Effect of *Vernonia amygdalina* Meal on Growth Performance in Weaned Piglets

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Abstract

Vernonia amygdalina (VA) commonly known as bitter leaves is a plan species on ethno veterinary importance with therapeutic and nutritional benefits to animal health and production. This research was conducted to evaluate the growth performance in piglets given bitter leaves in clean drinking water in the Benson Idahosa Research Farm. Forty-five piglets of mixed breed were used for thirty-five days of water infusion feeding trial. Three levels of 0g, 1.2g, and 2.4g of VA per 1000ml of clean drinking water designated as T_1, T_2, and T_3 were used. Piglets at different weeks of age (2, 3, 4, 5, and 6 weeks) were randomly assigned in a completely randomized design experiment with each treatment replicated three times (a piglet per replicate). Data were collected on feed Intake (FI), body weight gain (BWG), water intake (WI), and feacal pH on replicates basis. At 2 weeks of age, there was no significant difference (P>0.05) in the FI and FCR across the treatments. Water intake was highest (P<0.05) in piglets in T_2 (2057ml). Significant increase (P<0.05) in BWG and feacal pH was recorded in T_3 (6kg) and T_1 (28.99). At week 3, no significant difference (P>0.05) was observed in the FI across the treatments. There was significant difference (P<0.05) in the FCR, WI, BWG, and feacal pH of the piglets across the treatments with T_3 (1.680), T_2 (5642 ml), T_1 (3.133kg), and T_3 (28.460) having the highest. At 4 weeks, There was no significant difference (P>0.05) in the FI across the treatments. There was a significant difference (P<0.05) in the FCR and WI of the piglets in T_3 (1.424) and T_2 (5758ml). The BWG (3.30kg) and feacal pH (29.20) were significant (P<0.05) in T_1. At week 5, BWG, FI, FCR, and feacal pH were not significantly (P>0.05) different across the treatments. There was a significant difference (P<0.05) in the WI of the piglets, with T_2 having the highest (5815ml). At 6 weeks of age, significant increase was seen in the BWG and FCR (P<0.05) for piglet on T_3, WI on T_2, and feacal pH on T_1. It can be concluded that bitter leaf can be used to improve growth performance and reduce diarrhea in weaned piglets in piglets.

Keywords: *Vernonia amygdalina,* weaned piglets, post-weaning diarrhea, growth performance, water intake

Introduction

Pig farming is an income-generating activity for small–scale farmers, especially in developing countries (Malede, 2015). According to Uddin and Osasogie (2017), high fecundity rate (prolificacy) and efficient conversion of feed to useful products (Pork meat, skin, hair, and manure), high dressing percentage, high market demand, and high financial benefit to farmers are some of the advantages in pig production. Early maturity, short generation interval, relatively small space requirement and ability to produce maximally under varied management are also some of the benefits of pig production as compared to other livestock production. The pig industry globally is plagued with many drawbacks including under-developed infrastructure, the poor genetic performance of local breeds, feed challenges, poor management, and husbandry practices, shortage of trained manpower, cultural and religious taboos on marketing and consumption of pork, and widespread diseases (FAO 2018). However, it appears that diseases and high feed cost which represents between 60% and 70% of the total cost of production are the top two major challenges (Michael and Vesna, 2017). Furthermore, Post-weaning diarrhea (PWD) is one of the most serious threats to the swine industry worldwide (Rhouma *et al*., 2015).

Post-weaning diarrhea (PWD) due to Escherichia coli is an economically important disease in pig production that affects pigs during the first two weeks after weaning and is characterized by sudden death or diarrhea, dehydration, and growth retardation in surviving piglets (Rhouma *et al*., 2017). Moreover, many stress factors associated with the weaning period, such as removal from the sow, dietary changes, adapting to a new environment, mixing of pigs from different farms, and histological changes in the small intestine, may negatively affect the response of the immune system and lead to an intestinal gut dysfunction in pigs (Rhouma *et al*., 2017). *Escherichia coli* (ETEC) adhere to pig's small intestinal epithelium, causing an increase in the secretion of water and electrolytes into the intestinal lumen due to the release of enterotoxins. These also alter the functions of enterocytes by increasing secretion and reducing the absorption of water and electrolytes (Rhouma *et al*., 2015). Excessive secretion of electrolytes and water leads to dehydration, metabolic acidosis, osmotic diarrhea, and possible death (Roubos-Van et al., 2016). Moreover, the continuous rise in the cost of medicines (such as antibiotics) affects local producers, and also studies at the University of Montreal, Canada has reported the isolation of Colistin-resistant *E. coli* in swine (Luppi *et al*., 2016). Colistin is an effective antibiotic widely used in swine for the oral treatment of intestinal infections caused by *E. coli*, particularly of PWD, and is considered to be of high importance in humans, being used for the treatment of infections (Rhoads *et al*., 2017). The call of the World Health Organization (WHO) on the use of colistin only for therapeutic cases in animals will have negative consequences on the survival of the pig industry in most developing countries in the future (Asiama, 2018). Therefore, there is a need to seek alternative medication for pigs, while maintaining product quality (Uddin and Osasogie 2017) to compensate for the negative effects of their higher prices and ineffectiveness (Asiama, 2018). Pig's health and good management practices are the core component of the operational dynamics of a developing and profitable production industry (Anozie, 2016).

One of such alternative medication that could be used to reduce the high cost of conventional medications in pig production is Vernonia amygdalina. Vernonia amygdalina (VA) is a shrub or small tree that grows throughout tropical Africa. It is popularly called bitter leaf because of its abundant bitter principles (Evbuomwan *et al*., 2017). The leaves contain a considerable amount of anti-nutritive factors like high levels of tannic acid and saponin (Usunobun *et al*., 2016). The proximate composition of *Vernonia amygdalina* leaf meal (VALM) shows a chemical composition of 527.83 ME kcal/ kg, 86.40% DM, 21.50% CP, 13.10% CF, 6.80% EE, 11.05% Ash, and the result on mineral composition indicate that *V. amygdalina* has 3.85% calcium, 0.40% magnesium, 0.03% phosphorus, 0.006% Iron, 0.33% potassium and 0.05% Sodium (Gashe *et al*., 2017). Research has shown that *V. amygdalina* has some beneficial effects in disease management of pigs such as anti-bacterial, anti-parasitic, anti-oxidant, and as a stimulant of gastric acid secretion and increased intestinal motility through direct irritation of the gastric mucosa (Owu and Udia 2018) and as a growth promoter by enhancing the gastrointestinal enzymes thus increasing feed conversion efficiency (Huffman *et al*., 1996; Olobatoke and Oloniruha, 2009).

Therefore, this study is focused on the evaluation of growth performance and post-weaning diarrhea occurrence in piglets given *Vernonia amygdalina* in clean drinking water.

Materials and Methods

Experimental site

This study was conducted in the Piggery Unit of the Faculty of Agriculture and Agricultural Technology Teaching and Research Farms, Legacy Campus, Benson Idahosa University, Benin City, Edo State. It is located between Latitude 60 and 11’48”N of the Equator and Longitude 5039'21" E of the Greenwich Meridian, in the rainforest zone, with temperature of 27.6°C. Benin City has an average annual rainfall and relative humidity of

2162mm 72.5% respectively.

Sources of *Vernonia amygdalina* (VA) and preparation of Material

Fresh bitter leaves were collected from the Delta Steel Company Housing Complex, Warri, Delta State. The leaves were dried at room temperature while retaining the greenish colouration, and then ground into meal. The bitter leaf extract was prepared by soaking 1.2 and 2.4g of the ground bitter leaf meal in 1 litre of boiled water overnight (12 hours) respectively. This was filtered in the morning and the measured quantity of filtrate according to the experimental treatment was added to 1000ml of pure drinking water and served to the piglets. This protocol was described by Achinewhu and Obikaonu (2013). The treatment was available on daily basis.

Management of Experimental Piglets

A total of forty-five mixed-sex piglets, randomly picked from synchronized farrowed sows of mixed breed were used for the study. The piglets were weaned from the sows at ages 2, 3, 4, 5, and 6 weeks. Nine piglets per week were randomly allotted to three treatments with each treatment replicated three times with one piglet per replicate in a completely randomized design (CRD). Fifteen experimental units in all. The experimental treatment consisted of nine piglets maintained on 0g VALM/1000ml of water (T1), 1.2g VALM/1000ml of water (T2), and 2.4g VALM/1000ml of water (T3) for seven consecutive days. The experiment lasted seven days each week.

The experimental piglets were fed *ad libitum* on a commercially (Top feed) formulated starter diet and Palm Kernel Cake (PKC) combined in equal proportion.

Feed intake was recorded per replicate and this was done on daily basis. Daily feed intake was calculated as the weight of feed given, subtracted from the weight of the leftover feed. Daily water intake was calculated by subtracting the volume of water supplied from the volume of water left. The weaning weights of the piglets were determined at the beginning of the experiment using a weighing balance and their subsequent body weights were determined at the end of each week. The weight gain was determined by subtracting the weaning body weight from the final body weight. There was no mortality recorded throughout the experimental period.

Data Collection

The data were collected on body weight gain, feed intake, feed conversion ratio, water intake, and faecal pH. Proximate analyses of VALM and feacal samples were carried out using the method described by the AOAC (2004). Data were subjected to a one-way analysis of variance, and then the differences between the treatment means were compared using the Least Significant Difference Test. All statistical analysis was performed with Statistical Analysis Software (SAS 2012)

Results

Table 1 shows the results of the proximate composition of the bitter leaf meal used for the study.

Table 1: Proximate Composition of Bitter Leaf (*Vernonia amygdalina*) Meal

Parameters	(%)
Ash Content	16.03
Crude Protein	20.37
Ether Extract	8.29
Crude Fibre	13.95
Nitrogen Free Extract	41.36
Dry matter	93.8

Table 2 shows the performance of piglets weaned at 2 weeks of age given varying levels of bitter leaf (Vernonia amygdalina) meal for seven consecutive days. The initial body weight was not significantly ($p>0.05$) different between T_1 and T_2 but different ($p<0.05$) for piglets on T_3. There was a significant difference ($p<0.05$) in the final body weight of the piglets across the treatments with T3 having the highest (8kg) final body weight. The body weight gain was not ($p>0.05$) significantly different between T_1 and T_2 but different for piglets on T_3. The highest body weight gain was recorded in T3 (6kg) while the lowest value (2.8kg) was in T_1. There was no significant difference ($p>0.05$)

in the feed intake and feed conversion ratio (FCR) across the treatment means. There was a significant difference (p<0.05) in the water intake (WI) of the piglets across the treatments with T_2 having the highest (2057ml) and T_1 having the lowest (1552ml) WI. The feacal pH was not significantly (p>0.05) different between T_1 and T_2 but different (pH) for piglet on T_3. The highest feacal pH was recorded in T1 (28.990) while the lowest value was in T_3 (27.750).

Table 3 shows the performance of piglets weaned at 3 weeks of age given varying levels of bitter leaf (*Vernonia amygdalina*) meal for seven consecutive days. The initial body weight was significantly (p<0.05) different across the treatments. The highest initial body weight was recorded in T_1 (5kg) while the lowest value was in T_3 (3kg). There was a significant difference (p<0.05) in the final body weight of the piglets across the treatments with T_1 having the highest (8.133kg) final body weight and T_3 having the lowest (4.000) final body weight. The net BWG was significantly (p<0.05) different across the treatments. The highest (3.133kg) body weight gain was recorded in T_1 while the lowest (1.000kg) value was in T_3. Treatment 3 was significantly (p<0.05) higher than T_2 and T_3 in their feed intake. There was no significant difference (p>0.05) in the feed conversion ratio between T_1 and T_2 but different for T_3.

Table 2: Growth performance of piglets weaned at 2 weeks of age given varying levels of bitter leaf (*Vernonia amygdalina*) meal

	Dietary Groups				
Parameters	**TRT 1**	**TRT 2**	**TRT 3**	**S.E.M**	**STD**
Initial BW (kg)	1.200a	1.000a	2.000b	0.176	0.527
Final BW (kg)	4.000a	6.000b	8.000c	0.584	1.751
Net BWG (kg)	2.800a	5.000a	6.000c	0.480	1.441
Feed Intake (kg)	1.000	1.135	1.527	0.117	0.352
FCR	0.356	0.227	0.254	0.028	0.083
Water Intake (ml)	1522a	2057b	1868c	78.321	234.963
Feacal PH	28.990a	28.650a	27.750b	0.204	0.613

abcMeans along the same row with different superscripts are significantly different. VA-*Vernonia amygdalina*, BW-Body Weight, BWG-Body Weight Gain, FCR-Feed Conversion Ratio, TRT-Treatment, Trt 1 – 0g VALM/1000ml of water, Trt 2– 1.2g VALM/1000ml of water, Trt 3 – 2.4g VALM/1000ml of water, SEM.– Standard Error of Mean. FCR: Feed Conversion Ratio, STD-Standard Deviation

Table 3: Growth performance of piglets weaned at 3 weeks of age given varying levels of bitter leaf (*Vernonia amygdalina*) meal

	Dietary Groups				
Parameters	**TRT 1**	**TRT 2**	**TRT 3**	**S.E.M**	**STD**
Initial BW (kg)	5.000a	4.000b	3.000c	0.301	0.904
Final BW (kg)	8.133a	6.000b	4.000c	0.605	1.814
Net BWG (kg)	3.133a	2.000b	1.000c	0.309	0.926
Feed Intake (kg)	1.626	1.357	1.680	1.000	0.30
FCR	0.517a	0.679a	1.680b	0.191	0.572
Water Intake (ml)	3527a	5642b	4732c	322.382	967.145
Feacal PH	27.410a	27.670a	28.460b	0.180	0.540

abcMeans along the same row with different superscripts are significantly different. VA-*Vernonia amygdalina*, BW-Body Weight, BWG-Body Weight Gain, FCR-Feed Conversion Ratio, TRT-Treatment, Trt 1 – 0g VALM/1000ml of water, Trt 2– 1.2g VALM/1000ml of water, Trt 3 – 2.4g VALM/1000ml of water, SEM.– Standard Error of Mean, STD-Standard Deviation

The highest (1.680) feed conversion ratio was recorded in T_3 while the lowest (0.517) value was in T_1. There was significant difference ($p<0.05$) in the water intake of the piglets across the treatments with T_2 having the highest (5642ml) water intake and T_1 having the lowest (3527ml) water intake. The feacal pH was not significantly ($p>0.05$) different between T_1 and T_2 but different for piglet on T_3. The highest feacal PH was recorded in T_3 (28.460) while the lowest value was in T_1 (27.410).

Table 4 shows the performance of piglets weaned at 4 weeks of age given varying levels of bitter leaf (*Vernonia amygdalina*) meal for seven consecutive days. The initial body weight was significantly ($p< 0.05$) different across the treatments. The highest (7.000kg) initial body weight was recorded in T_3 while the lowest (4.20kg) value was in T_1. Treatment 3 was significantly ($p<0.05$) higher in the final BW of the piglets with T_3 having the highest (8.200kg) final BW and T_2 had the lowest (6.120kg) final BW. The net BWG was significantly ($p<0.05$) different across the treatments. The highest (3.300kg) BWG was recorded in T_1 while the lowest (1.087kg) value was in T_2. There was no significant difference ($p>0.05$) in the feed intake across the treatments. There was no significant difference in the FCR between T_1 and T_2 but different for T_3. The highest (1.596) FCR was recorded in T_2 while the lowest (0.570) value was in T_1. There was significant difference ($p<0.05$) in the water intake of the piglets across the treatments with T_2 having the highest (5758ml) WI and T_1 has the lowest (3819ml) WI. The feacal pH was significantly different across the treatments. The highest (29.200) feacal PH was recorded in T_1 while the lowest (24.610) value was in T_2.

Table 4: Growth performance of piglets weaned at 4 weeks of age given varying levels of bitter leaf (*Vernonia amygdalina*) meal

	Dietary Groups				
Parameters	**TRT 1**	**TRT 2**	**TRT 3**	**S.E.M**	**STD**
Initial BW (kg)	4.200a	5.033b	7.000c	0.424	1.272
Final BW (kg)	7.500a	6.120b	8.200c	0.318	0.953
Net BWG (kg)	3.300a	1.087b	1.200c	0.360	1.08
Feed Intake (kg)	1.880	1.731	1.709	0.091	0.272
FCR	0.570a	1.596a	1.424b	0.171	0.514
Water Intake (ml)	3819a	5758b	4962c	323.470	970.411
Feacal pH	29.200a	24.610b	26.930c	0.668	2.005

^{abc}Means along the same row with different superscripts are significantly different.VA- *Vernonia amygdalina*, BW-Body Weight, BWG-Body Weight Gain, FCR-Feed Conversion Ratio, TRT-Treatment, Trt 1 – 0g VALM/1000ml of water, Trt 2– 1.2g VALM/1000ml of water, Trt 3 – 2.4g VALM/1000ml of water, SEM.–Standard Error of Mean. STD-Standard Deviation

Table 5 shows the performance of piglets weaned at 5 weeks of age given varying levels of bitter leaf (*Vernonia amygdalina*) meal for seven consecutive days. The initial body weight, final body weight, net body weight change or body weight gain, feed intake, and feed conversion ratio were not significantly ($p>0.05$) different across the treatments. There was significant difference ($p<0.05$) in the WI of the piglets across the treatments with T_2 having the highest (5815ml) WI and T_1 has the lowest (4010ml) WI. The feacal pH was not significantly different across the treatments.

Table 6 shows the performance of piglets weaned at 6 weeks of age given varying levels of bitter leaf (*Vernonia amygdalina*) meal for seven consecutive days. The initial body weight was not significantly different ($p>0.05$) between T1 and T2 but different for piglets on T3. The highest (9.800kg) initial body weight was recorded in T1 while the lowest (8.800kg) value was in T2. There was no significant difference ($p>0.05$) in the final BW of the piglets between T1 and T2 but different for T3, with T3 having the higher (10.960kg) final BW and T2 having

Table 5: Growth performance of piglets weaned at 5 weeks of age given varying levels of bitter leaf (*Vernonia amygdalina*) meal

Parameters	Dietary Groups			S.E.M	STD
	TRT 1	TRT 2	TRT 3		
Initial BW (kg)	8.200	8.300	8.550	0.101	0.303
Final BW (kg)	9.800	9.943	10.130	0.119	0.357
Net BWG (kg)	1.600	1.643	1.580	0.384	0.115
Feed Intake (kg)	1.726	1.483	1.823	0.100	0.30
FCR	1.079	0.900	1.154	0.061	0.184
Water Intake (ml)	4010a	5815b	4980c	56.656	170.00
Feacal pH	27.600	27.350	27.420	0.092	0.279

^{abc}Means along the same row with different superscripts are significantly different.VA- *Vernonia amygdalina*, BW-Body Weight, BWG-Body Weight Gain, FCR-Feed Conversion Ratio, TRT-Treatment, Trt 1 – 0g VALM/1000ml of water, Trt 2– 1.2g VALM/1000ml of water, Trt 3 – 2.4g VALM/1000ml of water, SEM.– Standard Error of Mean. STD-Standard Deviation

Table 6: Growth performance of piglets weaned at 6 weeks of age given varying levels of bitter leaf (*Vernonia amygdalina*) meal

Parameters	Dietary Groups			S.E.M	STD
	TRT 1	TRT 2	TRT 3		
Initial BW (kg)	9.800a	8.800a	9.530b	0.101	0.303
Final BW (kg)	10.900a	9.900a	10.960b	0.119	0.357
Net BWG (kg)	1.100a	1.100a	1.430b	0.038	0.115
Feed Intake (kg)	3.886	3.476	3.789	0.01	0.30
FCR	3.533a	3.160a	2.650b	0.061	0.184
Water Intake (ml)	4066a	5921b	4900c	56.656	169.969
Feacal PH	30.650a	28.200b	30.540c	0.093	0.279

^{abc}Means along the same row with different superscripts are significantly different.VA- *Vernonia amygdalina*, BW-Body Weight, BWG-Body Weight Gain, FCR-Feed Conversion Ratio, TRT-Treatment, Trt 1 – 0g VALM/1000ml of water, Trt 2– 1.2g VALM/1000ml of water, Trt 3 – 2.4g VALM/1000ml of water, SEM.– Standard Error of Mean. STD-Standard Deviation

the lowest (9.900kg) final BW. The net BWG was not significantly different ($p>0.05$) between T_1 and T_2 but different for piglets on T_3. The higher (1.430kg) BWG was recorded in T_3 while the lowest value was in T_1 and T_2. There was no significant difference ($p>0.05$) in the feed intake across the treatments. There was no significant difference ($p>0.05$) in the FCR in T_1 and T_2 but different for T_3. Treatment 1 has the highest (3.533) FCR while T_3 has the lowest (2.650) value. There was significant difference ($p<0.05$) in the WI of the piglets across the treatments with T_2 having the highest (5921ml) WI and T_1 has the lowest (4066ml) WI. The feacal pH was significantly different ($p<0.05$) across the treatments with T_1 having the highest (30.650) while T_2 had the lowest (28.200) value.

Discussion

The result of the proximate composition of *Vernonia amygdalina* is presented in Table 1. The analysis showed that *Vernonia amygdalina* contained 20.37% crude protein, 13.95% crude fiber, 8.29% ether extract, 16.03% ash, and 41.3% NFE. These nutritive values were quite similar to that reported by Gashe *et al.* (2017). However, small variations exists when compared to past studies and could probably be attributed to variation in soil factors across space, such as soil type, texture, moisture and fertility. The findings of this study confirms that nutrient compositions of the diets are adequate and within the recommended range for piglets as reported by NRC (1994). Furthermore, provision of bitter leaves juice through drinking water to piglets did not affect feed consumption. Instead there was significant increase in body weight, weight gain, and feed conversion ratio. The high feed intake in piglets in T_3 weaned at weeks 2, 3, and 5 could be attributed to the high amount of *Vernonia amygdalina* in their drinking water. This is because the bitterness of *Vernonia amygdalina* enhances the gastro-intestinal enzymes especially chymotrypsin production. Chymotrpsin could enhance the digestion of sporozoites and other intestinal parasites that could cause decreased utilization of feed (Owu and Udia 2008 and Huffman *et al.* 1996) as reported by Owu and Udia (2018).

The improved growth performance of weaned piglets with Vernonia amygdalina leaves across age groups are in agreement with previous studies (Tangka 2003 and Durunna *et al*., 2011) The improvement observed in the improved weight gain is correlated with the lower FCR observed in the treated group. Olobatoke and Oloniruha (2009) reported that the inclusion of bitter leaf powder in cockerels feed significantly improved FCR. Weaners consumed bitter leaves had significant higher weight gain compared to the control across age groups, this confirms it's efficient utilization of a given feed. Similarly to Ndelekwute *et al*. (2017), shows the dietary effect of *Vernonia amygdalina* meal on growth performance, carcass and internal organs characteristics of finisher broilers. Recent reports and fears about their residual effects cumulating to antibiotics resistance have placed antibiotics in a disadvantaged position as growth promoters (Aarestrup 2015). Moreover, literature show plant-based feed additive also known as phytogenic may work as a growth-promoting feed additive because they lack residual effect. (Ndelekwute *et al*., 2017). Furthermore, Phytogenic feed additives are often associated with the improvement of flavour and palatability of feed (Abubakar *et al*., 2010). The effect of *Vernonia amygdalina* on poultry performance is relevant to this study because poultry and pigs are monogastric animals, they have similar digestive systems. *Vernonia amygdalina* known to contain many bioactive compounds falls into the category of phytogenic feed additives for many possible reasons. The non-residual effect is because the active principles of phytogenic feed additives are absorbed in the intestine by enterocytes and are quickly metabolized by the body (Ndelekwute *et al*., 2017). Phytogenic are plant-based feed additives added to animal diets to enhance production efficiency, improve health, and reduced morbidity (Kumar *et al*., 2018). They are added to improve feed utilization, improve the consumption and conversion of feed, and improve the digestibility and weight gain of animals (Onyekuru *et al*., 2020). Furthermore, increased bitterness levels of VA inclusion, the piglets were able to consume and efficiently utilize a large amount of feed. This may also be due to the developed state of the taste buds that enable them to recognize bitter compounds which leads to increased consumption to meet up with their nutrient requirements (Rhouma *et al*., 2017). Also, for piglets weaned at week 5, the highest weight gain (1.643kg) was in T2, the ability of the piglets in this treatment to consume and efficiently utilize the feed given to them can be attributed to the presence of *Vernonia amygdalina* which improve feed consumption, feed utilization, digestibility, and weight gain as reported by Adebowale *et al*. (2020) in their drinking water.

The feed conversion ratio of the piglets weaned at week 2 through week 6 with VA inclusion varied across the different weeks. For piglets weaned at week 2 and week 5, T2 (1.2g VALM inclusion) had an improved feed conversion ratio (0.227 and 0.900 respectively). This is in agreement with the works of (Egharevba *et al*., 2014 and Chiemela *et al*., 2015). Also, despite the level of bitterness of the water due to the level of VA inclusion (T3), the piglets weaned at week 6 were able to consume and efficiently utilize the feed given this may be due to the developed state of their taste buds that enable them recognize bitter compounds (Evbuomwan *et al*., 2017). Furthermore, careful observation of the feed conversion ratio of the piglets weaned at week two through week six showed that the inclusion of 1.2% of *Vernonia amygdalina* leaf meal in the drinking water of the piglets enable the piglets to efficiently utilize their feed better in comparison to other treatments.

The water intake of piglets weaned at

two weeks through six weeks for seven days followed a definite trend with VA inclusion. It was observed that the highest water intake was in piglets given 1.2% *Vernonia amygdalina* closely followed by 2.4% inclusion of *Vernonia amygdalina* and the lowest water intake was in piglets given 0% *Vernonia amygdalina*. This showed that *Vernonia amygdalina* inclusion in piglets' drinking water at 1.2% is very effective in improving the water intake of piglets which in turn will improve digestibility, weight gain, and healthy living of the piglets. Also, the water intake of the piglets weaned at week 2 through week 6 increased steadily across the treatments in all the weaning weeks, which showed that as the piglets grow in age, their water requirements increase and they drink more to meet their body requirement. These findings are in agreement with the findings of Evbuomwan *et al*. (2017) who stated that, the developed state of their taste buds enables them to recognize bitterness. Moreover, this finding was also supported by Chiemela *et al*. (2015) who stated that Vernonia amygdalina enhances the gastro-intestinal activities of the piglets which can be attributed to the bioactivities of *Vernonia amygdalina* included in the treatment. This revealed that when the weaning age is increased, the piglets' feed intake, digestibility, and feed conversion ratio would improve which would in turn improve the piglets' immunity to withstand the stress associated with the weaning period. These findings agree with the findings of Rhouma *et al*. (2017), many stress factors are associated with the weaning period. These stress factors includes removal from the sow, dietary changes, adapting to a new environment, mixing with piglets from different farms and histological changes in the small intestine, may negatively affect the response of an immune system and lead to an intestinal gut dysfunction in piglets.

The faecal pH at 2-6 weeks was largely consistent across treatments 1 and 2, with minor deviations at week 4, these could potentially be influenced by environmental factors. These environmental factors include type and composition of feed, adequate water supply which helps to maintain optimal fecal pH, extreme temperatures which can alter the fecal pH and humidity can lead to increased moisture in the gut, affecting fecal pH (Pluske *et al*., 2018 and Nofrarias *et al*., 2016). This showed that the inclusion of *Vernonia amygdalina* especially at 1.2% and 2.4% in piglets' drinking water had no negative effect on the piglets.

The inclusion of bitter leaf extract in the diets of piglets had no adverse effect on the performance traits. This implies that the administration of this natural herb at 1.2% and 2.4% levels of inclusion could be important in improving the productivity and health status of piglets.

Conclusion and recommendation

Results of the present study, therefore, indicate that 1.2% and 2.4% *Vernonia amygdalina* leaf meal can be conveniently added into the drinking water of piglets without causing any adverse effect on the performance of piglets weaned at week 2, 3, 4, 5, and 6. *Vernonia amygdalina* leaf meal inclusion in piglets' drinking water is shown as a practical approach to improving piglets' performance.

As the swine industry shift to early weaning of piglets to improve farrowing- crate utilization and increase the number of piglets farrowed per sow per year; weaning of piglets not earlier than twenty-eight days of age should be encouraged to improve performance.

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Declaration of conflict of interest

The authors declare that there is no conflict of interest with the study.

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