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Comparative evaluation of hydroponic maize fodder and conventional basal diet on performance, digestibility and blood profile of weaned pigs

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Abstract

High cost of conventional feedstuffs has resulted to the need to exploit the diverse feed resources for improved sustainability in swine production. Hydroponic sprouts which undergo nutritional modification during the sprouting process are a good source of nutrients that could improve the performance of pigs. Hence, nutrient digestibility, performance, haematological and serum biochemical parameters of weaned pigs fed hydroponic maize fodder (HMF) and conventional basal based diets were studied.

Thirty-six (36) crossbred weaned pigs were randomly allotted to three treatments with four replicates each in a completely randomized design. Treatment 1 (T1) had 50% hydroponically grown maize sprouts + 50% concentrate, Treatment 2 (T2) had 100% hydroponically grown maize sprouts and Treatment 3 (T3) had 100% basal diet (cassava peel +palm kernel cake +brewery dried grain). The experiment lasted 6 weeks. Significant differences (P<0.05) were observed in the apparent digestibility of nutrients, performance and blood profile of pigs across dietary treatments. T1 had higher (P<0.05) apparent crude protein digestibility (65.76%) while the lowest (55.27%) was observed in T2 with a similar trend observed for apparent crude fibre digestibility. Apparent ether extract digestibility was higher (P<0.05) in T2 (68.43%) and lowest in T3 (65.47%) while ash digestibility was (P<0.05) highest in T3 (46.08%). Significantly higher values were obtained in T3 for final weight (13.83kg), feed intake (12.79kg) and weight gain (3.83kg) while least values were observed in T2. However, T1 had the highest value for FCR (3.68kg) while comparable values were obtained for feed cost/weight gain in pigs fed T1 and T3. T1 had higher (p<0.05) RBC ($5.73\times10^{6}\mu l$), WBC ($1.80\times10^{4}\mu l$), lymphocytes (69%) and eosinophils (3.67%) values while lowest values were obtained in T2 for PCV (34.67%), RBC ($5.08\times10^{6}\mu l$) and lymphocytes (56.33%). Significant differences (P<0.05) were also observed for cholesterol, triglycerides, LDL, VLDL, total protein, globulin and albumin while glucose and HDL showed no differences (P>0.05). All values obtained for haematology and serum biochemical parameters were within the normal physiological range of the animals.In conclusion, hydroponics maize fodder when combined with concentrate feed had a positive impact on nutrient digestibility and performance of pigs. Also, haematological and serum biochemical indices of pigs were not negatively affected.

Keywords: Hydroponic maize fodder, performance, haematological and serum profile, weaned pigs

Introduction

Expansion of the pig industry is largely dependent on availability of good quality pig feeds in sufficient quantity and at low cost (Singh, 2005). Feed represents 60-75% of the total cost of swine production and the ability to judiciously manipulate feed ingredients to maximise productivity is central to the maintenance of a stable pig production enterprise. Therefore, in order to ensure sustainable swine production in many tropical countries, alternative feeding systems need to be studied and developed (Perez, 1997). Alternative feed materials in pig nutrition are industrial wastes such as cassava peels, brewery waste, palm kernel slurry etc and kitchen wastes. Feeding this type of feed ensures reduced production

cost. However, these alternative feed materials are not nutritionally balanced and not always available all-year-round. Another option available to pig farmers is offering concentrate diet to their pigs to boost weight gain, this is however not sustainable as a result of its high cost. There is therefore a continuous search for diet replacements or substitutes that will meet the nutritional requirements of the animals with all year round availability and which are less expensive to ensure higher economic gain for farmers.

One of the possible ways of solving this problem of feed scarcity in the pig industry is through the exploration of the hydroponic system to grow forages to be fed to pigs. Hydroponics is a technique for growing plants without using soil. It is a technology for growing plants in nutrient solutions that supply all nutrient elements needed for optimum plant growth with or without the use of an inert medium such as gravel, vermiculite, rock wool, peat moss, saw dust, coir dust, coconut fibre *etc* to provide mechanical support **(**Aatif *et al.*, 2014**)**. It has been recognised as a viable method of producing vegetables (tomatoes, lettuce, cucumbers and peppers) as well as ornamental crops such as herbs, roses, freesia and foliage plants. Different types of fodder crops such as barley (Reddy *et al.*, 1988), oats, wheat (Snow *et al.*, 2008); sorghum, alfalfa, cowpea (AI-Karaki and AI-Hashimi, 2012) and maize (Naik *et al.*, 2011; Naik *et al.*, 2012a) can be produced by hydroponics technology. Weldegerima (2015) reported that feeding of hydroponically grown maize and barley fodder to growing goats increased the total dry matter intake, feed conversion efficiency, body weight gain and was economically valid. Also, Miscera *et al.* (2009) reported that the integration of lactating Comisana sheep diet with hydroponically germinating oat in partial substitution of the complete feed did not modify biochemical and haematological parameters but caused an improvement in animal welfare and production of milk. Sharif *et al.* (2013) observed increased digestibility by using sprouted grain in the diet of broilers and large animals. Addition of sprouted grain also improved milk yield up to 8.7% in ruminant animals (Stür *et al.*, 2006).

Maize grain is a good choice for production of hydroponics fodder due to its availability, low cost, good biomass production and quick growing habit. Hydroponically grown maize fodder can be a better replacement or supplement for scarce feed stuffs because of its high nutritive value, high digestibility and all year round availability (Suraj *et al.*, 2016).

Pigs are prolific monogastrics which have great ability in converting feed from various sources into animal products. However, when pigs are not well fed from the early stage of their life, it may have negative effect on their weight at maturity. Therefore, this research was carried out to determine the effect of feeding hydroponically grown maize forage on the performance of weaned pigs.

Materials and methods

Experimental site

The study was carried out at the Piggery Unit of the Teaching and Research Farm, University of Ibadan, Ibadan, Nigeria. The farm is situated in Southern Nigeria at $7^0 20^1$N, $3^0 50^1$E at an altitude of 200-300m above sea level.

Production of hydroponics maize fodder

The production of hydroponic maize fodder was conducted under natural illumination at the growth chamber of the project site. The chamber is composed of metal frame and shelves with plastic trays (56cm x 40cm x7cm) used for growing maize seeds. Clean seeds of maize were washed and soaked in

tap water for 20h and then distributed in trays at 500g of maize seeds per tray. Trays were irrigated manually with organic hydroponics nutrient solution twice daily (07:30hr and 17:30hr) at a fixed rate of 250 ml/tray/day using a spray gun. The seed sprouts were grown for a period of 7 days. The fully grown fodder was thereafter harvested and fed to the pigs as whole feed. Samples of the green fodder were taken to determine the dry matter and nutrient contents.

Experimental animals, feeding and management

A total of 36 weaned pigs with average weight of ±9.5kg were purchased from a reputable farm in Ibadan, Oyo state, Nigeria. After adaptation for 2 weeks, pigs with similar weights were grouped into three treatments with three replicates each and four pigs per replicate. Pigs were fed *ad libitum* and cool clean water was also provided. The experiment lasted eight weeks. Pigs were housed in properly disinfected pens and all routine management practices were strictly observed. Treatment 1 was 50% hydroponically grown maize fodder + 50% concentrate; Treatment 2 (100% hydroponically grown maize fodder) and Treatment 3 (100% basal diet). Note-basal diet composition was conceived based on conventional choice of feed of many pig farmers. Such feed were fed without addition of concentrate that might provide possible nutrients balance for the animals.)

Table 1: Gross composition of experimental concentrate feed

Ingredient	Inclusion (%)
Maize	43.00
Soyabean meal	15.00
Wheat offal	15.00
Groundnut cake	7.00
Palm kernel cake	15.00
Palm oil	3.00
Limestone	1.25
Salt	0.50
Premix	0.25
Total	**100.00**
Calculated Nutrients	
Crude protein (%)	19.03
Metabolizable energy (Kcal/kg)	2905.20

Table 2: Composition of basal diet

Ingredient	Inclusion (%)
Cassava peels	50.0
Palm Kernel Cake	30.0
Brewery Dry Gain	20.0
Total	100.0

Data collection

Feed intake was obtained by subtracting the total leftover feed from the total quantity of feed served weekly. Body weight gain was determined by subtracting the initial live weight from the final live weight. Feed conversion ratio was obtained by dividing the total feed consumed by total weight gain for each pig. The experimental feed and faecal samples were analyzed for crude protein (CP), crude fibre (CF), ether extract (EE), ash contents using A.O.A.C (1990) official method of analyses.

Proximate composition of diets and faeces were determined according to AOAC (1990) procedure. The nitrogen free extract (NFE) contents of the samples were obtained by using the equation: NFE = 100 – (CF + CP + EE + Ash)

Apparent digestibility of the nutrients was

calculated using the formula:

Apparent Digestibility (%) =

$$\frac{\text{(Nutrient in feed – Nutrient in faeces)}}{\text{Nutrient in feed}} \times 100$$

Feeding costs was estimated by recording the cost of basal and concentrate diets, maize seed, hydroponics nutrient, labour etc per kg of diet and fodder grown.

Blood samples for haematological analysis was collected into EDTA-sample bottles and analysed for packed cell volume (PCV), haemoglobin, red blood cell (RBC), white blood cell (WBC), lymphocytes, monocytes, eosinophils and neutrophils according to methods described by Sastri (1985) while blood samples for serum biochemical analysis was collected into plain sample bottles and allowed to clot at room temperature. The clotted samples were spun in a centrifuge to separate the blood cells from the serum and this was analysed for serum total protein, serum glucose, serum total cholesterol, urea, albumin, creatinine, Aspartate Amino Transferase (AST) and Alanine Amino Transferase (ALT). Serum total protein was determined using the SP400UV/VIS spectrophotometer (Lowry *et al.,* 1951), serum glucose and serum total cholesterol concentrations were determined using colorimetric procedure (Lindner and Mann, 1960). Albumin was analysed using bromocresol green method (Doumas*et al.,* 1971) while aspartate amino transferase (AST) and alanine amino transferase (ALT) activities were determined using the method of Reitman and Frankel (1957).

Experimental design and statistical analysis

The experimental design was a completely randomized design. Data were subjected to Analysis of Variance of SAS (2010) at $\alpha_{0.05}$ and means were separated using Duncan Multiple Range Test of the same software package.

Results and discussion

Proximate composition of hydroponics maize fodder

Proximate composition of hydroponics maize fodder used in this experiment is shown in Table 3. The average DM content of hydroponic maize fodder (HMF) was 25.00%. Lower % DM of HMF is due to the large uptake of water which initiated an increase in metabolic activity of resting seeds and led to complete loss of dry weight (starch) during germinating cycles of hydroponic fodder (Naik *et al.,* 2014). Closely related result was observed by Thadchanamoorthy *et al.* (2012) with HMF of 26.07% DM. The crude protein content observed in HMF was 13.75% highly superior as compared to 8.7-10% in maize seed. Sprouting alters the amino acid profile of maize seeds and increases the crude protein content of hydroponic fodder (Morsy *et al.,* 2013). In this study, ether extract of HMF was 3.55% which was slightly higher than the result obtained by Naik *et al.* (2013) which ranged from 3.27-3.49% but was lower than the observed value (6.42%) by Thadchanamoorthy *et al.* (2012). Similar results (1.75-3.80%) were reported by Naik *et al.* (2013). NFE value (60.72%) was lower than what was observed by Singh (2011) which ranged from 66.7-75.3%. The crude fibre content (14.77%) was however comparable to the value (14.10%) obtained Naik *et al.* (2013). Cuddeford (1989) noted that the increase in the crude fibre of hydroponics maize fodder is due to the buildup of cellulose, varied proportions of hemicelluloses and lignin.

Table 3: Proximate composition of hydroponics maize fodder

Parameters	Percentage (%)
Dry Matter	25.00
Crude Protein	13.75
Ether Extract	3.55
Crude Fibre	14.77
Ash	3.33
Nitrogen Free Extract	60.72

Nutrient digestibility and performance of weaned pigs fed hydroponics maize fodder

Nutrient digestibility of pigs fed hydroponics maize fodder is shown in Table 4. Significant differences (P<0.05) were observed in the digestibility of nutrients in all the dietary treatments. T1 had higher (P<0.05) crude protein digestibility (65.76%) while the lowest (55.27%) was observed in T2, same trend was observed in crude fibre digestibility. Ether extract digestibility was highest (P<0.05) in T2 (68.43%) and lowest in T3 (65.47%) while ash digestibility was highest (P<0.05) for T3 (46.08%) and T2 had the lowest (42.41%) ash digestibility.

Table 5 shows the growth performance and cost analysis of diets fed to weaned pigs. Significant differences (P<0.05) were observed among the treatments in feed intake, final body weight, weight gain and FCR of the pigs. Significantly higher values (P<0.05) for final weight (13.83 kg), feed intake (12.79 kg) and weight gain (3.83 kg) were observed in T3 closely followed by T2. However, T1 had the highest FCR (3.68 kg), followed by T3 (3.38 kg). Least values were observed for T2 in all parameters. Difference was also observed in feed cost among the treatments with T1 having highest cost (61.96 ₦/kg) closely followed T2 (53.73 ₦/kg). Feed cost/weight gain for T1 (228.01 ₦/kg) was relatively higher than T3 (166.60 ₦/kg) while T2 recorded a negative ratio as loss of weight was observed in pigs fed 100% HMF diet.

Table 4: Nutrient digestibility of pigs fed hydroponics maize fodder

Parameter (%)	T1	T2	T3	SEM
CP	65.76^{a}	55.27^{c}	64.16^{b}	1.50
EE	67.23^{b}	68.43^{a}	65.47^{c}	0.57
CF	48.13^{a}	34.26^{b}	47.61^{a}	1.68
Ash	43.34^{b}	42.41^{c}	46.08^{a}	0.41

^{abc}Means on the same row with different superscripts are significantly (P<0.05) different.
CP= Crude protein EE= Ether extract CF=Crude fibre
Treatment 1: Pigs fed 50% hydroponically grown maize fodder + 50% concentrate
Treatment 2: Pigs fed 100% hydroponically grown maize fodder
Treatment 3: Pigs fed 100% basal diet

Table 5: Growth performance and cost analysis of diets fed to weaned pigs

Parameter	T1	T2	T3	SEM
Av. Initial BW (kg)	10.00	9.97	10.00	0.00
Av. Final BW (kg)	13.45^{a}	9.04^{b}	13.83^{a}	0.51
Feed intake (DM/Kg)	12.72^{a}	7.99^{c}	12.79^{a}	0.53
Weight Gain	3.46^{a}	-0.93^{b}	3.83^{a}	0.51
FCR	3.68^{a}	-8.69^{b}	3.38^{a}	1.36
Feed cost (₦/kg)	61.96	53.73	49.29	
Feed cost/weight gain(₦/kg)	228.01	-466.91	166.60	

^{abc}Means on the same row with different superscripts are significantly (P<0.05) different.
BW: Body Weight DM: Dry Matter FCR: Feed Conversion Ratio SEM: Standard Error of Mean
Treatment 1: Pigs fed 50% hydroponically grown maize fodder + 50% concentrate
Treatment 2: Pigs fed 100% hydroponically grown maize fodder
Treatment 3: Pigs fed 100% basal diet

If pigs are to fully express their potential for weight gain, feed intake must meet their nutritional requirement. Though, the experimental pigs were selected at random, they had almost the same live weight at the beginning of the experiment. At the end of the experiment, pigs in T1 and T3 had similar weight gains while feeding of hydroponics maize fodder reduced the total dry matter intake of the pigs. This is in support of the findings of Naik *et al.* (2014) who reported a decrease in the dry matter intake of the animals due to dry matter loss in hydroponic sprouts which resulted in low performance of the animals. During sprouting, starch is catabolised to soluble sugars for supporting the metabolism and energy requirement of the growing plants for respiration and cell wall synthesis, therefore, any decrease in the amount of starch causes a corresponding decrease in dry matter and organic matter (Naik *et al.*, 2014**).** Early researchers found lower weight gain when pigs were fed 10-day sprouted maize relative to ground maize, but when beef cattle were fed with hydroponics green fodder, an average of 200g higher daily gain was obtained in comparison to those fed with a maize-control diet (Leitch, 1939). Peer and Lesson (1985) found lower growth rate in pigs when fed sprouted barley compared to ground barley. Fazaeli *et al.* (2011) found no significant difference in live weight gain or feed conversion efficiency between a fodder diet and a control diet, consisting of barley grain. Farlin *et al.* (1971) also found no difference in performance of cattle fed sprouted or non-sprouted grain.

The cost of producing hydroponic maize fodder diets was higher than the cost of producing the basal diet. This therefore translated into the high feed cost/weight gain in animals fed the diets compared to those fed the basal diet. This was also observed by Reddy *et al.* (1988) for rations containing hydroponically sprouted grains. The non-significant difference observed for FCR in pigs fed basal diet and combination of HMF and concentrate diet showed that although at a slightly higher price, hydroponic maize fodder in combination with concentrate can be substituted for basal diet during scarcity of the basal ingredients without loss of weight of pigs which could result to economic loss to the farmer. The cost of producing hydroponic fodders is mainly influenced by the seed cost and the cost of hydroponic solution as they contribute about 90% of the total cost of production (Naik *et al.*, 2012b).

Haematology and serum biochemistry of weaned pigs fed hydroponic maize fodder

Haematology and serum biochemisty of weaned pigs fed diets containing HMF is presented in Table 6 and 7, respectively. Significant differences ($P<0.05$) were observed among the treatments for PCV, RBC, WBC, platelets, lymphocytes, heterophils, eosinophils and basophils except for haemoglobin and monocytes ($P>0.05$). Similar values were obtained for PCV and lymphocytes in T1 and T2 while higher values were obtained for RBC in T1 and heterophils in T2. Lowest values were obtained in T2 for PCV, RBC and lymphocytes. Significant differences ($P<0.05$) were also observed among the treatments for cholesterol, triglycerides, LDL, VLDL, total protein, globulin and albumin for the serum biochemical indices, while glucose and HDL showed no ($P>0.05$) difference.

Haematological parameters are good indicators of the physiological changes in animals (Adenkola and Durotoye, 2004). The blood consisting of blood cells and plasma fulfil the transport, regulatory, protective and homeostatic functions (Nasyrova *et al.*, 2006). From the results of

haematological parameters in this study, haemoglobin and monocytes of the pigs fed the different dietary treatments were within the normal range of 8-13g/dl and 2-10% respectively, as documented by Research Animal Resources (2009).

Table 6: Haematology of weaned pigs fed hydroponic maize fodder

Parameters	T1	T2	T3	SEM
PCV (%)	37.33[a]	34.67[b]	38.67[a]	0.39
Haemoglobin (g/dl)	7.57	7.10	7.80	0.62
RBC ($\times 10^6 \mu l$)	5.73[a]	5.08[c]	5.34[b]	0.06
WBC ($\times 10^4 \mu l$)	1.80[a]	1.75[a]	1.09[b]	0.07
Platelets ($\times 10^4 \mu l$)	19.90[b]	21.73[a]	11.60[c]	1.03
Lymphocytes (%)	69.00[a]	56.33[b]	66.33[ab]	1.30
Heterophils (%)	23.67[b]	40.67[a]	31.33[ab]	1.64
Monocytes (%)	3.33	3.33	4.33	0.11
Eosinophils (%)	3.67[a]	3.67[a]	1.33[b]	0.26
Basophils (%)	0.33[b]	0.33[b]	1.67[a]	0.15

[ab]Means with different superscript on the same row are significantly different (p<0.05)
Treatment 1: Pigs fed 50% hydroponically grown maize fodder + 50% concentrate
Treatment 2: Pigs fed 100% hydroponically grown maize fodder
Treatment 3: Pigs fed 100% basal diet
PCV- Packed cell volume RBC- Red blood cell WBC- White blood cell

Apart from the toxic constituent in a diet, a key factor that has been documented to affect WBC counts and its differential component is the level of protein in the diet (Unigwe *et al.,* 2016). High level of protein was recorded in T3 resulting in low level of white blood cell count in the treatment. High levels of WBCs in blood indicate increased antibody level with increased lymphocytes count (Frandson, 1986). Significant differences were observed in RBC counts, lymphocytes, heterophils, eosinophils and basophils of the pigs but all observed values fell within the normal physiological range reported by Research Animal Resources (2009).

Significant differences were observed in the values for serum cholesterol concentration, total protein, globulin and albumin of the pigs. There was a significant reduction in the serum triglycerides and VLDL concentrations with decreasing level of HMF in the diets.

Table 7: Serum biochemistry of weaned pigs fed hydroponic maize fodder

Parameters	T1	T2	T3	SEM
Glucose (mg/dl)	67.48	66.43	68.01	0.16
Cholesterol (mg/l)	93.64[ab]	95.38[a]	88.93[b]	0.64
Triglycerides (mg/dl)	148.50[a]	144.75[a]	136.10[b]	1.22
HDL (mg/dl)	50.37	47.02	57.41	1.02
LDL (mg/dl)	5.75[b]	5.82[b]	7.26[a]	0.16
VLDL (mg/dl)	29.70[a]	28.95[a]	27.22[b]	0.11
Total Protein (g/dl)	5.75[b]	4.96[c]	6.82[a]	0.18
Globulin (g/dl)	3.09[b]	2.54[c]	3.71[a]	0.11
Albumin (g/dl)	2.53[b]	2.42[b]	3.12[a]	0.07

[ab]Means with different superscript on the same row are significantly different (p<0.05)
Treatment 1: Pigs fed 50% hydroponically grown maize fodder + 50% concentrate
Treatment 2: Pigs fed 100% hydroponically grown maize fodder
Treatment 3: Pigs fed 100% basal diet
HDL- High density lipoprotein LDL- Low density lipoprotein VLDL- Very low density lipoprotein

On the other hand, there was a significant increase in the serum LDL concentration with decreasing level of HMF in the diet though values obtained were within the normal physiological range documented in Research Animal Resources (2009). Feeding hydroponic sprouts to livestock have been reported to have no effect on their blood profile. Miscera *et al.* (2009) conducted a trial in which lactating Comisana sheep were fed on hydroponically germinated oats. They found that the integration of hydroponic oats into the sheep diet did not modify the biochemical and haematological parameters. Marisco *et al.* (2009) completed a parallel study with goats and found no change in their biochemical and haematological profiles. The results of this study however contradicted the findings of these authors.

Conclusion

This study showed that combination of hydroponics maize fodder and concentrate feed had no negative effect on performance and blood profile of weaned pigs. It can therefore be concluded that hydroponics maize fodder inclusion in the diet of growing pigs is a welcome idea.

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