Average daily gain and the impact of starting body weight of individual nursery and finisher Ugandan pigs fed a commercial diet, a forage-based diet, or a silage-based diet

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Summary

Objectives: To compare average daily gain (ADG) of Ugandan nursery and finisher pigs fed a commercial diet, a forage-based diet, or a silage-based diet, and to compare the cost effectiveness of the diets.

Materials and methods: Each pig was randomly assigned to the commercial diet, the forage-based diet, or the silage-based diet. Pigs were weighed every 3 weeks from 65 to 230 days of age. Growth was compared within and across diet on the basis of starting body weight (BW). The cost of feed per kg of BW gain was determined.

Results: As age and BW increased, mean BW variability increased in pigs fed the forage-based or silage-based diets and decreased in pigs fed the commercial diet. Starting BW was positively associated with ADG (P < .01). Average daily gain of nursery pigs fed the commercial diet was higher than that of pigs fed the forage-based and silage-based diets. At sufficient BW (≥ 11.9 kg), pigs fed the silage-based diet achieved ADG similar to that in pigs fed the commercial diet.

Implications: At sufficient BW (11 to 12 kg), pigs grow well on forage- or silage-based diets. If some ingredients are in surplus on farms, the forage- and silage-based diets are more cost effective than the commercial diet when pigs reach 8.5 kg BW. Interventions to improve weaning weights and provision of creep feed, and identification of nutrient-dense, digestible, palatable feedstuffs for development of low-cost balanced diets are needed in order to improve pig growth performance in East Africa.

Keywords: swine, average daily gain, forage, silage, East Africa

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Resumen - Ganancia diaria promedio y el impacto del peso corporal inicial de cerdos individuales en destete y engorda de Uganda alimentados con una dieta comercial, una dieta a base de forraje, o una dieta a base de ensilado

Objetivos: Comparar la ganancia diaria promedio (ADG por sus siglas en inglés) de cerdos Ugandeses de destete y crecimiento alimentados con una dieta comercial, una dieta a base de forraje, o una dieta a base de ensilado

Materiales y métodos: Cada cerdo fue asignado al azar a la dieta comercial, la dieta a base de forraje, la dieta a base de ensilado. Los cerdos se pesaron cada 3 semanas desde los 65 a los 230 días de edad. El crecimiento se comparó dentro y entre la dieta en base al peso corporal (BW) por sus siglas en inglés) inicial. Se determinó el costo de alimento por kg de peso ganado.

Resultados: Conforme la edad y el peso, incrementó la variabilidad del peso promedio en cerdos alimentados con las dietas a base de forraje y ensilado y disminuyó en los cerdos alimentados con la dieta comercial. El peso inicial fue asociado positivamente con la ADG (P < .01). La ganancia diaria promedio de los cerdos en destete alimentados con dieta comercial fue más alta que la de los cerdos alimentados con las dietas a base de forraje y a base de ensilado. En un peso aportal (≥ 11.9 kg), los cerdos alimentados con la dieta a base de ensilado lograron una ADG similar a la de los cerdos alimentados con la dieta comercial.

Implicaciones: En un peso aportal (11 a 12 kg) los cerdos crecen bien en dietas en base a forraje o ensilado. Si existen algunos ingredientes extra en las granjas, las dietas basadas en forraje y ensilado son más costo efectivas que la dieta comercial cuando los cerdos alcanzan 8.5 kg de peso. Las intervenciones para mejorar los pesos al destete y el suministro de alimento a los lechones en maternidad, y la identificación de piensos densos en nutrientes, digestibles, apetecibles para el desarrollo de dietas balanceadas de bajo costo son necesarios para mejorar el desempeño del crecimiento del cerdo en África del Este.

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The objectives of this study were to compare average daily gain (ADG) of nursery and grower Ugandan pigs each fed one of three diets (commercial, forage-based, or silage-based) and to compare the cost effectiveness of the diets.

Materials and methods

The study was reviewed and approved by the institutional animal care and use committees of the International Livestock Research Institute (ILRI), Nairobi, Kenya, and the University of Guelph, Guelph, Canada. The research site was a commercial pig operation in Masaka District, Central Region, Uganda.

Diet formulation

The nutritional requirements of 8-kg to 65-kg pigs in Uganda were estimated using the methods reported previously. Briefly, the dynamic nutrient requirement model for growing-finish- ing pigs was converted into a static model to represent the use of daily intake of digestible energy (DE kcal per kg of dry matter [DM]) for body protein deposition (kg per day), body lipid deposition (kg per day), and maintenance for pigs weighing between 8 and 65 kg. The energy density in corn and soybean meal diets was used to establish nutrient requirements.

To determine the least-cost diet per unit of energy and other nutrients, diet costs were calculated at each 1% decrease in nutrient density, keeping ratios among the nutrient constraints and energy content constant. Diets were formulated at 80% of the reference nutrient density, since nutrients were optimal to improve pig performance, but still affordable to smallholder farmers. To limit fibrous feedstuffs, diet neutral detergent fibre (NDF) content was limited to 350 g per kg of DM, which is higher than that in conventional diets. However, local and cross-breed pigs may tolerate NDF at higher dietary levels than American or European breeds.

Salt and mineral-based diets were formulated (Table 1) using methods previously described.

Sample size

Sample size was calculated using a two-sample t test with 80% power to detect a significant difference in ADG of 0.20 kg at the 5% confidence level. Between-pig standard deviation (SD) of gain per day was estimated to be 0.25 kg. Twenty-five pigs per diet were required; therefore 30 pigs were randomly allocated to each diet group using a random number generator.

Pre-study pig management

One hundred and ten pigs from 14 local smallholder farms, born within 3 days of each other, were enrolled in the study. At 10 days of age, pigs were individually ear-tagged and received 2 mL of a single product containing iron and vitamin B12 by intramuscular injection (Bremer Pharma GMBh, Werkstr 42, 34414 Warburg, Germany). Males were castrated and birth dates were recorded. At 56 days of age, all pigs arrived at the research farm and received 300 mg per kg BW of ivermectin subcutaneously (V.M.D., Hoge Mauw 900, 2370 Arendonk, Belgium). At 56 days of age, all pigs arrived at the research farm and received 300 mg per kg BW of ivermectin orally (Ashish Life Science PVT Ltd 213, Mumbai-53, India) and ivermectin as above.

Pen management

Pens were labelled with a number and diet type, scraped daily, and washed weekly. Uneaten feed was weighed and discarded daily. One handful of chopped straw was put in each pen daily for environmental enrichment.

Diets

Pigs were each fed one of three diets ad libitum three times daily. The three diets included a...

Smallholder pig farmers in East Africa report that the high cost, poor quality, and lack of feed are key constraints to pig rearing. Commercially prepared pig diets are beyond their financial means. Pigs are fed carbohydrate-rich diets with little to no protein, which contributes to slow growth and poor farmer profit. Well-balanced, cost-effective diets are needed to improve pig performance in East Africa. Fresh and ensiled locally available feedstuffs can be used to meet the nutrient requirements of pigs. The vine:tuber:salt ratio reflected reported optimal nutrient and pH results for silage in East Africa. Each layer was compacted by hand-rolling with a heavy log, then was tightly wrapped with polythene for > 30 days before use. The appropriate amount of each ingredient (post wilting) was weighed and mixed, a 0.30-kg sample was collected for nutrient analysis, and then the diet was stored in uncovered 60-L plastic containers.
Table 1: Compositions of diets (as-fed basis) used in a growth study of nursery and finisher pigs in Uganda

<table>
<thead>
<tr>
<th>Age (days)</th>
<th>Forage-based diet*</th>
<th>Silage-based diet*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingredient (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avocado (<em>Persea americana</em>); ripe, with peel, seed removed</td>
<td>18.02</td>
<td>19.6</td>
</tr>
<tr>
<td>Banana leaf (<em>Musa sapientium</em>); centre vein removed</td>
<td>1.1</td>
<td>1.3</td>
</tr>
<tr>
<td>Cassava leaf, blade, and axil (<em>Manihot esculenta</em>); wilted</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Cottonseed meal</td>
<td>0.0</td>
<td>1.4</td>
</tr>
<tr>
<td>Jackfruit (<em>Artocarpus heterophyllus</em>); ripe, with peel and seeds</td>
<td>39.9</td>
<td>16.8</td>
</tr>
<tr>
<td>Maize bran</td>
<td>0.0</td>
<td>4.1</td>
</tr>
<tr>
<td>Papaya leaf (<em>Carica papaya</em>); wilted</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Ground sun-dried fish (<em>Rastrineobola argentea</em>)</td>
<td>7.5†</td>
<td>2.2‡</td>
</tr>
<tr>
<td>Sweet potato vine (<em>Ipomoea batatas</em>); wilted</td>
<td>33.3</td>
<td>54.2</td>
</tr>
<tr>
<td>Sweet potato vine and tuber silage (<em>Ipomoea batatas</em>)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Limestone</td>
<td>0.19</td>
<td>0.10</td>
</tr>
<tr>
<td>Common table salt</td>
<td>0.12</td>
<td>0.10</td>
</tr>
<tr>
<td>Vitamin and mineral premix§</td>
<td>0.05</td>
<td>0.04</td>
</tr>
</tbody>
</table>

* Non-compliance in diet formulation occurred when pigs were 168 to 198 days of age. Data not presented.
† Pre-ground livestock-grade.
‡ Whole human-consumption grade ground at research site.
§ The premix provided the following per kg of complete feed (dry matter): vitamin A 15,000,000 IU; vitamin D₃ 2,000,000 IU; vitamin E 20,000 IU; vitamin K₂ 6000 mg; vitamin B₁ 1000 mg; vitamin B₂ 5000 mg; nicotinic acid 20,000 mg; pantothenic acid 16,000 mg; choline chloride 200,000 mg; biotin 110 mg; folic acid 1500 mg; manganese 40,000 mg; iron 150,000 mg; zinc 110,000 mg; copper 40,000 mg; cobalt 280 mg; iodine 1500 mg; selenium 120 mg.

Table 2: Analyzed nutrient compositions of study diets (% of DM) used in the growth study of nursery and finisher pigs in Uganda

<table>
<thead>
<tr>
<th>Diet</th>
<th>Forage-based</th>
<th>Silage-based</th>
<th>Commercial</th>
</tr>
</thead>
<tbody>
<tr>
<td>DE (kcal/kg of DM)†</td>
<td>1531</td>
<td>2333</td>
<td>2385</td>
</tr>
<tr>
<td>Ash</td>
<td>21.2</td>
<td>11.9</td>
<td>11.9</td>
</tr>
<tr>
<td>Crude protein</td>
<td>17.9</td>
<td>18.8</td>
<td>18.4</td>
</tr>
<tr>
<td>Neutral detergent fibre</td>
<td>35.6</td>
<td>41.5</td>
<td>39.9</td>
</tr>
<tr>
<td>Ether extract</td>
<td>5.9</td>
<td>9.8</td>
<td>9.9</td>
</tr>
<tr>
<td>Total calcium</td>
<td>1.84</td>
<td>0.88</td>
<td>0.83</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>0.58</td>
<td>1.09</td>
<td>1.07</td>
</tr>
<tr>
<td>Total Ca:total P</td>
<td>3.17</td>
<td>0.81</td>
<td>0.78</td>
</tr>
</tbody>
</table>

* Non-compliance in diet formulation occurred when pigs were 168 to 198 days of age. Data not presented.
† Digestible energy (DE), estimated from analyzed nutrient composition of the diets according to NRC (2012). Ca = calcium; P = phosphorus; DM = dry matter.
commercially prepared diet labeled “Sow and weaner ration” (Ugachick Poultry Breeders, Kampala, Uganda); a forage-based diet; and a silage-based diet. It is important to note that the “Sow and weaner ration” is the only commercially-prepared ration available in Uganda, ie, grower and finisher rations are not available. Diet ingredient composition and analyzed nutrient composition are presented in Tables 1 and 2, respectively.

Diet sampling
A 0.30-kg subsample of each diet type from a composite of the samples collected daily over a 4-week period was used for feed analysis. Each sample was weighed upon arrival, dried to constant weight at 60°C in a Leader oven model GP180CIA02501110 (Leader Engineering Heat Control, St Helens, Merseyside, United Kingdom), weighed again, then ground to pass through a 1-mm screen (Model CE96, United Kingdom). Samples were analyzed for DM,18 crude protein,19 ash and NDF,20 phosphorus,21 and calcium22 at ILRI Laboratories, Addis Ababa, Ethiopia, and were analyzed for ether extract19 at ILRI Laboratories, Hyderabad, India.

Nursery study (65- to 140-day-old pigs)
Ninety 56-day-old pigs were each randomly assigned to one of three diets (commercial, forage-based, or silage-based) and to pens that were each blocked by one of two rooms, resulting in 10 pens per diet. All pigs were fed the commercial diet for a 7-day acclimation period, then introduced to their study diets over a 3-day period. At 65 days of age, the study began, when the pigs were fed only their study diets until they reached 140 days of age.

Finisher study (146- to 167-day-old pigs and 199- to 230-day-old pigs)
The 140-day-old pigs remained in the same diet as during the nursery study. All feeding and sampling methods were performed to determine if mean BW differed between diet treatments at the start of each weigh period (Table 3). The mean BW (kg), SD, and coefficient of variation (CV) within diet treatment were determined for nursery pigs at each weigh date (Table 4). All statistical analyses were performed using Stata 13.1 (StataCorp, College Station, Texas). Values of P < .05 were considered statistically significant.

Comparative cost analysis
Using the price per kg of the commercial diet and of each ingredient from 199 to 230 days, ie, the most recent market price available prior to publication (Table 5), the cost of 1 kg of each diet was determined in two ways: first, assuming all ingredients were purchased, and second, assuming that the ingredients farmers could produce rather than purchase were free (ie, avocado, banana leaf, jackfruit, papaya leaf, sweet potato tubers and vines for use fresh or ensiled). Free ingredients were included in the diets, since others have shown that, in order to earn profits, East African pig farmers must feed diets containing some free ingredients.8 Those costs of 1 kg of each diet were then used to calculate the cost of feed per kg of BW gain (Table 5).

Results
Diets
Ingredient compositions of the forage-based and silage-based diets are presented in Table 1. Ingredient composition of the commercial diet was unknown protected proprietary information. Diet nutrient compositions (analyzed) of all diets are presented in Table 2. Throughout the study, analyzed nutrient content was numerically different from estimated pig requirements and estimated values for diets. Due to high analyzed ash and NDF content, final DE in diets, determined by nutrient analysis, was numerically lower than the expected calculated DE that was based on the assumed nutrient contents of individual ingredients, especially from 65 to 86 days of age. When pre-ground sun-dried fish and unripe avocado were replaced with higher quality whole dried fish and ripe and overripe avocado, respectively, lower ash content and higher ether extract resulted in numerically higher calculated DE content, determined by analyzed diet nutrient contents. None of the diets provided the estimated DE requirement. The DE content of the commercial diet was numerically higher than the DE content of the forage- and silage-based diets from 65 to 167 days of age. From 199 to 230 days of age, the DE content of...
Table 3: Mean starting body weight (BW; kg), mean average daily gain (ADG; kg/day), and standard deviation (SD) of nursery pigs (65-140 days old) and finisher pigs (146-230 days old)*

<table>
<thead>
<tr>
<th>Pig age (days)</th>
<th>Commercial diet</th>
<th>Forage-based diet</th>
<th>Silage-based diet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Starting BW (kg)</td>
<td>ADG (kg/day)</td>
<td>SD (kg)</td>
</tr>
<tr>
<td>65-86</td>
<td>6.8a</td>
<td>0.201</td>
<td>0.0816</td>
</tr>
<tr>
<td>87-107</td>
<td>11.1a</td>
<td>0.405</td>
<td>0.0969</td>
</tr>
<tr>
<td>108-127</td>
<td>19.6a</td>
<td>0.460</td>
<td>0.1392</td>
</tr>
<tr>
<td>128-140</td>
<td>29.2a</td>
<td>0.264</td>
<td>0.2017</td>
</tr>
<tr>
<td>146-167</td>
<td>24.1a</td>
<td>0.552</td>
<td>0.1710</td>
</tr>
<tr>
<td>199-209</td>
<td>52.6a</td>
<td>0.744</td>
<td>0.1973</td>
</tr>
<tr>
<td>210-230</td>
<td>60.0a</td>
<td>0.604</td>
<td>0.1385</td>
</tr>
</tbody>
</table>

* Non-compliance in diet formulation occurred when pigs were 168 to 198 days of age. Data not presented.

Table 4: Coefficient of variation (CV), within diet treatment, of bodyweight (BW; kg) of nursery pigs at 65, 86, 107, 127, and 140 days of age

<table>
<thead>
<tr>
<th>Pig age (days)</th>
<th>Commercial diet</th>
<th>Forage-based diet</th>
<th>Silage-based diet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean BW (kg) (SD)</td>
<td>CV</td>
<td>Mean BW (kg) (SD)</td>
</tr>
<tr>
<td>65</td>
<td>6.8 (2.12)</td>
<td>0.31</td>
<td>7.0 (2.21)</td>
</tr>
<tr>
<td>86</td>
<td>11.1 (3.43)</td>
<td>0.31</td>
<td>7.5 (2.58)</td>
</tr>
<tr>
<td>107</td>
<td>19.6 (4.79)</td>
<td>0.25</td>
<td>8.4 (3.08)</td>
</tr>
<tr>
<td>127</td>
<td>29.2 (6.55)</td>
<td>0.22</td>
<td>10.9 (3.85)</td>
</tr>
<tr>
<td>140</td>
<td>32.6 (7.48)</td>
<td>0.23</td>
<td>13.0 (5.00)</td>
</tr>
</tbody>
</table>

SD = standard deviation.

Table 5: Cost of feed* per kg of weight gain (US$) for commercial, forage-, and silage-based diets according to age

<table>
<thead>
<tr>
<th>Age (days)</th>
<th>Commercial diet</th>
<th>FB buy all</th>
<th>FB some free</th>
<th>SB buy all</th>
<th>SB some free</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>0.97</td>
<td>5.17</td>
<td>2.48</td>
<td>4.55</td>
<td>2.11</td>
</tr>
<tr>
<td>107</td>
<td>1.29</td>
<td>2.29</td>
<td>1.10</td>
<td>1.98</td>
<td>0.92</td>
</tr>
<tr>
<td>127</td>
<td>2.11</td>
<td>1.31</td>
<td>0.63</td>
<td>1.66</td>
<td>0.77</td>
</tr>
<tr>
<td>146</td>
<td>2.91</td>
<td>1.30</td>
<td>0.62</td>
<td>1.39</td>
<td>0.65</td>
</tr>
<tr>
<td>199</td>
<td>3.04</td>
<td>1.59</td>
<td>0.76</td>
<td>1.51</td>
<td>0.70</td>
</tr>
</tbody>
</table>

* At the following ingredient cost per kg as-fed basis (US$): avocado 0.11; banana leaf 0.12; cottonseed meal 0.42; jackfruit 0.11; maize bran 0.14; human grade whole sun-dried fish 2.04; sweet potato vine 0.12; papaya leaf 0.12; sweet potato vine and tubers for silage 0.12; limestone 0.03; salt 0.27; mineral and vitamin pre-mix 4.50.

FB = forage-based diet; SB = silage-based diet.
the commercial diet was numerically lower than that of the forage-based diet and higher than that of the silage-based diet.

**Mean BW in each 3-week growth period**
Mean BW did not differ between diet treatments at the start of the nursery study (65 days) ($P > .05$) or the start of the finisher study (146 days) ($P > .05$) (Table 3).

Mean BW of pigs differed between the commercial diet and the forage-based diet, and between the commercial diet and the silage-based diet, at the start of all other growth periods ($P < .05$) (Table 3). Mean BW differed between all diet treatments at 210 days ($P < .05$) (Table 3).

**Average daily gain of nursery pigs (65 to 140 days of age)**
On the basis of the regression analysis, when controlling for starting BW for the first three 3-week growth periods in the nursery phase (65 to 127 days of age), ADG of pigs fed the forage-based diet was lower by 0.176 (± 0.0172), 0.306 (± 0.0181) and 0.196 (± 0.0181) kg per day than ADG of pigs fed the commercial diet ($P < .001$), respectively, in each 3-week weighing period. Similarly, ADG of pigs fed the silage-based diet was 0.181 (± 0.0165), 0.269 (± 0.0181), and 0.163 (± 0.0399) kg per day lower than ADG of pigs fed the commercial diet ($P < .001$), respectively, in each 3-week weighing period. For every 1-kg increase in starting BW, ADG increased by 0.012 (± 0.003), 0.015 (± 0.002), 0.013 (± 0.003), and 0.009 (± 0.003) kg per day, for the four 3-week growth periods, respectively ($P < .001$).

**Average daily gain of finisher pigs (146 to 230 days of age)**
From 146 to 167 days of age, when controlling for starting BW, ADG of pigs fed the commercial diet was 0.424 (± 0.0350) and 0.221 (± 0.0372) kg per day higher, respectively, than ADG of pigs fed the forage-based and silage-based diets ($P < .05$). From 209 to 230 days of age, when controlling for starting BW, ADG of pigs fed the commercial diet was 0.186 (± 0.0420) kg per day higher than that of pigs fed the forage-based diet ($P < .001$). For every 1-kg increase in starting BW, ADG increased by 0.004 (± 0.0012), 0.008 (± 0.0012), and 0.004 (± 0.0009) kg per day for the three 3-week growth periods of finisher pigs, ($P = 0.01$, $P > .001$, and $P < .001$, respectively).

**Variability in mean BW of nursery pigs**
Variability (coefficient of variation; CV) in mean BW increased with age in pigs fed the forage-based and silage-based diets, but decreased with increasing age in pigs fed the commercial diet (Table 4). The CV of pigs fed the commercial diet was highest in 65- and 86-day-old pigs and lower in heavier, older pigs. The CVs of pigs fed the forage-based and silage-based diets were lowest in 65- and 86-day-old pigs and higher in older pigs.

**Comparative cost analysis**
The cost of feed per kg of weight gain (US$) for each of the three diets when all ingredients were purchased or some ingredients were free is presented in Table 5. The cost per kg of weight gain of pigs fed the commercial diet was less than the cost per kg of weight gain of pigs fed the forage-based and silage-based diets when pigs weighed < 10.9 and < 11.9 kg BW, respectively. However at BW ≥ 10.9 and ≥ 11.9 kg, the cost per kg of weight gain of pigs fed the commercial diet was more than the cost per kg of weight gain of pigs fed the forage-based and silage-based diets.

When some ingredients were free, the cost per kg of weight gain of pigs fed the commercial diet was less than the cost per kg of weight gain of pigs fed the forage- and silage-based diets when pigs weighed < 8.4 and < 8.7 kg BW, respectively (tables 4 and 5). At BW ≥ 8.4 and ≥ 8.7 kg, the cost per kg of weight gain of pigs fed the commercial diet was more than the cost per kg of weight gain of pigs fed the forage-based and silage-based diets, respectively, when some ingredients were free (tables 4 and 5).

**Discussion**
The results of this study show that East African farmers can improve pig growth performance by feeding forage- and silage-based diets. Empirical studies characterizing the ADG of pigs raised under smallholder management conditions (wherein pigs are tethered to graze on grass or roam free and scavange) in Uganda have not been done. Pigs at mean BW ≥ 10.9 and ≥ 8.7 kg, fed the forage- or silage-based diet in this study, respectively, or fed the commercial diet, had higher ADG than pigs raised by smallholder farmers in Kenya (0.130 kg per day) under management practices similar to those observed in Uganda.14,15,17

The weaning weights of local breeds of pigs reported elsewhere in the tropics (4.87 ± 0.28 kg at 56 days of age;13 5.6 to 7.4 kg at 93 to 117 days of age14) were similar to the starting BW of pigs enrolled in this study.

Factors contributing to low ADG include introduction of a novel diet that potentially caused transient gastrointestinal hypersensitivity,25 genotype, the composition and nutrient content of the diet, and the pigs’ limited feed intake and digestive capacity for fibrous feeds due to age and size.

The composition and nutrient content of the diets may have contributed to low ADG. Given that the energy density of the forage- and silage-based diets was 70% to 80% of the energy density in the NRC15 reference corn and soybean meal diets, and the high ash content, especially during the nursery phase, it is unlikely that pigs fed the forage- and silage-based diets consumed sufficient nutrients to reach their genetic growth potential. Although the energy density was reduced in an effort to increase the likelihood that Ugandan smallholder farmers could afford to adopt the forage- and silage-based diets, it is a limitation of this study. Future research is needed to investigate the growth of Ugandan pigs fed diets containing 100% of the nutrient density of NRC15 reference corn and soybean meal diets.

In commercial settings, nutrient-dense, highly-digestible diets comprising oils, plasma, milk and fishmeal products, and feed additives are formulated to enable young pigs to maximize nutrient intake and potential growth performance.15,25 However, these ingredients were not available to East African smallholder farmers and commercial creep feed was not available for purchase. The diets studied here contained more NDF and less estimated DE than the estimated amount required by pigs to achieve maximum growth.14 Others reported that feeding fibrous feeds is cost-effective for pigs > 50 kg BW because pigs’ ability to digest fibre increases with age.26 However, for young growing pigs, dietary fibre provides little or no energy, and the digestibility of energy and nutrients are reduced as dietary fibre content increases.27 As previous research28 suggests, pigs may have adapted to fibrous feed through ongoing exposure to the study diets, and their ability to digest dietary fibre may have improved with increased age and BW. This may have been reflected in the higher ADG of finisher pigs compared...
Implications

- Cost-effective balanced forage- and silage-based diets can be made for smallholder farmers in East Africa to enhance growth of finisher pigs.

- It is less expensive to feed small nursery pigs a commercial diet until they achieve sufficient BW (10.9 and 11.9 kg) before feeding forage-based and silage-based diets, respectively.

- If some ingredients are in surplus on East African farms, forage- and silage-based diets are more cost effective than a commercial diet when the pigs reach 8.5 kg BW.

- Nutrient-dense, digestible, palatable feedstuffs to improve growth of newly weaned pigs should be identified and their nutrient content characterized for development of low-cost balanced diets.

- Interventions related to improving weaning weights and provision of creep feed are needed in order to improve pig growth performance.

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Conflict of interest

None reported.

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References


29. Baltazar J, Balderama V, Calderon D, Reis de Souza TC, Petrigrew J, Mariscal G, Brana D, Czaron J. Formulating feed to the standardized total tract digestible phosphorous (STTDP) requirement prevents productive failure, as long as the calcium to phosphorous ratio is correct. *Proc IPVS*. Cancun, Mexico. 2014;278.


*Non-refereed reference.