P>0.05) (Table 6 and 7). Regardless of treatments, the wet and fermented commercial hog ration revealed the same microbial content present to enumerate as follows: *Yeast, Lactobacillus* and *Streptococcus*. As it has been proven, even just mixing feeds with plain water and under anaerobic conditions, lactic acid bacteria and yeasts naturally occurring in the feed proliferate and produce lactic acid, acetic acid and ethanol which reduces the pH of the mixture. The consequent reduction in pH suppresses pathogenic organisms from developing in the feed. Likewise, the low pH mixture decreases the pH in the stomach of pigs and restrains the proliferation of pathogens such as coliforms and Salmonella in the gastrointestinal tract. Besides, the higher TPC (6.3×10^6 and 2.7×10^6) on wet and fermented commercial hog ration with wood vinegar suggests favoring the growth of beneficial microorganisms that could act as probiotics as reflected by the result on the differential count. The findings of this study were supported by Watarai and Tana (2005) that wood vinegar stimulates the growth of normal bacterial flora which serves as prebiotics. Moreover, Rastall and Gibson (2015) cited that wood vinegar contains pectin, cellulose, xylanes, which favors the development of various beneficial microorganisms and Kim (1996) also revealed that wood vinegar contains over 200 compounds. Moreover, Missoten *et al.* (2015) cited that to successfully control the development of pathogenic organisms, fermented liquid feed must contain adequate amounts of lactic acid that can arise from spontaneous fermentation or by inoculating the feed with a culture of lactic acid bacteria before fermentation. The percent (%) crude protein (CP) and percent (%) dry matter contents of the wet and fermented commercial hog ration are not influenced by varying levels of wood vinegar (Table 7) in this study.

Table 5: Sale, cost and profit (PHP) of grower-pigs *(Sus scrofa domesticus* L.) given wet and fermented commercial hog ration with different levels of wood vinegar.

Treatment	Sales/pig	Total cost/pig	Profit philippine peso (PhP)
T_0 - 0% WV	5,700.00	3,199.98	$2,500.01^{b}$
T_1 - 2% WV	6,000.00	3,322.42	$2,677.57^{ab}$
T_2 - 5% WV	6,750.00	3,562.56	$3,187.44^{a}$
p - value	0.250	0.592	0.047

Table 6: Differential identification and total microbial plate count on wet and fermented commercial hog ration with different levels of wood vinegar given to grower-pigs (*Sus scrofa domesticus* L.).

Treatment	Microbial Identified	TPC
T_0 - 0% WV	*Yeast, Lactobacillus, Streptococcus*	1.0×10^6
T_1 - 2% WV	*Yeast, Lactobacillus, Streptococcus*	2.7×10^6
T_2 - 5% WV	*Yeast, Lactobacillus, Streptococcus*	6.3×10^6
p-value		0.528

TPC-Total Plate Count.

Table 7: Crude protein and dry matter contents of the wet and fermented commercial hog ration with different levels of wood vinegar given to grower-pigs *(Sus scrofa domesticus* L.).

Treatments	Means	
	Crude protein (%CP)	Dry matter (%DM)
T_0 - 0% WV	16.31%	26.80 %
T_1 - 2% WV	16.99%	25.35%
T_2 - 5% WV	17.05%	26.09%

Statement of conflicting interests

The authors state that there is no conflict of interest.

CONCLUSION

The current study revealed that grower-pigs given wet and fermented commercial hog ration with different levels of WV improves BWCFI and BWCBWG during week 4, however, no significant differences during weeks 2, 6 and 8. No significant differences were noted on ADG and FCR throughout the study. Another important finding of this study was that the grower-pigs given wet and fermented

commercial hog ration with 5% WV displayed significantly higher profit among the treatments. Moreover, no differences in microbial and nutritional contents were noted on fermented feeds. A further study should be conducted of the same treatment until the finishing stage to compare the result of the study.

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