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ORIGINAL RESEARCH

A description of local pig feeding systems in village smallholder farms of Western Kenya

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Abstract We used face-to-face interviews to gather data on pig feeding practices in rural Busia District, Kenya. We visited 164 pig farms three times in the course of the study period. The pigs were weighed in kilograms during the visits. Feeds offered to pigs were described during the interviews. The most frequently fed feedstuffs were; ground maize or "ugali" (88%), kitchen leftovers (83%) and dried fish locally called "omena" (78%). Farmers provided pigs with water separately from the feeds. Sweet potatoes, "ugali" and cassava were available and could serve as good sources of energy for pigs in the district. Fruits and vegetables were also available and could potentially act as good sources of vitamins. Sweet potato vines, "omena" fish and slaughter blood were available and could provide pigs with proteins. The average daily gain (ADG) for pigs ≤5 months of age, pigs of 5.1–9.9 months of age and pigs of ≥10 months old was 94.5 (±43), 127 (±49.8) and 99 (±92) g, respectively (p=0.000). This study has outlined the different local pig feeds available in Busia district. We recommend two things: first, additional research on nutrient composition for the identified local feeds, and second, developing and validating simple local feed combinations that would achieve balanced local pig rations.

Keywords Pigs · Feeding · Weight gains · Local feedstuffs · Smallholder farms

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Introduction

The pig population in Kenya stands at 334,689, 26% of which is found in Western Province (Census 2009). Pigs are sold to earn family income which is in turn used to meet basic needs such as buying food, medicine, school fees and clothing. The pig sector in Western Kenya is characterized by low input investments with farmers relying on family labour to manage the pigs (Kagira et al. 2010). Farmers keep local (non-descript) breeds, an average of two pigs per household. The pigs are mostly tethered or allowed to scavenge on their own for food (Githigia et al. 2005; Mutua et al. 2007). Considering that local pigs are adapted to harsh conditions and can survive on poor quality feeds (Nwakpu and Onu 2007), it is unlikely that such breeds will disappear given their good qualities and local farmer preferences. Thus, research should focus on their management as a means of enhancing productivity. Improved feed resources and pig feeding practices are key interventions that could empower pig farmers to increase farm returns. A pig's diet should contain adequate amounts of carbohydrates, proteins, minerals and vitamins (Goodman 1994; Aherne et al. 1999; de Lange and Mohn 1999; Adesehinwa 2008). Incomplete diets may limit nutrient balance and subsequently affect growth potential (Paul et al. 2007). Commercial feeds, though available in Busia, are expensive and unaffordable to most households.

An understanding of the existing local feeding systems, their distribution and utilization was essential before promoting their balanced use in this rural community. This paper is the first phase of this whole process by providing baseline data on the utilization of local feed resources in the rural villages of Busia. These feeds provide viable options through which pig farmers can be empowered to improve production and livelihoods.

Materials and methods

A complete list of pig-keeping households in two purposively selected sub-locations of Busia District was identified. Households were randomly selected to include 65–75% of farms in each village. All villages in the identified sub-locations participated in the study. Pigs kept in the district were of the local (non-descript) breed, that are usually black in colour, but may sometimes be white, or white with black patches. A total of 164 pig farms were selected, each farm was visited 3–4 months apart, for the period of June 2006 to February 2008. Pig feeding data were collected during interviews with the pig owners. The questionnaire included a recording of the quantity and frequency of 27 specified and of non-specified feedstuff that were being offered to pigs, as well as the frequency of watering pigs. We defined pig feed as any feedstuff provided to the pig by the farmer, and included both the local and commercial feed types. The food was weighed on a digital (Salter RTM) scale. Cost of the feeds per kilogram was determined at market centres in July 2009. Live weight of pigs (in kilograms) was obtained by actual weighing the pigs with a weighing scale.

Analyses were performed in Stata 9.0® (StataCorp LP, College Station, TX). Average daily weight gain (ADG) was calculated in grams per day. Weight gain was calculated from all pigs that were measured twice during the study period, i.e., those weighed during the first and second visits, or the first and third visits, or the second and third visits, simplified as (A) below. Pigs measured once were thus not included in the ADG calculations.

(A) ADG = (final weight − initial weight)/(days between initial and final visit)

Total amount given to pigs each day was calculated by multiplying the estimated amount given per meal with the daily feeding frequency stated by the farmer. Since farmers stated different feed units for the same feeds, we converted these to a common measurable unit for analyses, for example, a "gorogoro" is a tin can that is commonly used in the local market places to sell approximately 2 kg of maize. The same size of tin is traditionally used to sell many food products in the market place. We have converted a "gorogoro" for all the feedstuff investigated in the study to kilogram after weighing.

Farmers used local feed names to describe brewers waste ("machicha") and fish ("omena"). "Machicha" constitutes the fermented maize residue that is typically prepared through fermentation of maize in water. The sour composition is dried in the sun on iron sheets. Then millet and water are added, the liquid is squeezed out using a sac and used as brew while the residue is utilized as local pig feed. "Omena" (*Rastrineobola argentea)* is a small freshwater fish normally dried prior to sale. A "posho mill" is the grist mill mostly used to grind maize, cassava, millet and beans. The "posho mill waste" is the collection of dust that is on the floor of the mill after the food has been ground. "Ugali" is cooked ground maize floor. The blood and bone meals include fresh blood from the slaughter slabs. Rumen content is available after ruminants are slaughtered. It is composed of non-digested feed, rumen micro organisms and the products of rumen fermentation (Salinas-Chavira et al. 2007).

Sample means and standard deviations were calculated for the ADG data while percentiles were used to describe the amounts fed to pigs each day. Frequency tables were generated for all feeds provided — the individual feed frequency calculations were based on the total number of completed questionnaires resulting from the three farms visits. Calculations for the fruit types were based on the total number of feed observations since farmers had the option of providing more than one fruit type at each visit. The overall proportion of farms reporting each feed type was based on the number of farms that had fed a particular feed type at least once in the course of the study period. A chi-square test statistic was used to examine if there were any associations among seasons the farm visits were made and the specific feeds given to the pigs. A p value of ≤ 0.05 was considered significant. Pigs were classified based on their ages; young (≤5 months), market (5.1–9.9) months, and breeding (≥10 months) pigs, ADG was described for each category.

Results

Pig management practices

Only 13% (22/164) of farms visited owned a pig house. The houses were constructed using locally available materials. On farms where a pig house existed, pigs were typically confined during the night and only allowed to scavenge during the day. Farmers preferred keeping pigs outdoors for fear that the pigs could damage the houses (22%), because they lacked the food to provide to the pigs (31%), the houses became muddy during the rainy season (13%) and because they lacked time to manage the confined pigs (13%). The construction of the pig structures, according to

the farmers, required skills which they lacked (11%), time investment (12%), and money investments for purchasing construction materials (30%). Tethering of pigs (>50% of the daytime) was frequent during the planting (91%; 263/290), growing (90%; 263/290) and harvesting seasons (78%; 227/290). Pigs were confined in pens (at least >50% of the daytime) by 3%, 2%, and 2% of the farmers for the planting, growing, and harvesting seasons, respectively. There was no difference ($p>0.05$) in the percentage time pigs were housed, tethered or allowed on free range across the three farm visits in the district.

Available local pig feeds

A total of 164 farms were visited in Busia and resulted in a total of 455 completed farm questionnaires during the first, second and third farm visits. A larger denominator (4,902) is used for fruit observations since farmers identified multiple fruits for each questionnaire administered. A pig farmer typically tethers her pig under a tree, usually within the farm compound. This pig is expected to feed on grass with little supplementation during the day. Common feeds were "Ugali" (99.4%; 163/164), "Omena" (98% of farms; 161/164), sweet potato vines (96%; 158/164), fruits (89%; 147/164), cassava (79%; 130/164), waste from *posho* mill (68%; 113/164) and "Machicha" (66%; 109/164). The most frequently fed foodstuff during the three farm visits was "Ugali" (88%; 404/455), kitchen leftovers (83%; 382/455), dried fish ("omena") (78%; 357/455), sweet potatoes (75%; 343/455), sweet potato vines (65%; 298/455), cassava (57%; 262/455), brewers waste which was the mash left from home made beer (locally called "machicha") (48%; 220/455), maize (33%; 151/455) and innards from fish (30%; 138/455). Infrequent feeds were as follows: commercial feeds (7%; 34/455), maize stocks/cobs (12%; 55/455), rumen contents (1%; 5/455), school waste (2%; 13/455), vegetables (9%; 43/455) and banana peels (14%; 64/455).

Twelve percent of feed reports were fruits (631/4,902), which included avocado (24%; 150/631), pawpaw (23%; 147/631), mangoes (11%; 69/631), bananas (9%; 58/631), jack fruits (1%; 5/631), guava (1%; 8/631) and oranges (0.01%; 1/631). Peels from bananas, avocados and mangoes were also provided to the pigs. Four (4/631) fruit observations were from farmers who reportedly tethered their pigs under fruit trees allowing the pigs to easily pick the spoilt ones falling on the ground. Feeding fruits to pigs was more frequent in the months of October and November (26%) than in the months of June and July (7%) or February (12%) ($p<0.05$).

Vegetables, including kale, spoilt tomatoes and other local vegetables, were rarely fed to pigs (9%; 43/455). Green leaves (1%; 5/455) were from bananas leaves, cassava, yam and leaves from local weeds as Black Jack (*Cannabis indica*) and Wandering Jew (*Setcreasea purpurea*). The weeds were uprooted from the farms and directly fed to pigs. Sugarcane stems were chopped into pieces and fed to pigs in 25% (117/455) of the farm visits. Food waste materials fed to pigs included kitchen food remains (84%; 382/455), school waste (2%; 13/455), hotel waste (16%; 71/455) and remains from celebrations including village parties and funerals (2%; 8/455). Farmers mixed the food remains with waste kitchen water before feeding these to pigs. Forty percent (65/164) of the interviewed farmers provided pigs with water that was separate from the main feeds.

Daily feeding frequencies

Among the 445 household visits to the 164 study farms, pigs were fed three times in a day only in 36 (0.1%) visits. In this category, "Ugali" was the most frequently (58%; 21/36) feed. Out of the 445 household visits to the 164 pig farms, about half of the time (223/445) farmers fed their pigs two times a day. Dried cassava (4%; 10/223), kitchen left over (21%; 47/223), "ugali" (47%; 105/223) and waste from "posho" mill (10% 23/223) were given to pigs two times each day. Feeds occasionally ($n=942$) fed to pigs included fruits (46%), maize (9%), remains left on the farms after the harvest season (6%) and vines from sweet potatoes (4%). Waste from "posho" was given to pigs either raw or was used to prepare "ugali" that was subsequently fed to the pigs. Other sources for the "ugali" flour included the flour made from spoilt maize that had remained on the farms after harvest season.

Pig weight performance

The ADG information was based on measurement pairs: 121 between the first and second visit, 14 between the first and third visit and 42 between the second and third visit. Overall, pigs gained an average of 110 g/day (25th percentile of 66 g/day, median of 108 g/day, and a 75th percentile of 150 g/day). The ADG for pigs up to 5 months of age was 94.5 (±43) g, for those 5.1–9.9 months of age was 127 (±49.8) and 99 (±92) g for pigs aged ≥10 months old. The observed ADG differed significantly across the three age categories studied ($p<0.001$).

Description of the feed's nutrient composition

The following protein-rich feed for pigs were available in the district; "omena" fish, blood, rumen contents, sweet potato vines and beans. The foods that would provide energy or carbohydrates to pigs were "ugali", sweet potato tubers, bananas, waste from "posho" mill and cassava. Food waste (hotel and kitchen) would be considered more balanced in its nutrient composition. Feeding pigs with

vegetables and fruits provides them with vitamins. The minerals required by pigs were in the following local foods; green vegetables, bones, fish (innards and "omena"), food wastes, soil (rooting) and wastes from the markets.

Daily feeding amounts and estimated costs

We restrict our analyses to those feedstuffs which we were able to purchase and weigh at the local markets. These included "machicha", rumen contents, waste from "posho" mill, slaughter blood, "omena", cassava and beans. Table 1 shows the median, 25th and 75th percentiles for the amount and cost of feeds offered to pigs in the district. Use of waste from "posho" mill was the cheapest option, while "Omena" was the most expensive feed in the villages.

Discussion

Farmers participating in the current study opted to use a range of local feedstuffs as alternatives to feeding. The use of such feedstuffs would reduce the cost of pig production and increase farm income. Although we estimated the average cost of feeds offered to pigs in the villages, we do not imply that farmers bought feeds every time they needed to feed the pigs. For example, the farmer may have had brewers waste ("machicha") available from making beer at the farm, or perhaps he had a free access from a relative or a friend. It is unlikely that the amount offered was adequate to meet the daily needs for the pigs. Combining the "machicha" with other rations could provide pigs with more balanced diets.

Energy, amino acids, minerals, vitamins and water are all needed by pigs for maintenance, growth, reproduction and for lactation (NRS 1998). Farmers in the study fed their pigs only one or two times per day, mostly with carbohydrates rich foods such as "ugali", "posho" mill waste and cassava. Pigs will fail to show their full potential when fed limited amounts of amino acids (Aherne et al. 1999; de Lange and Mohn 1999). Blood from the slaughter slab, beans, sweet potato leaves and vines, brewers waste, "omena" and rumen contents are some of the potential protein rich food identified in the study. Adesehinwa (2008) listed blood meal, bone meal, and chicken offal meal as protein alternatives for pigs. "Omena" fish and its waste dust (fish scraps) were described as the readily available source of protein for pigs in Busia District. The tendencies to feed only a handful of these to pigs a few times in a week, owing to the high cost, will unlikely meet the daily protein demand of the pig. Others are the brewer's yeast, which can stimulate growth when used as an additive for pigs fed a diet of cassava, and the rumen contents, which have a relatively good crude protein composition (Akinfala and Tewe 2004; Salinas-Chavira et al. 2007; Adeniji 2008). Payne and Williamson (1978) discussed the role of different feed rations in pig nutrition.

The feeding of waste food from school and hotels was rare in the villages, perhaps because of the relatively high local demand of the product as a pig feed, and the long distances between farms and schools or hotels. Waste food will provide pigs with a mixture of nutrients. These should be cooked prior to being fed to pigs to minimize the risk of disease transmission particularly the African swine fever (ASF) virus. Maize, cassava, sweet potato roots, sugarcane, green vegetables, *posho* mill waste that includes ground maize, cassava and millet, and waste from the market, spoilt fruit, kitchen waste and selected garbage feeding were the energy sources identified in the study. A number of health risks could be associated with the feeding rotten or mouldy

Table 1 Daily amounts of pig feed in Busia District, Western Kenya and their estimated costs in 2007–2009

Food type	Amount (kg) given				Cost[a] (KSH)/kg		
	N	25th percentile	Median	75th percentile	25th percentile	Median	75th percentile
Machicha[b]	169	0.2	0.9	2	8.5	34.3	74
Rumen contents[c]	3	0.25	0.5	2	13.04	26.1	104.3
Waste from *Posho* mill[d]	175	1	2	2.5	6.8	13.4	17.2
Slaughter blood (fresh)	23	0.25	0.5	1	20.12	40.3	80.5
"Omena"[e]	235	0.25	0.5	1	42.5	85	170
Cassava	151	0.5	1	2	14.4	28.9	57.7
Maize	25	0.25	0.5	1	13.70	27.50	55.0

[a] 1 KSH (Kenya shilling) = US$0.01282

[b] *Machicha*, the local name for brewers mash

[c] At times, the rumen contents were mixed with fresh blood from the slaughter slabs

[d] Waste from *Posho* Mill, a waste from maize milling

[e] "Omena", *Rastrineobola argentea*, a small dried fish

maize to pigs observed in the current study (Lemke et al. 2006). Although farmers may mix the good and the bad grains, grain dilution of contaminated maize only reduces the magnitude of exposure to the mycotoxin but does not eliminate the negative health effects (Osweiler 1999).

Fruit such as mangoes, avocados and paw paws are available and could be utilized as potential sources of vitamins for pigs. The challenge is determining how to establish a sustainable feeding strategy that would utilize these taking into consideration the observed seasonality variations. As feed shortages are known to occur in the months before successive harvest periods (Lemke et al. 2006), pig farmers in Busia should be encouraged to utilize fruits when in season as more research on continued availability are undertaken.

Growth rate in pigs is driven by feed intake (Lemke et al. 2006; Magowan et al. 2007). The average growth performance of 110 (±69) g/day and the median of 108 g/day observed in the current study is below what has previously been reported even in smallholder farms. A growth rate of 130 g/day was reported in local Nigerian pigs by Essien and Fetuga (1989), while Kumaresan et al. (2007) reported growth rates of 120 g/day in India. A median growth rate of 130 g/day was reported in Kenya, in grower pigs on commercial farms keeping exotic breeds (Wabacha et al. 2004). Feeding pigs with low quality diets may result from insufficient knowledge on the nutritional requirements of the animals (Adesehinwa et al. 2003; Adesehinwa 2008). Training farmers on the importance of including other components of nutrients such as vitamins and proteins, to achieve a balanced diet and maximise growth and production, is one way to overcome the challenge.

Studies on how the discussed feedstuffs could be combined to achieve an inexpensive and balanced pig ration are needed to meet the needs of different production systems. Cassava and sweet potato roots are available and could supplement the use of maize as an energy source in pig diets. Sugarcane farming and local brewing are also common in this region of Kenya. Their by-products, molasses and brewers waste, respectively, could be incorporated in pig diets as additional energy sources. Slaughter waste by-products including blood, rumen contents, fish innards and "omena" dust processing wastes are potential protein sources. The nearness of the study sites to Lake Victoria presents an opportunity that could be utilized to incorporate fish by-products in formulating pig feeds. The numerous fruits could be utilized to offer source of vitamins, particularly when these are on season.

Conclusion

The findings of this study are descriptive and rely on what pig farmers were able remember and report. The study has however highlighted a number of local feedstuffs that can be utilized in formulating balanced feed rations. This would promote growth, increase productivity and lower feed costs. The variations in the feed types offered across farms and villages indicate differences in availability and perhaps knowledge of their utilization. Detailed mapping and nutrient analyses are required to quantify the nutrient composition of each of the feeds identified. Extension on better management practices including pig confinement and biosecurity will need to be strengthened to maximise production and ensure safe pork production.

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References

Adeniji, A.A., 2008. The feeding value of rumen contents—maggot meat mixture in diets of early weaned pigs. Asia Journal of Animal and Veterinary Advances, 3(2), 115–119.

Adesehinwa A.O.K 2008. Energy requirements of pigs and the utilization of fibrous feedstuffs in Nigeria. A review. African Journal of Biotechnology, 7(25), 4798–4806.

Adesehinwa, A.O.K., Makinde, G.E., Oladele, O.I., 2003. Socioeconomics characteristics of pig farmers as determinant of pig feeding pattern in Oyo state, Nigeria (2003). Livestock Research for Rural Development, 15 (12.) http://www.lrrd.org/lrrd15/12/ades1512.htm Retrieved on 11th October 2010.

Aherne, F.X., Foxcroft, G.R., Pettigrew, J.E., 1999. Nutrition of the sow. Pages 1029–1043 in Diseases of Swine. 8th ed. B. E. Straw, S. D'Allaire, W. L. Mengeling, and D. J. Taylor, ed. Iowa State Univ. Press, Ames.

Akinfala, E.O and Tewe, O.O., 2004 Supplemental effects of feed additives on the utilization of whole cassava plant by growing pigs in the tropics. Livestock Research for Rural Development, 16: 82. http://www.lrrd.org/lrrd16/10/akin16082.htm. Retrieved on 11 October 2010.

Census (2009). Population and Housing Census, Kenya. Released on 31st August 2010

de Lange, C.F and Mohn, S., 1999. Feeding management of Grower-Finisher Pigs. Chapter 70, pp 1057–1065. in Diseases of Swine. 8th ed. B. E. Straw, S. D'Allaire, W. L. Mengeling, and D. J. Taylor, ed. Iowa State Univ. Press, Ames.

Essien, A and Fetuga, B., 1989. A note on the live-weight growth in indigenous Nigerian pigs. Animal Production, 49, 143–146.

Kagira, J.M., Kanyari, P.W.N., Ndicho Maingi, N., Githigia, S.M., Ng'ang'a, J.C., aruga, J.W., 2010. Characteristics of the smallholder free-range pig production system in western Kenya. Tropical Animal Health and Production, 42, 865–873.

Kumaresan, K.M., Bujarbaruah, K.A., Pathak, S.K., Anubrata, D and Ahmed, S.K., 2007. Performance of pigs reared under traditional tribal low input production system and chemical composition of non-conventional tropical plants used as pig feed. Livestock Science, 107, 294–298.

Githigia, S.M., Murekefu, A., Otieno, R.O., 2005. Prevalence of porcine cysticercosis and risk factors for *Taenia solium* taeniosis in Funyula Division of Busia District, Kenya. The Kenya Veterinarian, 29, 37–39.

Goodman, D.E., 1994. Raising Healthy Pigs Under Primitive Conditions, 3rd edition. Christian Veterinary Mission, Seattle, WA, USA, pp 37–61

Lemke, U., Kaufmann, B., Thuy, L.T., Emrich, K., Valle Zarate, A., 2006. Evaluation of small-holder pig production systems in North Vietnam: Pig production management and pig performances. Livestock Science, 105, 229–243.

Magowan, E., McCann, M.E., Beattie, V.E., McCracken, K.J., Henry, W., Smyth, S., 2007. Investigation of growth rate variation between commercial pig herds. Animal, 1(8), 1219–1226.

Mutua, F.K., Randolph, T.F., Arimi, S.M., Kitala, P.M., Githigia, S.M., Willingham, A.L., Njeruh, F.M., 2007. Palpable lingual cysts, a possible indicator of porcine cysticercosis in Teso District, Western Kenya. Journal of Swine Health and Production, 15(4), 206–212.

NRS., 1998 National Research Council. Nutrient requirements of Swine, 10th edition. National Academic Press, Washington, DC

Nwakpu, P.E and Onu, P.N., 2007. Utilization of Nigerian native pig in breeding: 1. A genetic assessment of cross-bred Heterosis in growth and litter size. Research Journal of Animal Sciences, 1 (4), 139–145.

Osweiler, G.D., 1999. Mycotoxins. In: B. E. Straw, S. D'Allaire, W. L. Mengeling, and D. J. Taylor, (Eds), Diseases of Swine, 8th ed. Iowa State University Press, Ames, IA, pp 731–739.

Paul, S.S., Madal, A.B., Challerjee, P.N., Bhar, R., Pathak, N.W., 2007. Determination of nutrient requirement for growth and maintenance of growing pigs under tropical conditions. Animal, 1, 269–282.

Payne and Williamson (1978). An Introduction to Animal Husbandry in the Tropics, 3rd edition. Longman, UK, pp 559–573.

Salinas-Chavira, J., Dominguez-Munoc, M., Bernal-Lorenzo, R., Garcia-Castillo, R.F., Arzola-Alvarez, C., 2007. Growth performance and carcass characteristics of feedlot lambs fed diets with pig manure and rumen contents. Journal of Animal and Veterinary Advances, 6(4), 505–508.

Wabacha, J.K., Maribei, J.M., Mulei, C.M., Kyule, M.N., Zessin, K.H and Oluoch-Kosura, W., 2004. Health and production measures for smallholder pig production in Kikuyu Division, central Kenya. Preventive Veterinary Medicine, 63, 197–210.