Modern Agriculture

WILEY

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REVIEW ARTICLE OPEN ACCESS

Indigenous Technical Knowledge and Its Potential Application to Uganda's Pig Sub-Sector

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Received: 30 August 2023 | **Revised:** 7 December 2023 | **Accepted:** 22 October 2024

Funding: The authors received no specific funding for this work.

Keywords: high feeding costs | indigenous technical knowledge | smallholder farmers

ABSTRACT

Uganda's pork consumption is speculated to exceed any other livestock meat consumption by 2050. However, the current trend in pig production may not meet the demand due to pig production constraints such as recurrent disease incidences and high feeding costs. The proposed modern practices are not cost-effective, especially for resource-constrained pig farmers. This review, therefore, synthesises previous studies on the practicability of integrating Indigenous Technical Knowledge (ITK) in pig production to mitigate the prevailing pig production challenges in Uganda. By employing ITK, smallholder farmers have realised that indigenous pig breeds are disease-resistant and suit the prevailing harsh tropical conditions. In addition, affordable plant-based concoctions have been developed to cure diseases in pigs. For example, *Centella asiatica* has been identified as a potential purgative for diarrhoeal infections. Integrating pigs in cropping systems has also been adopted as a low-cost alternative to effectively feed pigs for optimal performance. Fortunately, most of the ITK options for solving pig production challenges are feasible in Uganda. Thus, ITK should be embedded in the country's extension system to increase smallholder farmers' awareness about its potential of improving pig production. An ITK-modern technology integration would probably meet the acceptance and be suitable for commercial pig producers.

1 | Introduction

In this era of agricultural modernisation, technology advancement has significantly contributed to the development of the agriculture sector [1]. Nonetheless, the adoption of improved technologies is still low, especially among resource-constrained farmers [2]. Even with this low usage of improved technologies, smallholder farmers meet over 80% of the world's food consumption needs [3]. This could imply that these farmers employ their '*magical*' practices to ensure that they sustain production for the high population of food consumers. These magical practices are termed '*Indigenous Technical Knowledge*' [4].

Indigenous Technical Knowledge (ITK), also known as Indigenous Knowledge System (IKS) or Traditional Knowledge (TK) or Local Knowledge (LK) [5], refers to farmer-friendly practices developed over time for and by the locals of a given area, aimed at obtaining a sustainable use of their natural resources [4, 6, 7]. These practices are favourable to smallholder farmers as they offer practical solutions to their problems and are readily

Summary

- The growth of Uganda's pig sub-sector is constrained by a set of challenges such as diseases and high feeding costs;
- The use of ITK could contribute to mitigating these challenges, mainly if the ITK is embedded in the country's extension system for easy diffusion in farming systems;
- Integrating ITK with modern technology could be adopted in commercial pig production systems and possibly lead to a productive and sustainable pig sub-sector.

available with no or minimal side effects to the environment [8]. ITK is developed over a period of time by experimentation within a farming community [9, 10]. From this continued experimentation, ecologically sound technologies have been formulated and proved valid in different communities [11, 12]. Several communities all over the world have relied on this knowledge for centuries to sustain agricultural production systems [13, 14]. Unfortunately, ITK seems obsolete in this era of modern technology, which cannot solely solve traditional farmers' challenges.

Indigenous Technical Knowledge is preserved in a way that the bearers pass it on to future generations-verbally or by observation, and it is modified time and again to suit the prevailing conditions [14]. Integration of '*new*' ITK from external communities in already established IK systems is possible as individuals from different knowledge systems interact [7]. Hence, cross-sharing and adoption of indigenous knowledge between communities occurs, especially upon successful experimentation. Integration of such '*foreign*' ITK into an established IK system is, however, based on the level of trust in the source [7].

The use of ITK has proven sustainable in mitigating farming challenges especially in crop production and adaptation to climate change [15–21]. Smallholder farmers have particularly applied ITK to ensure continued crop production within a fragile climate to obtain sustainable food supply and income generation. In Uganda, ITK is less studied, especially in the field of livestock production. This is notwithstanding the significant role of smallholder livestock systems in Uganda's agricultural economy.

Specifically, pig production is of increasing importance, and pork is foreseen to be the most consumed meat type in Uganda in the next 2 decades [22]. However, pig production is constrained by several challenges, especially high costs of commercial feeds and frequent disease incidences [23, 24]. Although these challenges are documented, the suggested alternatives are expensive and have, therefore, seemed inefficient in smallholder systems. The use of manufactured drugs, for example, to treat illnesses or vaccines for vaccination is a barely adopted technology among smallholder farmers [25]. However, disease incidences still prevail in smallholder operations, and have deterred the advancement of their enterprises. On the other hand, minimal information exists on the use of ITK to curb these challenges in Uganda's pig production [20]. Elsewhere, however, ITK has been applauded for sustaining smallholder livestock production systems [18, 26–29]. The current review, therefore, scrutinises literature on the contribution of ITK to pig production primarily from other countries, and applies the feasible practices to Uganda's setting to draw conclusions on the potential of using ITK in improving pig production. The review unearths the potential of integrating ITK in initiatives to solve Uganda's pig production challenges. Unearthing this wealth of knowledge is crucial in the trending interventions to improve the pig sub-sector of Uganda where the demand for pork is steadily increasing.

2 | Underlying Problem

Pig populations have persistently remained low globally [30] and locally in Uganda [31]. This low pig population is attributed to a set of practical challenges, among which high feeding costs and diseases feature as the most deterring [32, 33]. Different stakeholders in pig production have tirelessly devised means of developing practical solutions, such as alternative feeding strategies to reduce feeding costs [34]. Nonetheless, the outstanding interventions are only feasible for commercial farmers, who only contribute a meagre percentage to Uganda's pig population. Solutions to smallholder pig production systems which are in a dire state and need of low-cost interventions are still needed. Such farmers rely on traditional practices to address their production challenges, which, for the case of pig production, are less documented purportedly because the importance of pig production has just recently been realised in Uganda [20]. To augment scientific interventions- which primarily favour intensive pig farming- it is necessary to establish the potential role of ITK in addressing pig production challenges. For example, ITK is a rich reservoir of knowledge that is critical to sustainable indigenous livestock management in different communities [18]. Since it is possible to adopt '*foreign*' Indigenous Knowledge [7], exploring the different indigenous practices used in pig production in other parts of the world, and applying them to Uganda could contribute to solving the common challenges in Uganda's pig production systems. This is the scope of the current review.

3 | Indigenous Technical Knowledge in Breed Selection and Breeding

Farmers have a set of traits that they prefer in traditional pigs and that influence the selection process. Disease resistance and high fertility rates were, for example, considered essential traits of local pigs by farmers in Zambia, which made them prefer local to exotic pigs [35] (Table 1). In Naga land, indigenous pigs were reported to reach sexual maturity earlier than the crossbred pigs [62]. This early sexual maturity was attributed to the faster testicular growth of the indigenous pig breeds compared to the crossbreeds [63]. In Serbia, it was realised that traditional pigs were used to the prevailing free-ranging conditions and are '*knowledgeable*' about the most palatable plant species [36]. This has reduced cases of ailment or even death accruing from eating poisonous plants by pigs. Since this knowledge is developed over time of ranging, it is not found in intensively managed exotic

TABLE 1 | A summary of the different indigenous technical knowledge practices that can potentially sustain pig production in Uganda.

Author(s) and year	Country	Application	ITK practices	Remarks
Molnár et al. [36]	Serbia	Breed selection and breeding	Selection of indigenous pig breeds for the free-range system	Indigenous pigs have evolved to differentiate palatable and poisonous plants; hence they can survive on free-range with minimal fear to the farmers that they will die from poisoning
Abigaba et al. [35]	Zimbabwe			Indigenous pigs are tolerant to prevailing draught conditions and disease incidences
Karthickeyan and Gajendran [37]	India		Sharing boars between communities	This is aimed at improving herd productivity through sharing highly productive males among herds. It also curbs the disadvantages of inbreeding
Petrus et al. [38]	Namibia		Feeding boars on watermelon fruit and leaves	Increases libido
Shai et al. [39]; Tutubalang et al. [40]; Morakinyo, Adeniyi, and Arikawe [41]	South Africa; Nigeria		Feeding male rats and ruminants with *Zingiber officinale* root extracts and cocks with *Moringa oleifera* leaf extracts	Shai et al. [39] suspected potential use in pigs and recommended the two extracts be tried on boars
Liufu et al. [42]	China		Crossing of indigenous pigs with exotic pig breeds	The Luchuan females in China, are for example applauded as good parents for the hybrids; the practice of crossbreeding is also practiced in Uganda
Borah, Bey, and Deka [43]; Doley et al. [44]	India	Pig health management	*Centella asiatica* paste cures diarrhoeal complications and fever in pigs	Administering 50–100 mL extract of the whole plant twice a day for a maximum of 7 days effectively manages diarrhoea and fever in pigs. The plant is readily available in Uganda
Doley et al. [44]	India		Administering *Carica papaya* fruit to pigs against diarrhoea	Cooking pieces of papaya fruit with rice bran and feeding the cooked mixture to pigs twice a day for about 5 days cures diarrhoea. The two ingredients are available in Uganda
			Administering neem paste purges pigs of worms	Neem (*Azadirachta indica*) powder mixed with water and administered orally for about 5 days is effective in controlling worms in pigs. Neem readily grows in different parts of Uganda and the practice can be sustained
Singh et al. [45]	India		Feeding anthill soil as a strategy to control anaemia in piglets	Anthill soil is readily available in Uganda and this practice can potentially be sustained by smallholder farmers

(Continues)

TABLE 1 | (Continued)

Author(s) and year	Country	Application	ITK practices	Remarks
Shadap and Dkhar [8]	India		Spreading water from banana pseudo-stem around fractures/ dislocated bones	The pseudo-stem is rubbed around the fractured spot ensuring water is smeared all over the place. Banana is available in most parts of the country and the pseudo-stems can easily be accessed
			Turmeric rhizome paste mixed with mustard oil enhances healing of fractures	The turmeric rhizome paste-mustard oil mixture is applied and bamboo stick tied around the fractured spot to hasten the healing process
Sithole [46]; van Ryssen [47]	Zimbabwe		Wood ash as a mineral source	Can be supplemented in pig diets to contribute to the calcium requirements of the pigs
Aliro et al. [48]	Uganda		Burying carcass of dead pigs to avoid spread of African swine fever	Unfortunately, farmers could not specify the recommended depth
Ibrahim, Graham, and Leitner [49]; Devanand and Kamala [50]	Uganda; India	Managing manure and offensive smell in pig houses	Heaping pig manure to decompose	Farmers utilise decomposed pig manure as an organic fertiliser in their gardens. Pig manure is said to not only improve crop yield but also has pesticidal properties
Das et al. [51]	India		Mixing pig manure with rice husks and spreading the mixture in fields of turmeric and ginger	Applying the mixture just after emergence of the ginger and turmeric increases yield by 27%
Parodi et al. [52]; Nguyen, Tomberlin, and Vanlaerhoven [53]; Diener et al. [54]; Newton et al. [55]	Netherlands; Costa Rica		Degradation of pig manure using black soldier fly larvae	The practice reduces pig manure by 39% without producing offensive smell and the resulting composted material (frass) is an organic fertiliser
Baul and McDonald [56]; Egeru [57]; Shadap and Dkhar [8]; Lumu et al. [58]	India; Uganda	Feeding pigs	Feeding pigs on crop and food wastes	Pigs are raised in the prevailing cropping system which also includes beneficial trees; farmers feed pigs on crop and food wastes, and palatable weed species
Shadap and Dkhar [8]	India		Supplementing daily rations with fermented rice	This is increases growth rate of the pigs
Yang et al. [59]; Komolafe and Sonaiya [60]	China; Nigeria		Feeding chicken manure to pigs	This reduces feeding costs and improves carcass quality characteristics
Molnár et al. [36]; Argemí-Armengol et al. [61]	Serbia		Letting pigs to forage by the roadside	This is aimed at ensuring production of pork with enhanced eating quality. However, caution should be taken as forages by the roadside could have a high heavy metal load

pigs. Besides the foraging ability, indigenous pigs can survive on a range of feedstuffs, most of which are even less nutritious. This attribute was greatly applauded by the farmers in South Africa [64]. Smallholder farmers in Zimbabwe have also selected indigenous pigs owing to their tolerance to prevailing draught conditions, which they have developed over time [35]. These aforementioned traits have given indigenous pig breeds a comparative advantage in smallholder farming communities as opposed to the exotic pigs.

Communities in India have developed the practice of sharing good boars as a strategy to improve herd productivity [37]. This also curbs the disadvantages of inbreeding that would accrue from repeatedly using the same boar even on its offspring. It was also reported that feeding water melon and its leaves to boars increases libido [38]. Feeding boars with watermelon could therefore increase litter size and farrowing index in a herd. In ruminants, feeding *Zingiber officinale* root extracts and *Moringa oleifera* leaf extracts to male animals was reported to potentially increase sperm count, and hence reproductive performance [39]. In pigs, however, there is scanty information on the potential of these plant extracts to improve reproductive performance, and Shai et al. [39] recommended exploring this potential. It is quite inconclusive whether pig farmers have explored this potential as little about the subject is known in the pig sub-sector.

Although indigenous pigs are hardy, a characteristic that smallholder farmers prefer them for, they have a low productivity [42]. Farmers have therefore studied the potential of utilising their hardiness while at the same time improving productivity. In China, for example, the Luchuan female pigs are superior parents of hybrids. Consequently, the farmers cross these females with Duroc boars to produce highly adaptive and productive offspring [42]. In Uganda, the rearing of crossbred pigs is also on the rise, owing to the fact that they are more productive than the indigenous breeds and more adaptable than the pure exotic breeds [65–67]. It is most likely that the farmers in Uganda have also realised the superiority of rearing crossbreed pigs over the locals. In India, the Nicobari pigs are reared traditionally with the breeding boars always in the wild [68]. According to Jeyakumar et al. [68], the females look for the boars to mate and come back while pregnant to be looked after by the owners. This practice is similar to the scenarios of indiscriminate breeding which occur in Uganda's predominant extensive system of management.

4 | Indigenous Technical Knowledge in Pig Health Management

Sustaining pig health remains a challenge among Ugandan smallholder pig farmers [69]. Utilising local knowledge could help either to build the immune system or cure some disease cases. The paste of *Centella asiatica* has, for example, been reported as a curative agent for several illnesses in pigs [43]. Administering a 50–100mL extract of the whole plant twice a day for a maximum of seven days effectively manages diarrhoeal complications and fever in pigs [44]. In Uganda, this plant is in abundance, locally known as *Kabbo K'abakyala* [70]. Therefore, adopting its use in pig health management could be a sustainable strategy. In addition, *Carica papaya* fruits are effective in treating diarrhoeal cases and also possess anthelminthic properties. According to Doley et al. [44], cooking pieces of papaya fruit with rice bran and feeding the cooked mixture to pigs twice a day for about 5 days cures diarrhoea. For worm infestations, Neem (*Azadirachta indica*) powder mixed with water and administered orally for about 5 days was realised as an effective purgative [44]. In addition, farmers in Nagaland were reported to feed anthill soil to piglets as a strategy to reduce anaemia [45].

To treat fractures, smearing water from banana pseudo-stem on the surface of the fractured point was reported to be an effective practice in India [8]. Applying a paste of fresh turmeric rhizome mixed with mustard oil, and then tying a bamboo stick around the fractured point could also enhance healing [8]. Furthermore, wood ash has been reported to have health benefits to pigs due to its high mineral composition [46]. Predominantly, wood ash contains calcium [47], which is an essential constituent of bones. To avoid the spread of African Swine Fever amongst herds, farmers have realised that burying the dead pigs in a deep pit is a practical solution [48]. Unfortunately, the farmers have no specific depth that they refer to as '*deep*' but use their own judgement.

5 | Indigenous Technical Knowledge for Managing Manure and Offensive Smell in Pig Houses

The offensive odours from pig houses due to poor waste management make pig rearing a nuisance. To reduce these offensive odours, many farmers clean their pig houses and heap dung in designated areas for future use in their gardens as organic fertilisers [49]. Since pig production is a component of traditional farming systems [71], farmers find it sustainable to use pig manure in crop production. Pig manure not only improves crop yields but also has pesticidal properties and, farmers in India apply it as a preventive measure against pests and disease incidences [50]. In fact, farmers have realised pig dung to be superior to cow dung in its use as an organic fertiliser and as a pesticide [72]. In Vietnam, pig manure is also used to fertilise fish ponds and fish in such ponds grow faster compared to when other fertilisers are used [73]. Apropos manure management, farmers who intensively manage their pigs always flush pig manure with water into slurry pits [74]. Such kind of manure management is not environmentally friendly as it enhances methane emission [75]. Unfortunately, it is quite hard to regulate such a mode of manure management, especially among smallholder settings that dominate pig production in Uganda. Thus, methane production from manure stored in slurry form is also a key challenge in Uganda's pig production [75]. As a means of managing this constraint, farmers in India mix the manure with rice husks and spread the mixture in fields of ginger and turmeric shortly after emergence [51]. The practice was reported to increase yield by about 27%.

Recently, there has been increasing interest in the use of black soldier fly (*Hermetia illucens*) larvae in managing wastes.

Reports have shown that Black soldier fly larvae have a higher preference for pig manure than any other organic waste [52]. The black soldier fly (BSF) larvae can reduce pig manure (Nguyen et al., 2015) by up to 39% without producing any offensive smell [54]. In addition, compost from pig manure degraded by BSF larvae was reported to promote the growth of Basil plants [55]. This implies that BSF larvae can effectively convert pig manure into high-quality organic fertilisers.

Smallholder pig production, which is dominant in Uganda's pig sub-sector, is primarily characterised by an extensive system of management [67]. In this system, manure management is not given priority since collection of the pig manure is quite impossible [75]. Farmers consider this an advantage with the claim that the manure is directly incorporated into the soil [74]. Although farmers think so, it is hazardous to the environment since manure is '*disposed of*' without any treatment. It is quite unfortunate that the proposed intensification of pig production as a means of improving manure management and land use efficiency [75, 76] could be an unsustainable pursuit with smallholder communities. This is because intensive pig production is capital intensive and input oriented, a practice that smallholder farmers can hardly afford. On the other hand, the potential effect of the extensive pig production as regards to pollution due to obnoxious emission is also minimal since the pigs scavenge on feeds with imbalanced diets. High protein diets are culprits in culminating obnoxious gases from pig manure [77], and such diets are only feasible in intensive pig production.

6 | Indigenous Technical Knowledge in Feeding Pigs

Ideally, traditional pig farming is mainly backyard [78]. In other words, traditional pig farming is primarily a smallholder venture; hence, feeding in such systems is sustained with no commercially balanced concentrates, which are expensive and unaffordable to resource-constrained farmers [45]. Traditional practices in feeding pigs are embedded in the ideology that pig production is a component of a farming system [79, 80]. In this system, pigs and other livestock species are grown together in the prevailing cropping system with beneficial trees incorporated into the same farmstead [56, 57]. This ensures a complete package that sustains the livelihoods of smallholder farmers. The farmers are actually knowledgeable about the dynamics in feeding pigs in this system [81]. Farmers usually give crop and food waste to their pigs [58]. They also give a diverse array of weeds and other plant species which farmers, due to experience, realise are edible to the pigs.

As a strategy to increase growth rates, pig farmers in Meghalaya supplement daily pig rations of grower pigs with fermented rice [8]. The use of chicken manure to feed pigs has also been reported as a strategy to reduce feeding costs and improve carcass quality traits [59, 60]. In Serbia, it was reported that farmers let pigs forage by the roadside [36]. Feeding pigs on forage is used as a means of producing pork with enhanced eating quality [61]. Forage by the roadside should, however, be used judiciously as there are high risks of heavy metal buildup within the animal system thereby ending up in the food chain [82, 83].

7 | Application to Uganda's Pig Sub-Sector

For any initiative towards improving livelihoods of farming communities to be successful, there is need to include farmers at all stages [84]. Their inclusion should not be coercive to have farmers embrace all the components of the intervention but rather put into consideration their practices. This is where ITK proves its importance in farming communities. The prime importance of ITK lies in its economic affordability and social acceptance by the smallholder rural communities [84]. On the other hand, modern interventions have scarcely been adopted by smallholder farmers because they can hardly be afforded by these resource-constrained farmers. Among Ugandan farmers, for example, it was realised that adoption of vaccination technology is low among the poor farmers [25]. In addition, modern technology initiatives are forecast to be void of sustaining production for the ever-increasing populations [85]. Consequently, ITK has received attention, and its potential in sustaining future food demands is gradually being realised. Therefore, with the high and continuously increasing level of pork consumption in Uganda [22], sustaining pork production will necessitate exploring local alternatives to production constraints. Fortunately, Uganda is endowed with essential natural resources for sustainable pig production, most of which are within the reach of smallholder farmers. An example is the abundant crop wastes, which are a potential ingredient in pig diets [86]. However, it is possible that farmers are either not utilising this knowledge or are unaware of how to apply ITK to improve their piggery enterprises. The current review has highlighted the potential mechanisms through which smallholder pig farmers in Uganda can integrate ITK initiatives, if not already using them, to sustain pig production. From the evidence of availability of the resources around which ITK in pig production rotates, it is possible that Uganda's pig production could be boosted by integrating ITK into pig production. To ensure a sustained and productive piggery sub-sector, we recommend that the ITK be integrated into modern technology initiatives, tested, and promoted even in commercial pig production. We postulate that this would hasten and sustain the growth of pig production in Uganda, as integration will exploit the benefits of both interventions, as shown in Figure 1.

8 | Possible Challenges in Using ITK in Pig Production

The current system generally selects against traditional practices among farmers. There has been a wrong perception, especially among young farmers (below 50 years) that '*scientific*' approaches are superior and are the only solutions to the trending pig production challenges, hence limiting the use of ITK. This perception could negatively impact Uganda's IKS since the agricultural sector is increasingly being dominated by young farmers. On the other hand, some experienced and older

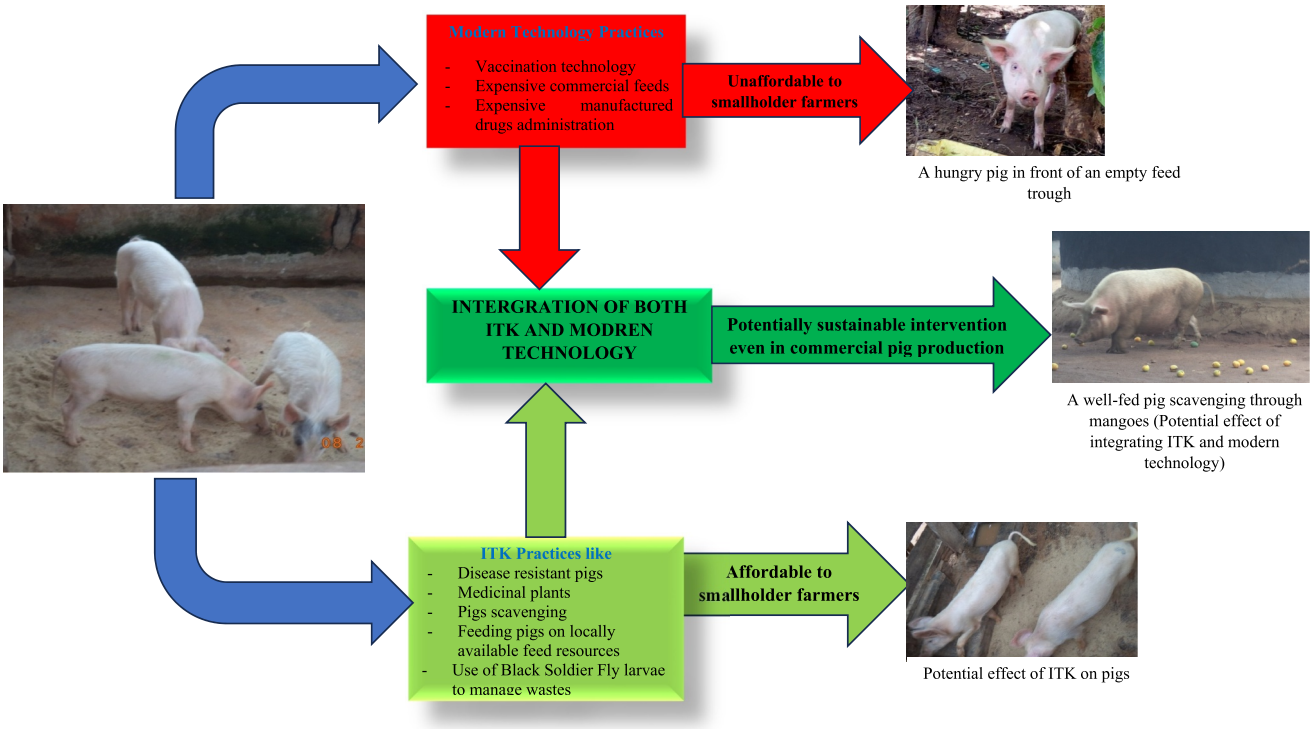

FIGURE 1 | This figure explains the potential of integrating indigenous technical knowledge (ITK) in pig production in Uganda. The figure illustrates that pigs are either produced using modern technologies or indigenous technical knowledge/indigenous practices. Modern technologies (red box) are less adopted by smallholder farmers, especially because of the high costs involved in using them, unlike the affordable and environmentally friendly indigenous practices (light green box). The two practices, however, cannot result in optimal production independently due to the limiting factors attributed to the use of each. Indigenous technical knowledge alone is affordable to smallholder farmers but cannot yield optimal pig enterprise performance. Modern technologies are costly and non-sustainable in smallholder operations. Thus, we recommend integrating both modern practices (middle dark green box) as it could lead to sustainable pig production. This integrated approach should be piloted and promoted in commercial pig production.

farmers have to some extent continued employing the local knowledge they have in livestock management [8].

9 | Conclusion

In line with the reviewed literature, there is a strong possibility that strengthening farmers' innovations through ITK would contribute to solving pig production challenges in Uganda. The country's extension system has a great role to play in reviving the farmers' knowledge by not 'just introducing modern knowledge' but by tickling their minds to think, reflect and synthesise the knowledge they already have. Documentation of ITK practices may be essential to prevent its extinction with increasing access to modern technology.

Author Contributions

Junior Senyonga Kasima: conceptualization (lead), data curation (lead), investigation (lead), project administration (lead), writing–original draft (lead), writing–review and editing (lead). **Basil Mugonola**: supervision (equal), writing–original draft (equal), writing–review and editing (supporting). **Harriet Muyinza**: conceptualization (supporting), supervision (supporting), writing–original draft (equal), writing–review and editing (equal). **Sarah Kizza-Nkambwe**: conceptualization (equal), supervision (equal), writing–original draft (equal), writing–review and editing (equal). **Geoffrey Akiiki Beyihayo**: conceptualization (supporting), writing–original draft (equal), writing–review and editing (equal). **Kenneth Kidega**: writing–original draft (equal), writing–review and editing (equal). **James Nokrach**: conceptualization (supporting), writing–original draft (equal), writing–review and editing (equal). **Maxmillan Mpewo**: writing–review and editing (equal). **Marx Kisaame**: writing–review and editing (equal). **Elly Kurobuza Ndyomugyenyi**: conceptualization (equal), supervision (equal), writing–original draft (equal), writing–review and editing (equal).

Acknowledgements

The authors are grateful to all their respective institutions for providing a favourable environment for preparing this paper. Great thanks to the authors whose work has been cited in this paper.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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