EFFECTS OF FEEDING HYDROPONICS MAIZE FODDER ON PERFORMANCE AND NUTRIENT DIGESTIBILITY OF WEANED PIGS

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Abstract. A study was conducted to investigate the effects of feeding hydroponics maize fodder on performance and nutrient digestibility of weaned pigs. A total of 36 pigs were allocated in a completely randomized design to 3 treatments. Treatment 1 contained 100% concentrate (Con_{100}); Treatment 2 contained 50% concentrate and 50% hydroponics maize fodder ($Con_{50}HM_{50}$) while Treatment 3 had 100% hydroponics maize fodder diet (HM_{100}). Each treatment had 12 weaned pigs with three replicates of four pigs per replicate. The experiment lasted for six weeks. Dietary treatments had significant effects ($P < 0.05$) on final weight, weight gain and feed conversion ratio of the pigs. Pigs fed Con_{100} had the highest ($P < 0.05$) final weight while the lowest weight was recorded in pigs on diet HM_{100}. Feed intake and weight gain were highest ($P < 0.05$) in pigs fed concentrate diet (Con_{100}) while the lowest intake was in animals fed HM_{100}. Feed conversion ratio (FCR) was improved ($P < 0.05$) in pigs fed Con_{100} and $Con_{50}HM_{50}$ respectively. Crude protein, crude fibre and ether extract digestibilities were improved ($P < 0.05$) in animals fed Con_{100}. Pigs fed dietary mixtures of concentrate and hydroponics maize fodder ($Con_{50}HM_{50}$) had better ($P < 0.05$) CP and CF digestibility as compared to those on HM_{100}. Inclusion of hydroponics maize fodder in pig nutrition improved performance and nutrient digestibility of weaned pigs.
Keywords: *sprouted, monogastric, technology, diet, concentrate*

Introduction

Pig production is one of the fastest growing livestock sector in developing countries like Nigeria (Imonikebe and Kperegbeyi, 2014). Compared to ruminants, pigs are prolific, have high feed conversion efficiency, early maturing, require small space and easy to manage (Ouma et al., 2014). According to Tewe and Egbunike (1998), pig production represents the cheapest means of correcting animal protein shortage among the impoverished people in Nigeria. However, their production is facing tremendous set back and on the verge of collapse due to unavailability of feed, which accounts for 70-80% of the total cost of production (Olomu and Oboh, 1995). The major factors responsible for the shortage of green fodder are scarcity of land due to small land holding size, water shortage and labour (Naik et al., 2015).

A possible way of solving this problem of feed scarcity in pig industry is through the use of hydroponic farming systems. Fodder produced by growing plants in water or nutrient rich solution but without using any soil is known as hydroponics fodder, sprouted grains or sprouted fodder (Dung et al., 2010a). Production of hydroponics fodder involves

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growing of plants without soil but in water or nutrient rich solution in a greenhouse (hi-tech or low cost devices) for a short duration - approx. 7 days - (Naik et al., 2015).

Hydroponics technology has been recognized 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., 2012) can be produced by hydroponics technology. Hydroponics fodder is more palatable, digestible and nutritious while imparting other health benefits to the animals (Suraj et al., 2016). Naik et al. (2015) reported yields of 5-6 folds of fresh hydroponics maize fodder in 7 days. Supplementation of sprouted fodder in the ration of pigs is a viable possible alternative technology to conventional green fodder (Naik et al., 2015). However, there is paucity of information on the use of hydroponically sprouted maize fodder in weaned pigs. Therefore, the objective of this study was to determine the effect of feeding hydroponics maize fodder on the growth performance and nutrient digestibility of weaned pigs.

Materials and methods

Study site and experimental design

This study was carried out at the Piggery Unit, 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 200-300 m above sea level. A total of 36 weaned pigs were purchased from a reputable farm in Ibadan, Oyo state, Nigeria. The pigs were fed *ad libitum* and cool clean water was provided. The pigs were allotted into three groups consisting of 12 animals per group, replicated three times with four pigs per replicate in a completely randomized design. The groups were allocated into 3 treatments as follows- Pigs fed 100% concentrate diet (Con_{100}), pigs fed 50% concentrate diet and 50% hydroponics maize fodder ($Con_{50}HM_{50}$) and pigs fed 100% hydroponics maize fodder (HM_{100}). The concentrate composition is presented in *Table 1*. The experiment lasted for six weeks. Pigs were housed in properly disinfected pens and all routine management practices were strictly observed.

Table 1. *Gross composition of concentrate fed to weaned pigs*

Ingredient	**Percentage (%)**
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 nutrient	
Crude protein (%)	19.03
Metabolizable energy (kcal/kg)	2905.20

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The hydroponic system

The production of hydroponic maize fodder, that is, sprouted maize grown in a nutrient solution was conducted under natural illumination in growth chamber as described below. The maize used was grown for 7 days.

Planting material

Maize grains were obtained from a local market. The seeds were cleaned from debris and other foreign materials and were subjected to a germination test to check for viability. Clean seeds were washed, sterilized in Hydrogen Peroxide (H_2O_2) solution and soaked in tap water for 24 h before distribution in the trays.

Seed planting and irrigation

Seeds of maize were sown in the planting trays. The seedling rate used was 500 g of maize grain per tray. Trays were irrigated manually with organic hydroponics nutrient solution twice a day (07:30 and 17:30 hr) at a fixed rate of 250 ml/tray/day using a spray gun for 20 s. Drained water were collected in plastic containers which were placed under each planting tray and measured. The seeds were scattered uniformly within the tray. The tray was kept in cool and well illuminated environment.

Green fodder harvesting

The sprouted seeds were grown in the greenhouse for a period of 7 days. The fully grown fodder (*Fig. 1*) was then given to the pigs as whole feed.

Figure 1. *Hydroponic maize fodder (Source: Adebiyi et al., 2018)*

Fodder yield

Samples of the green fodder were taken weekly to determine the dry matter and nutrient contents. The quantity of hydroponics fodder and biomass production was recorded daily by weighing the seeds before planting and weighing the fodder produced.

Growth performance

Growth parameters of the pigs were observed and recorded throughout the experiment. Feed intake was obtained by subtracting the leftover feed from the total quantity of feed served. Weight gain was determined by subtracting the initial live

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weight from the final live weight. Feed conversion ratio was defined as the quantity of feed (kg) consumed to gain a unit of live weight (kg):

$$\mathrm{FCR} = \frac{\text{Feed Intake}}{\text{Weight Gain}}$$

Nutrient digestibility

At day 37, three animals were randomly selected from each treatment. The selected pigs were kept in metabolic cages for 5 days. Feed intake and total faecal collection from individual animals were recorded. The experimental feed and faecal samples were dried. The feed and faecal samples were further analyzed for crude protein (CP), crude fibre (CF), ether extract (EE) and ash contents using the procedure of AOAC (2000). The nitrogen free extract (NFE) contents of the samples were obtained using the equation:

$$\mathrm{NFE} = 100 - (\mathrm{CF} + \mathrm{CP} + \mathrm{EE} + \mathrm{Ash})$$

Statistical analysis

Data on performance and nutrient digestibility were analysed using the General Linear Model (GLM) procedures of the statistical analysis of variance (SAS, 2010). Duncan Multiple Range Test was applied for mean separation where there were significant differences ($P < 0.05$).

Results and discussion

The results of the proximate composition of the hydroponics maize fodder are presented in *Table 2*. There are changes in the nutrient content of the maize grains and hydroponics fodder. The average dry matter (DM) content of the maize seed was 95.08% whereas the hydroponic maize fodder was 25.00%. The decrease observed in the DM may be due to the decrease in the starch content of the hydroponics fodder. During sprouting, starch is catabolized to soluble sugars for supporting the metabolism of energy requirement of the growing plants for respiration and cell wall synthesis, so any decrease in the amount of starch causes a corresponding decrease in DM (Naik et al., 2015). This result is similar to the findings of Thadchanamoorthy et al. (2012), who reported a DM content of 26.07% for sprouted maize fodder. The crude protein content in the present study showed that hydroponic maize fodder contained 13.75% CP as compared to 8.7% in maize seed. This observation has been reported by other authors (Dung et al., 2010a; Naik et al., 2015). According to Dung et al. (2010a), the use of nutrient solution enhances the CP content of the hydroponics fodder which is higher than the tap water, thus leading to the uptake of nitrogenous compounds. Additionally, sprouting has been reported to alter the amino acid profile of maize seeds and increases the crude protein content of hydroponic fodder (Morsy et al., 2013). In the present study, ether extract of the hydroponics maize fodder was 3.55%. The value reported in the current study was slightly higher than the range of 3.27-3.49% obtained by Singh (2011) and Naik et al. (2015). The increase in the EE content of the hydroponics fodder

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may be due to the increase in the structural lipids and production of chlorophyll associated with the plant growth (Naik et al., 2015).

The CF content of 14.77% was within the range of 7.35-21.20% reported by Naik et al. (2015). Increase in CF contents of hydroponics maize fodder may be attributed to the build-up of cellulose, hemicelluloses and lignin (Cuddeford, 1989). The value of total ash (3.33%) observed in the hydroponic maize fodder in the current study is within the range of 1.75-3.80% reported by Naik et al. (2014). During the sprouting process, the total ash content increases due to the absorption of minerals by the root (Dung et al., 2010b). The NFE content observed (60.72%) was higher than that of hydroponically sprouted grains reported by earlier workers - 1.56-3.64% (Naik et al., 2015).

Table 2. *Proximate composition of hydroponics maize fodder*

Parameter	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

The results of hydroponics maize fodder on the performance of pigs are shown in *Table 3*. Dietary treatments had significant effects ($P < 0.05$) on final weight, weight gain and feed conversion ratio of the pigs. The final weight ranges from 9.04-17.08 kg. Pigs fed Con_{100} had the highest ($P < 0.05$) final weight while the lowest weight was recorded in pigs fed HM_{100}. Feed intake and weight gain were highest ($P < 0.05$) in pigs fed concentrate diet (Con_{100}) while the lowest intake was in animals fed HM_{100}. Feed conversion ratio (FCR) was improved ($P < 0.05$) in pigs fed Con_{100} and $Con_{50}HM_{50}$ respectively. In the present trial, pigs fed dietary mixture of concentrate and hydroponics maize fodder ($Con_{50}HM_{50}$) performed better than those fed solely on sprouted fodder (HM_{100}). Helal (2015) reported higher dry matter intake, final body weight and improved FCR in goats fed dietary mixture of sprouted barley grains and barley straw. Similar results were reported by Fayed (2011) and Helal (2012). Hydroponic sprouts are rich sources of bioactive enzymes and contain grass juice ingredients that improve the performance of livestock (Naik et al., 2013). The increase in weight gain of pigs may be attributed to enhancement of microbial activity in the gut. According to Kruglyakov (1989), hydroponics fodder has simpler forms of vitamin, starch, protein and lipids which have positive effect on the performance of the animals. Nutritional value of sprouted fodder improves due to the modification of heterogeneous compounds into essential form (Chavan et al., 1989). Sprouting of grains has resulted into increase in quantity and quality of protein, sugars, minerals and vitamin (Naik et al., 2015). Weight loss was recorded in pigs fed solely on hydroponics fodder (HM_{100}). This observation may be due to the low DM intake of the pigs. Additionally, pigs being monogastric cannot thrive solely on fodder-based diet.

Feeding hydroponics maize fodder to pigs led to a decrease in the total daily feeding costs of experimental rations, $Con_{50}HM_{50}$ (#61.96) and HM_{100} (#53.97) as compared to Con_{100} (#70.00) which was mainly a concentrate diet (*Table 3*). Feed costs (#/kg)

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significantly reduce as the inclusion of the maize fodder increases. This result is similar to the findings of Fayed (2011) and Helal (2012) who found the lowest feed cost and highest profit in lambs fed dietary mixture of sprouted barley grains and *Tamarix mannifera*. In terms of economic efficiency, it is more profitable (feed cost per weight gain) to feed pigs on $Con_{50}HM_{50}$ (#228.01) as compared to Con_{100} (#316.4) and HM_{100} (#-446.91).

Table 3. *Performance and cost benefit of feeding hydroponics maize fodder to pigs*

Parameters	Con_{100}	$Con_{50}HM_{50}$	HM_{100}	SEM	P-value
Initial BW (Kg)	9.90	10.00	9.97	0.009	0.6094
Final BW (Kg)	17.08^{a}	13.35^{b}	9.04^{c}	0.775	0.0026
Feed intake (DM Kg)	30.89^{a}	12.72^{b}	8.00^{c}	1.334	0.0001
Weight gain	7.18^{a}	3.46^{b}	-0.93^{c}	0.783	0.0021
FCR	4.52^{a}	3.68^{a}	-8.69^{b}	1.425	<0.0001
*Feed cost/kg (#)	70.00	61.96	53.73		
Feed cost/weight gain (#/kg)	316.4^{a}	228.01^{b}	-466.91^{c}		

SEM: Standard error of the mean
^{a,b,c}Means within the same row with different letters are significantly different ($P < 0.05$)
BW: body weight, DM: dry matter, FCR: feed conversion ratio
*Calculated by multiplying the cost/kg of each ingredient used to formulate the diet by the quantity of the ingredient

Nutrient digestibility of pigs fed hydroponic maize fodder is presented in *Table 4*. Crude protein, crude fibre and ether extract digestibilities were improved ($P < 0.05$) in animals fed Con_{100}. However, animals fed dietary mixtures of concentrate and hydroponics maize fodder had better ($P < 0.05$) CP and CF digestibility as compared to those on HM_{100}. Helal (2015) recorded highest digestibility coefficients of CP, CF, EE, NDF and hemicellulose in goats fed sprouted barley. Similar results were reported by Fayed (2011) and Naik et al. (2015). Feeding of hydroponics fodder increased the digestibility of the nutrients which could be attributed to the tenderness of the fodder (Naik et al., 2014). The digestibility of the nutrients of the hydroponics fodder was comparable with the highly digestible legumes like berseem and clovers (Pandey and Pathak, 1991). According to Chung et al. (1989), highly soluble protein and amino acids in response to the early plant growth and enzymatic transformations of sprouted grains are responsible for improved digestibility in animals. The low CF digestibility reported in HM_{100} may be attributed to the minimal crude fibre utilization in monogastrics.

Table 4. *Nutrient digestibility of pigs fed hydroponics maize fodder*

Parameter	Con_{100}	$Con_{50}HM_{50}$	HM_{100}	SEM	P-value
CP	70.51^{a}	66.27^{b}	55.41^{c}	1.50	<0.0001
EE	72.98^{a}	67.37^{c}	68.43^{b}	0.57	<0.0001
CF	50.91^{a}	48.77^{b}	34.82^{c}	1.68	<0.0001
Ash	39.45^{b}	43.52^{a}	42.63^{a}	0.41	0.0001

SEM: standard error of the mean
^{a,b,c}Means within the same row with different letters are significantly different ($P < 0.05$)
CP: crude protein, EE: ether extract, CF: crude fibre

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Conclusion

Inclusion of hydroponic maize fodder in pig nutrition improved performance and nutrient digestibility of weaned pigs. Thus, there is great potential for developing hydroponic technology for fodder production in pig farming. Sole feeding of hydroponic maize fodder exerted negative effects on the performance of the animals. Further research is needed to establish the potential health benefits of hydroponic fodder in monogastrics.

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