POTENTIALS OF PASTURE FEEDING OF PIGS IN NIGERIA: A REVIEW

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Abstract
Piggery industry in Nigeria currently is constrained by scarcity and high cost of conventional feedstuffs, which accounts for 70 - 80% of the total cost of production. Nigerian researchers have therefore continued to the search for locally available non-conventional feed ingredients or feeding practices that could reduce cost of feeding pig in the country. This paper reviews the available information on the science and technology of feeding pigs with forages in Nigeria. Pigs are ominivorous animals that have inert foraging instincts and behavioral patterns that allow them to consume diverse feed materials, including herbs and grasses. They can use their snouts to dig up plants to get to the nutrient dense roots, highlighting their highly explorative and naturally successful omnivory. Pasture feeding of pigs has recently re-emerged as an extensive system of pig production in which pigs of varied productive categories are kept on pasture so that they can graze, receive feed and water, while being provided with shelter. Many forage legumes have high protein content of 18 - 25%, are excellent sources of essential minerals, and can be used supplement low-protein tubers and cereals in pig diets. Numerous feeding trials have pasture feeding reported the effects on growth performance, carcass, hematology and overall performance of pigs at different stages of development. Inclusion of high fibre vegetables like potato or green fodder in pig diets had some beneficial effects on both their health and meat quality. Separation of grass silage into liquid and solid fractions and using the silage juice to fatten growing pigs was shown to lower the dry matter intake of pigs without adverse effects on growth performance. Potential forages for feeding pigs in the country include local grasses, legumes, aquatic plants, and leaves from shrubs and trees, which could be fed, either fresh or processed as hay or silage. Some forages may however contain anti-nutrients which may affect their utilization by pigs. The cost effectiveness of using forage to feed pigs however remains perhaps the most critical factor to the pig farmer and will therefore determine the adoption of pasture feeding.

Keywords: Pig, feed, forage, pasture, grass, shrubs, trees

Introduction

Pig production contributes significantly to the livelihood of many Nigerians by supplying animal protein and essential nutrients (Anyiro *et al.,* 2013). Activities in the piggery industry have particularly increased in recent years in response to the increasing demand for animal products from a rising population, especially in the southern and north-central parts of the country, probably because of the lower cost of its products (Onyekuru *et al.,* 2020; FAO, 2021). For example, Knoema (2020) reported that 807, 027 tons of pig was produced in Nigeria in 2019, rising from the 28,350 tons produced in 1970, and indicating an annual growth rate of 4.49% during the period. Despite the economic leverage and nutritional advantages of the pig, its production in Nigeria remains the least in terms of meat supply when compared with other livestock species like poultry, goats, sheep and cattle (Central Bank of Nigeria, 2008; Alionye *et al.,* 2019). Research has particularly shown that pig production in Nigeria is inadequate, and thus requires strategic intervention measures to ensure its economic improvement and sustainability (Onyekuru *et al.,* 2020). The industry has witnessed setbacks and is currently constrained chiefly by unavailability of feedstuff, which accounts for 70 - 80% of the total cost of production (Esonu, 2015). This has been attributed chiefly to the prevailing high cost of conventional and previously unconventional feedstuffs like maize, soybean, palm kernel cake (PKC) and brewers spent grains (BSG) (Alao, 2023).

Over the years, Nigerian researchers have through the results of several studies advocated the use of the abundant and cost-effective agro-industrial wastes and other non-conventional feed ingredients, such as cassava peels, PKC and BSG in reducing feed costs in pig production (Tonukari *et al.,* 2016; Aladi *et al.,* 2018; Aimuamhosa *et al.,* 2022). The use of fermented feed ingredients and various feed additives to enhance the growth performance of animals while reducing the cost of feed inputs have been studied and promoted in the country (Aladi, 2016; Xu, *et al.,* 2020). Research into the nutritional effects of phytogenics derived from local plants such as *Azadirachta indica* and *Moringa oleifera* on pig performance have also been reported (Njoku *et al.,* 2018; Ekpo *et al.,* 2022). Varying levels of successes have been reported with these strategies possibly because of the influence of factors such as genotype, diet composition, digestible nutrient content, energy to protein ratio, feed form and processing, environment and disease (Ahaiwe *et al.,* 2018). Pig farmers have also developed different on-farm cost effective methods of feeding their pigs with highly fibrous biomass which have been studied and shown to have limited positive performance effects, especially on reproduction (Ohanaka *et al.,* 2017; Okoli *et al.,* 2018). Some of these materials, especially PKC, and BSG have in recent years become too expensive for most small holder farmers, indicating the need for continuous search for other innovative approaches to reducing the cost of feeding pigs in the country.

Although modern pigs are housed and fed concentrate diets, they are ominivorous animals that have inert foraging instincts and behavior patterns that allow them to consume diverse feed materials, including herbs and grasses. There is indeed a history of pasture rearing of pigs in all production environments globally (Edward, 2003; Sehested *et al.,* 2004). This is because, pasture could serve as an important source of nutrients especially for the smallholder pig-feeding systems in tropical areas, where protein concentrates are either scarce or expensive and inaccessible to most farmers (Kambashi *et al.,* 2014). Interest in the potential value of herbs and pasture in the feeding of pigs have recently increased particularly because of the promotion of organic pig production over the conventional factory farming approach (Edwards, 2003). The nutritional contribution from pasture is usually influenced by its availability, nutrient composition, grazing intake and digestibility of the forage, and have been shown to vary considerably in natural or even cultivated fields (Edwards, 2003; Cuevas *et al.,* 2013). Forage is nonetheless still widely used by low-income smallholders' pig farmers since their production system would not be sustained by the high prices of imported grains or oil-seed cakes (Kagira *et al.,* 2010; Kaensombath *et al.,* 2013).

Kambashi *et al.* (2014), reported that the inclusion of forages in the right proportion in the pig diet enhances the nutritional quality of traditional pig diets by increasing the crude protein and mineral intake, and possibly lowering the feeding cost. Gao *et al.,* (2022) reported that up to 20% inclusion of elephant grass (*Cenchrus purpureus*) in the diet of pigs enhanced growth performance and carcass characteristics. Studies conducted by Obua *et al.* (2012), shows that 38 forage plants comprising trees, grasses, shrubs, herbs, forbs, lianas and woody vines are fed to pigs in the Southeastern Nigeria, while Moses (2019), listed 13 forage plants fed to pigs in Imo State alone. Supplementation of sprouted fodder in the ration of pigs has also been shown to be a viable alternative technology to conventional green fodder in pig production (Rachel *et al.,* 2015; Adebiyi *et al.,* 2018 a&b). Pasture feeding of pigs or cultivation of fodder for pig feeding however competes with food crops, necessitating the determination of whether fodder production will be more economically beneficial than food crop production at a given animal production location (Jakobsen, 2014). It also raises several issues related to their high fibre and secondary metabolites contents as well as their lower overall nutritive value.

This paper reviews the available information on the physiological bases of pasture feeding of pig.

Pasture Feeding of Pigs

Pigs possess monogastric digestive system, which is also common in omnivores and carnivores. The monogastric system comprises an acidic stomach that dissembles protein and passes on nutrients to the small intestines for subsequent absorption (Shapovalov *et al.,* 2020; Penn State Extension, 2022). Herbivorous livestock species such as cattle, sheep, and goats, possess ruminant digestive system which could ferment and break down forage fibers within the rumen, thus making the nutrients more available for absorption (Parish, 2011). Pigs, on the other hand, are not as well equipped to utilize forages as their main source of nutrients, and are rather omnivorous, which means that they consume and digest both plants and animal derived foods, thus giving them the ability to survive in a variety of environments (Brunberg *et al.,* 2016). The term "rooting" which refers to the ability of pigs to use their snouts to dig up plants to get to the nutrient dense roots; highlights their highly explorative and naturally successful omnivory (Stolba and Wood-Gush, 1989).

Pasture feeding of pigs is a re-emerging practice that offers a sustainable and potentially profitable approach to pig farming and could be of beneficial to organic farmers economically, since the practice is likely to reduce feed costs (Rachuonyo *et al.,* 2005; Zollitsch *et al.,* 2004). It is an extensive system of pig production in which pigs of varied productive categories are kept on pasture so that they can graze, receive feed and water, while being provided with shelter (Miao *et al.,* 2004). Several studies have shown that sows are able to consume 40 - 65% of their energy requirements as clover-grass (Sehested *et al.,* 2004; Fernández *et al.,* 2006), and 50-60% as maintenance requirements (Rivera *et al.,* 2001). Mowat *et al.* (2001), however reported a low intake from direct foraging of clover-grass by 50-60 kg pigs fed *ad libitum* with concentrate, corresponding to 4% of daily organic matter intake. Fortina *et al.* (2011) also reported that pigs grazing forages in a crop-pasture rotation system performed best when 50% of their energy requirements were supplied by supplements/concentrates, and forages were grazed in the early vegetative stage. Whittemore *et al.* (2003), showed that the ability of pig to ingest bulky feeds is correlated to their live weight. For example, 600 g sugar beet pulp /kg of diet was constrained the growth of young for pigs of 12 kg, while 600 g/kg and 800 g/kg did not limit the live weight gain at 36 kg and 108 kg respectively. Bulky diets are known to cause significant increases in the sizes of different parts of the gut in response to their digestion and fermentation (Whittemore *et al.,* 2003;

Len, Hong, Ogle and Lindberg, 2009). Thus, adult pigs have larger hindgut in proportion to their live weight and lower feed intake relative to gut size compared to young pigs which increases feed retention and fermentation times in the intestines (Hoogeveen *et al.,* 2020). The expansion of hindgut volume in adult pigs enhances their capacity to digest dietary fibre, which explains their higher energy digestibility from fibrous substrates compared to younger pigs. This observation is supported by Noblet and Le Goff (2001), who documented that adult pigs possess significantly larger and more fermentatively active hindguts. Recent work by Wisbech (2023) further confirms that fiber-rich diets in mature sows promote microbial fermentation and increase nutrient utilization, particularly in the hindgut. Additional insights by Noblet et al. (2022) describe how fermentative capacity and fibre digestibility are functionally related to intestinal length, microbial colonization, and digesta retention. (Noblet and LeGoff, 2001; Wisbech, 2023). Furthermore, fibre, energy and protein digestibility of plant leaves are influenced by live weight (Son *et al.,* 2023).

For example, Leterme *et al.* (2006), observed that when tropical foliage is included at 300 g/kg DM diet, protein digestibility is higher in sows than, in 18 to 35 kg growing pigs for which the digestibility of the diet decreases sharply when the rate of incorporation of leaves increases from 0 to 200 g/kg diet (Leterme *et al.,* 2005;2009). Intake of fresh clover-grass, clover-grass silage, barley-pea silage and fodder beet by growing pigs has also been found to range between 2 and 19% of dry matter intake in 30 kg pigs (Carlson *et al.,* 1999; Kelly *et al.,* 2007; Jørgensen *et al.,* 2012). In other studies, by Danielsen *et al.* (2000) the intake of fresh grass or silage by 25 kg pigs counting for to 4-6% of total energy intake was found to depend on *ad libitum* versus restricted feeding regimes.

Forage-based feeding systems have the advantages of reduced costs of buildings and equipment compared to indoor housing and feeding although they may be more labour demanding and may require a larger part of the crop rotation compared to indoor systems (Tvedegaard, 2005; Jakobson, 2014). Foraging above and below ground by the pigs may also have the added advantage of supplying the essential amino acid requirement of the animal under organic production system (Jakobson, 2014). The pasture essentially approximates the natural environment of the pigs under this type of production and allows them to express their natural attributes such as foraging, rooting and exploratory behaviors (Miao *et al.,* 2004; Pietrosemoli and Green, 2018). Therefore, the implementation of stocking rate suitable to the climatic and socioeconomic conditions of the farming environment and the grazing animal categories would help to maintain and sustain the pasture cover (Miao *et al.,* 2004; Pietrosemoli and Tang, 2020). Management of the pasture is therefore crucial since the pigs tend to root and dig pasture grasses.

Weather conditions such as rainfall, extreme temperatures, humidity and solar radiation, and other environmental factors could also cause stress to pigs kept on pasture (Parrini *et al.,* 2019), which manifest as restlessness, irrigation and aggressiveness in the animals (Olczak *et al.,* 2015). Pasture pig production may also pose challenges to animal welfare, health and productivity of the pigs and therefore requires careful design systems to operate. Specifically, pigs managed on pasture may be challenged by inclement weather conditions, contact with wildlife and predators, exposure to pathogens, poor pasture and malnutrition, increased mortality among young pigs, and poor monitoring of biosecurity of the facility (Pietrosemoli and Tang, 2020). Any pasture pig operation may therefore have positive or negative impact on the pasture and the animals.

Plant cover selection is also a critical factor for both pasture management and nutrient availability to the pigs. Most pastures are designed to contain different pasture grass varieties that pigs could utilize. The establishment of pasture crops with higher nutrient values would therefore ensure that the pasture provides the proper nutrition for pigs (N R C, 2012). For example, establishment of clover, oats, and corn pastures help to increase nutritional value of the pasture thereby reducing the amount of feed supplement needed to meet the nutritional requirements of the pigs (SAN, 2003). Ideally, the pasture should not be grazed until the new crop reaches maturity, possibly one full season, before the animals are allowed to graze on it (Miao *et al.,* 2004; Pietrosemoli and Green, 2018). Again, the established grasses should not be utilized until they reach 8 to 10 inches in height (Kenny, 2022). The optimal land carrying capacity of three sows per acre of land has been recommended by SAN, (2003), although this would greatly depend on the availability of water, appropriate climate, and growing season.

The Physiological Bases of Feeding Pig with Forage

Several studies have reported varied effects of forages as sources of dietary fiber and bioactive substances such as vitamins, antioxidants, minerals and even antinutrients on pig nutrition. Numerous feeding trials have also reported the effects on growth performance, carcass, hematology and overall performance of pigs at different stages of development. The cost effectiveness of using forage to feed pigs however remains perhaps the most critical factor to the pig farmer and will therefore determine the adoption of the research outcomes.

Forage and fibre digestion in pigs: Dietary fibre, usually defined as the indigestible portion of food derived from plants and forages forms a key component of many pig diets, which although not fully digested, could affect a wide range of physiological processes, in the gut (Esonu, 2015). Dietary fibre for example could directly influence gut fill (Omede, 2010) or indirectly the production of gases in the gut and physiologically the production of active by-products following fermentation in the colon (Luo *et al.,* 2022). Dietary fibre also changes the nature of the contents of the gastrointestinal tract, which in turn affects how other nutrients and chemicals are absorbed (Jarrett and Ashworth, 2018). The ability of the pig gastrointestinal tract to adapt to high fibre diets usually takes several days and even upto 5weeks for raw potato diets as reported by Martinez-Puig *et al.* (2003). This is because the duration of consumption of the high fibre diet usually alters the digestive processes in the digestive tract since the fibres are not hydrolysed by the by the endogenous enzymes but by the fermentative activities of bacteria in the large intestine (Hoogeveen *et al.,* 2020). Dietary fibre also modifies the microbial equilibrium in the intestine, with positive or negative outcomes on the intestinal health depending on the dietary fibre source and the physiological status of the pig (Hu *et al.,* 2023). For example, Owusu-Asiodu *et al.* (2006) reported that the addition of guar gum or cellulose to a standard pig diet increases the ileal Bifidobacteria and Enterobacteria populations in growing pigs.

The dietary fibres can also act as an antinutrient thereby reducing the digestibility of dietary energy and proteins (Noblet and Le Goff, 2001), and particularly amino acids, particularly threonine, absorption (Blank *et al.,* 2012). Again, most of the proteins in the fiber which could be as high 30% are in the form of nitrogen is bound to neutral detergent fibres and are therefore not available to the animal (Bindelle *et al.,* 2008). The various methods used to reduce proposed to reduce the anti-nutritive properties of dietary fibres include particle size reduction to improve digestibility, de-hulling or scarification to reduce tannin content, and heat treatments to reduce heat-labile anti-nutritive factors (Woyengo *et al.,* 2014). The digestibility coefficient of dietary fibre is however relatively low and varies from 0.40 to 0.60, compared to proteins, fats, sugars or starch which have values above 0.80 (Akinmoladun *et al.,* 2021). Studies have also shown that the predominant fiber fraction in a fibrous material also determines its digestibility for example, wheat straw is poorly digested because of the presence of lignin, whereas sugar beet pulp is more digestible because of the abundance of pectic substances in it (Karr-Lilienthal *et al.,* 2005; Zagury *et al.,* 2021).

Several studies have shown that inclusion of high fibre vegetables like potatoes or green fodder in pig diets has some beneficial effects on both their health and meat quality. For example, potato fodder as a dietary ingredient although rich in starch and relatively low in protein has a high biological value and good digestibility (Jentsch *et al.,* 1992; Turyk *et al.,* 2014) and has been shown to moderate both commensal and pathogenic bacteria count in excreta, indicating its potential value as an alternative antimicrobial agent (Jin *et al.,* 2008; Zhang *et al.,* 2022). Other studies reported that intake of green roughage has significant positive effect on meat sensory attributes such as tenderness and taste (Danielsen *et al.,* 2000; Turyk *et al.,* 2014), and the intestinal microflora and mucosal health (Zhang *et al.,* 2022). The use of forages rich in dietary fibre was also proposed by Bindelle *et al.* (2008) for more extensive systems, including tropical extensive production systems where the ability to reduce urinary nitrogen emission is of great interest as a means to promote nutrient recycling (Pu *et al.,* 2020), reported improvements in the diversity and metabolic capacity of the distal intestinal microorganisms in finishing pigs although the fiber digestibility or growth rate (Pu *et al.,* 2020), also reported that Chinese indigenous pig breeds have better digestibility for crude fiber, as shown by the optimal growth performance of growing-finishing pigs fed a high crude fiber (20%) alfalfa based diets.

Effect of feeding forage on pig performance: Since pigs are opportunistic omnivores capable of foraging above and below the ground surface, it has been postulated that pasture feeding of pigs could help to contribute to the nutrient requirement of pigs (Jakobson *et al.,* 2015; Kyntaja *et al.,* 2014), for example foraging activity found by Kongsted *et al.* (2018) to increase among feed restricted pigs compared with non-feed restricted ones, while Rodrique-Estevez *et al.* (2009) reported up to 15% total DM intake of forage in such pigs. Jakobsen *et al.* (2015) also reported that pigs fed 80% of their recommended energy requirements and had access to 4 M^2 of pasture/pig/day during 40 days trial were able to gain weight indication that the strategy could be valuable for organic farming. Sreng *et al.* (2020) reported that offering morning glory (*Ipomoea aquata*) to growing castrated male Yorkshire x Duroc cross breed pigs fed a restricted level of complete diet improved the final body weight without any economic advantage over the unrestricted feeding of complete diet. Friman *et al.* (2001) also reported that feeding of grass/clover silage to growing pigs at 20% replacement of dietary CP content resulted in similar performance results with feeding commercial control diets.

Again, Leterme *et al.* (2006) observed that the inclusion of tropical foliage at 300 g/ kg DM diet, resulted in higher protein digestibility in sows (0.12 to 0.36) than in growing pigs among which the digestibility of the diet decreased sharply when the rate of incorporation of the leaves increased from 0 to 200 g/kg diet (Leterme *et al.,* 2005; Leterme *et al.,* 2009). In a recent study by Bollido (2024) different mixtures of forage such as Madre De Aqua (*Trichantera gigantea*) and taro (*Colocasia esculenta*) were fed to native pigs with significant influence on the feed conversion ratio of native pigs. The pigs on 100% commercial feeds recorded the lowest and better feed conversion ratio of 3.95 while those fed the 50% taro, and 50% kitchen leftover mixture also recorded higher feed conversion 0f 7.86. Toan and Preston (2010) had earlier reported that feed intake live weight gain and feed conversion ratio are generally improved when ensiled taro leaves and stems are fed to growing pigs. Keto *et al.* (2021) fractionated grass silage into liquid and solid fractions and used the silage juice to fatten growing pigs and reported a lower dry matter intake among the pigs without adverse effects on growth performance, indicating its potential value as feed ingredient. Hermansen *et al.* (2017) reported 30 – 50% DM and 40 – 60% CP in a typical grass silage juice, with the other components being minerals, fermentation and products and water-soluble carbohydrates, especially residual sugars, (Keto *et al.,* 2021).

Effect of feeding forage on pig carcass traits: The carcass traits of growing-finishing pigs reared on sowed forages have also been shown to vary between studies. For example, Fortina *et al.* (2011), reported no statistical differences in the carcass traits of pasture fed castrated male and female pigs, although the castrated males showed a slightly better hot carcass yield, higher percentage of total fat cuts and ham weight than the females. Even if there are possibilities for further improvement of the Fortina *et al.* (2011) also reported that the breeding period of pigs reared outdoor is usually longer than that of pigs reared indoor, and that pasture can be used to replace 50% of the nutritional needs, such pig thereby helping to save on grain costs, without affecting carcass characteristics. Specifically, Edward *et al.* (2011) reported that grazed vegetation intake has been estimated to 0.1 kg DM/d for growing pigs that had access to supplemental feed *ad libitum*, and 2.0 kg DM/d for dry sows in restricted feeding programs. This intake could fulfill approximately 50% of the daily maintenance energy requirement for dry sows, but less than 5% of growing pig requirements. A recent study by Becker *et al.* (2024) however reported that rearing pigs on pasture had minimal impact on pork composition in terms of meat, PH, loin eye area, colour and marbling, although such pigs recorded lower back-fat thickness. Friman *et al.* (2001) however reported growing pig fed grass/clover silage recorded slightly lower carcass and dressing weights but similar lean meat content and much lower lean meat growth than the control pigs fed commercial feed. These studies show that forage could replace substantial levels of the nutrient requirements of pigs with satisfactory growth performance and carcass traits. In a comparative study using commercial feeds and local forages however, Bollido (2024) reported higher cost of production with commercial feeds resulting in negative profit and return on investment, although higher final weight and weight gain were recorded. Increased income of up to 40% per year from the sales of piglets, was however reported for pigs fed with Madre de Aqua, (*Trichantera gigantea*) and kitchen leftovers indicating significant response to growth and piglet production (Bollido *et al*., 2021).

Constraints to pasture feeding of pigs: Several risk factors and constraints can arise from the pasture feeding of pigs. For example, forage feeding of growing pigs could lead to unmet nutritional requirements or introduce anti-nutritive factors to the diet (Moerman, 2019), therefore highlighting the need for producers to be aware of these risks (Killbride, *et al.,* 2009; Edward *et al.,* 2011). Forage availability in terms of quantity and quality, may also be seasonal in response rainfall patterns and temperature (Edwards, 2003). These seasonal effects could alter the availability of feedstuff, thereby impacting animal welfare and productivity; and thus, necessitating adjustments in feed supply (Miao *et al.,* 2004) in many tropical countries, feed scarcity periods could lead to higher incidences of livestock ingesting toxic plants (Poppenga, 2010). Again, pasture and indoor-confinement environments and might generate different welfare needs for pigs managed in two different production systems. For example, raised by Pandolfi *et al.* (2017) reported that previous rearing environment, management, pig health, wetness, filthiness conditions of pens and paddocks, and stocking rates could lead to unexpected responses in pig when released on similarly to pasture systems. Similarly, weather conditions such as precipitation, temperature, humidity, solar radiation, wind strength, wind direction, rainfall, and atmospheric pressure could serve as stressors to pigs kept on pastures (Lukovic *et al.,* 2017; Parrini, *et al.,* 2019). The initial manifestations of such stress to weather are restlessness, irritation, and aggressiveness (Olczak *et al.,* 2015), followed by other behavior changes, injuries, lower growth rate, and reproductive performance in extreme cases (Oliveira Júnior *et al.,* 2011). The impact of environmental conditions on pigs usually vary according to the age, weight, reproductive stage, health condition, feeding status, and production systems (Barnett *et al.,* 2001; Olczak *et al.,* 2015). Excessive heat or cold could cause thermal stress on grazing pigs with the upper limit of the temperature comfort zone decreasing as pigs age (Wegner *et al*., 2014; Lukovic *et al.,* 2017; Edward, 2003). (Parois *et al.,* 2018) reported 32 to 35 °C for pigs under 3 kg, 26 to 35 °C for pigs in pre-nursery, and 10 to 35 °C for grower-finishers and sows and boars greater than 100 kg.

Again, on pasture pigs are exposed to greater risks of pathogenic diseases that could impair their health and welfare, or could be transmitted to humans (Lukovic *et al.,* 2017; Stelzer *et al.*, 2019). Additionally, the implementation of bio-security measures and control programs is far more complex in pasture systems (Davies, 2011; Jensen and Baggesen 2006; Maes *et al.,* 2019). Pathogens such as salmonella and campylobacter may accumulate in soils from paddocks pigs (Jensen *et al.,* 2020), such that higher prevalences of salmonellosis, toxoplasmosis (Jensen *et al.,* 2020; Thomas *et al.,* 2013), *trichinellosis* (Thomas *et al.,* 2013), *Loptospirosis* (Bratislava, Jackson and Cockcroft, 2007; Maes *et al.,* 2019) *Ascariosis* (Roepstorff *et al.,* 2011; Sutherland *et al.,* 2013), and tape worm infection (Thomas *et al.,* 2013) have been reported in pigs raised on pasture.

Types of Pastures Fed to Pigs

Forage used in the diets of pigs in the tropics covers a wide range of plant species. It includes grasses, legumes, aquatic plants, and leaves from shrubs and trees. Forage is fed, either in fresh or preserved form as hay or silage (Ogle, 2006). Some tropical forage species such as *Manihot esculenta*, *Ipomoea batatas, Leucaena leucocephala, Arachis hypogaea, Stylosanthes guianensis, Colocasia esculenta, Azolla filiculoides, Salvinia molesta, Xanthosoma sagitifolium*, *Lucerne,* alfalfa, red clover, *Brassicas* and *Morus alba* have been already assessed in vivo in pigs (Feedipedia, 2013). However, although there are locally used by smallholders, most species have not been assessed further than the determination of their chemical composition and, sometimes for their in vitro digestibility for pigs (Feedipedia, 2013). Examples of such plants are numerous, and they include, among others, *Moringa oleifera*, *Psophocarpus scandens* (Kambashi *et al.,* 2014), *Crassocephalum crepidioides* and *Amaranthus viridis* (Phengsavanh *et al.,* 2010). Obua *et al.* (2013) listed 38 forage species made up of trees, shrubs, herbs, lianas and woody vine which smallholder farmers fed to pigs in Southeastern Nigeria. Moses (2019) also reported that 13 plant species were used in the feeding of pigs in imo state. Ayoade and Onigemo (2003) reported improvements in the hematological values of pigs fed Amaranthus spinosus leaves as part of other diets, while Adebiyi *et al.* (2018) report normal blood parameters in pigs fed maize fodder.

Advantages and Disadvantages of Feeding Pigs with Forages

Advantages: Forages have several advantages as feedstuff for pigs such as being readily available sources of highly nutritious leaf supplements at the time of year when other feeds are in short supply. Many forage legumes have high protein content of 18-25%, are excellent sources of essential minerals, and can be used as supplements to low-protein tubers and cereals (Stür *et al.,* 2006; Crawley, 2015). Forage legumes such as *Stylosanthes guianensis* could be used to feed pigs. Forage can make a valuable contribution to at all stages of development, as a source of minerals and vitamins, enhancing feed intake, supporting gut health and reducing nutrient losses (Crawley, 2015). Forage-based systems also benefit organic farmers economically by reducing overall feed costs through saving in labour costs and faster pig growth rates. (Stür *et al.,* 2007; O'meara, 2006). The provision of herbage-based diets also facilitates foraging behaviors that can engage pigs in natural activity for 70% of their time. Thereby displacing abnormal aggressive behaviors such as tail biting (Crawley, 2015). Studies conducted on benefits of feeding pigs on forages in the USA indicate that forages simplify feeding, increases milk flow of the sow, increases weight gain of piglets and improves the health of piglets (Zeller, 2014).

Disadvantages: A major disadvantage of feeding pigs with forage is that fibre utilization is affected by the age of the pig, (Noblet and Goff, 2001), although the digestive processes adapt gradually over time to exposure to fibre-rich diets (Wenk, 2001). Through the stimulation of the development of the microbiota aided in the hindgut. Consequently, adult growing pigs and sows utilize forage and high fiber diets better than young pigs (Le Goff *et al.,* 2002 a&b; 2003). Fresh forages are also generally low in dry matter (Okoli *et al.,* 2024a) which means that the pig must consume more forage material to obtain similar nutrient value from a conventional supplemented feed, this has limited use of pastures and forages in the diets of young pigs and lactating sows that require higher concentration of nutrients for their physiological needs. Again, unavailability of pasture during some periods of the year may require that the feeding program be modified from one season to the next. Similarly, there may be need to rotate off pastures periodically to prevent bacterial and parasite build-up (Phengsavanh *et al.,* 2010). Some forages may contain anti-nutrients which may affect their utilization by different animal species. Example includes, Lectins found in *Glycine max*, *Amaranthus cruentus* (Makkar, 2007); polyphenolic compounds such as tannins found in shrub legumes (Jeroch *et al.,* 1993; Cannas, 2008); saponins found in *Brachiaria decumbens, B. brizantha, Amaranthus hypochondriacus* (Cheeke and Carlsson, 1978), cyanogenic glycosides found in Phaseolus and Psophocarpus, and alkaloids found in lupins (Acamovic *et al.,* 2004). Phytates and oxalates found in *Vigna unguiculata, Desmodium velutinum, Lablab purpureus and Setaria* (Weiss, 2009) are also among the common compounds that may limit the effective utilization of forages in pig feeding since they often cause digestive and health disorders and even death (Esonu, 2015).

Conclusion

Forages have several advantages as feedstuff for pigs such as being readily available sources of highly nutritious leaf supplements at the time of year when other feeds are in short supply. Many forage legumes have high protein content of 18 - 25%, are excellent sources of essential minerals, and can be used supplement low-protein tubers and cereals in pig diets. The major disadvantage of feeding pigs with forage is that fibre utilization is affected by the age of the pig, although the digestive processes adapt gradually over time to exposure to fibre-rich diets. Some forages may also contain anti-nutrients which may affect their utilization by pigs. The cost effectiveness of using forage to feed pigs however remains perhaps the most critical factor to the pig farmer and will therefore determine the adoption of pasture feeding.

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