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Effect of root and tuber peels on livestock and poultry production in Nigeria (A Review)

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Abstract

This review was undertaken to examine the potential value of roots and tubers like cassava (Manihot utilissima), sweet potato (Ipome abatatas), cocoyam (Xanthosoma sagittifolium), yam (Dioscorea spp) and their by-products as dietary supplements for non-ruminants. Studies on these roots and tubers showed that, on a dry-weight basis, contained 2.0 – 7.9% crude protein, 0.3 – 3.1% crude fibre and 72.4 – 77.9% starch. The practical use of these roots and tubers in non-ruminant feeds is generally low. This level of utilization is attributed to the low protein, dry matter and the potentially toxic cyanogenic glycosides in fresh cassava and irritating substance in cocoyam. Processing techniques such as fermentation, soaking, boiling, ensiling and sun-drying are adopted to remove the deleterious substances, and effects on animals. The comparable performance of pigs and poultry fed varying levels of roots and tubers and their by-products with those maintained on maize showed that they can be used as substitutes in non-ruminants' diets at certain levels without detrimental effects. To achieve increase in the use of these root crops and their by-products for maize replacement in intensive non-ruminant production systems, adequate protein supplementation and proper processing are essential.

Keywords: *Roots and Tubers, By-Products, Ensiling, Ruminants and Non-Ruminants*

Effet des ecorces racinaires et tubercules sur la production de betail et de volaille au Nigeria (UNE CRITIQUE)

Résumé

Cette revue a été entreprise pour examiner la valeur potentielle des racines et tubercules comme le manioc (Manihot utilissima), la patate douce (Ipomea batatas), le taro (Xanthosoma sagittifolium), l'igname (Dioscorea spp) et leurs sous-produits en tant que compléments alimentaires pour les non-ruminants. Des études sur ces racines et tubercules ont montré que, sur une base de poids sec, elles contenaient 2,0 à 7,9 % de protéines brutes, 0,3 à 3,1 % de fibres brutes et 72,4 à 77,9 % d'amidon. L'utilisation pratique de ces racines et tubercules dans l'alimentation des non-ruminants est généralement faible. Ce niveau d'utilisation est attribué à la faible teneur en protéines, en matière sèche et aux glycosides cyanogènes potentiellement toxiques du manioc frais et à la substance irritante du taro. Des techniques de traitement telles que la fermentation, le trempage, l'ébullition, l'ensilage et le séchage au soleil sont adoptées pour éliminer les substances nocives et les effets sur les animaux. La comparaison des performances des porcs et des volailles nourris à des niveaux variables de racines et tubercules et de leurs sous-produits avec ceux maintenus au maïs a montré qu'ils peuvent être utilisés comme substituts dans l'alimentation des non-ruminants à certains niveaux sans effets néfastes. Pour augmenter l'utilisation de ces racines et de leurs sous-produits pour remplacer le maïs dans les systèmes de production intensive de non-ruminants, une supplémentation adéquate en protéines et une transformation appropriée sont essentielles.

Mots-clés : *Racines et Tubercules, Sous-Produits, Ensilage, Ruminants et Non-Ruminants*

Introduction

The ever increasing prices of conventional raw materials for livestock and poultry feed production, caused by inadequate supply and stiff competition between human, animals and various industries for many decades, hence the need to look for alternative unconventional feedstuffs such as peels of root and tuber crops which are suitable, readily available and cheap energy sources for livestock and poultry production. The demand for livestock and poultry products has consistently increase over the years as a result of increase in the world population which has led to inadequate supply of animal protein causing malnutrition and to meet this demand at a profitable rate, requires the need for an unconventional feed ingredient. According to Ravindran (1990), the highest increase in production occurs in developing countries. This increase in poultry production has a direct effect on the availability and price of feed. Large numbers of agro by-product feedstuff with enormous potentials exist in Nigeria. These agro-based by products are sources of energy but also have their limitations. The feeding values of these agro-by products are well documented. It is reported that 800 million people were still undernourished, which is due to insufficient access to balanced supply intake of macronutrients (carbohydrate, protein and fat) resulting in different forms of malnutrition, such as vitamin A deficiency or anaemia (FAO, 2015).

All roots and tubers store their starchy products in the stems, roots, rhizomes and tubers. Cassava and sweet potatoes are roots while potatoes and yam are tubers (Anoma and Thaminili, 2016). One of the products obtained from root and tubers are the peels which represents 5-15% of the whole tuber as in the case of cassava (Aro *et al*., 2010).

Cassava and yam peels have inestimable value in livestock and poultry feeding because of their reported energy values and mineral contents (Jiwuba *et al*., 2018a). Cassava and yam are not the only examples of root and tuber crops, cocoyam, sweet potato and ariods are also regarded as root and tubers depending on their modes of propagation (Lebot, 2009). These peels have been extensively exploited in ruminant feeding. Their use in poultry has been limited due to the low protein content (Salcedo *et al*., 2010) high cyanide content, high fiber and high moisture contents (Jiwuba *et al*., 2018a). It was reported that yam peel can replace maize in sheep feed at 100% and 66.7% level of replacement accounted for highest weight gain and return on investment. Also there were no negative effects on growth performance and digestibility of Red Sokoto goats at 100% replacement of yam peel with maize offal likewise weaner rabbits at reduced cost (Uchewa and Orogwu, 2013). When yam peel replaced maize at 50% in juvenile snails, there were similar weight gain, feed efficiency and dressing percentage and at a reduced feed cost (Omole *et a*l., 2013).

Peels and other forms of wastes from roots and tubers are low value by-products which are still underutilized and pose disposal problems in most developing countries. Seasonality in supply, high fiber contents and presence of anti-nutrients are major factors hindering efficient use of peels in poultry and livestock production. High moisture content also makes the processing of peels much difficult in humid tropical environment where these by-products are readily available.

It has been well documented that the widespread utilization of cassava peel as a primary feed ingredient in livestock and poultry feeding has been hindered due to the presence of toxic cyanogenic compounds in various fractions and cultivars, high fiber and Ash levels in peels and deficiencies of specific nutrients other than energy (Amino

Acids; particularly Methionine and Tryptophan), fatty acids, minerals and vitamins.

Feed constitutes the highest cost of expenditure in livestock production, with the exception of ruminants whose feed is based on pasture. In non-ruminants such as pigs and poultry, feed ingredients represent 65 to 70% of the total cost in an intensive production system in Nigeria as in many developing countries (Tewe, 1997). Energy source constitutes between 45 and 60 percent of finished feeds for these animals (Egbunike,1992), and at present, maize is the commonly used source of energy in livestock feeds (Olurin *et al.*, 2006). The competition on the use of maize by humans and animals coupled with the cost of maize which fluctuates with the time of the year, thus making the cereal grain to be either scarce or expensive, stimulate the use of alternative sources of energy that are locally available, particularly the starchy roots and tubers that abound in many areas of humid tropics. In addition, their byproducts such as peels, vines and leaves are non-competitive feed materials that can be developed as components of poultry and pig feeds. Although roots and tubers are cheap sources of energy, the extent of their practical use in non-ruminant feeding has been limited. For example, in Nigeria, 5% of total cassava production is used as feed. The presence of toxic cyanogenic glycosides and other undesirable substances, dustiness of the dried products, moldiness during processing and the high fibre of the peel account for the low utilization in non-ruminant production. (Olurin *et al.*, 2006;Agwunobi *et al.*, 2002).

Recently, emphasis has been placed on the expanded programme of cassava, sweet potato, yam and many high yielding varieties of cassava have developed and released through the improvement efforts of International Institute of Tropical Agriculture (IITA) and other collaborating institutions, suggests that production in excess of direct human consumption will become available for feeding farm animals in Nigeria. This paper reviews the potential value and constraints to increase use of these roots and tubers and their by-products as dietary supplements for non-ruminants. Additionally, this paper refers to ways that could increase the use of these feed sources. The aims of this review were to assess the holistic effect of root and tuber peels on livestock and poultry production in Nigeria and also to highlight the effect with respect to the availability and acceptable inclusion levels without being detrimental to the physiological status of the animals, anti-nutritional factors and possible return on investment.

Anti-nutritional Factors

Foods are complex substances that contain many chemical compounds, more than 50 of which are required to nourish the body. These nutrients include water, protein, lipid, carbohydrate, minerals and vitamins. Most plant foods consist of natural compounds or anti-nutrients that appear to function generally in defense against herbivores and pathogens. Anti-nutrients are potentially harmful and give rise to a genuine concern for human and animal health in that they prevent digestion and absorption of nutrients. They may not be toxic as such, but can reduce the nutritional value of a plant by causing a deficiency in essential nutrients or preventing thorough digestion when consumed (Eyo, 2003). The most commonly known and studied anti-nutritional factors in roots and tubers include cyanogenic glycosides, saponin, phytate, oxalate, enzyme inhibitors and total alkaloids. They must be inactivated or removed before they are suitable for non-ruminants (Bhandari and Kawabata, 2004; Agbor-Egbe and Mbome, 2006).

The cyanogenic glycosides or cyanogens are glycosides of 2-hydroxynitriles that are synthesized and stored in cassava and are widely distributed among plants (Rosentha and Berenbaum, 1991;Bisby *et al*., 1994). The peel component has the highest concentrations of cyanogenic glycosides in cassava. In cocoyam tubers, Abdulrashid and Agwunobi (2009), Olajide, *et al*. (2011), reported wide variation (2.10 – 17.13mg/100g) in the level of these undesirable substances. Hydrolysis of cyanogenic glycosides releases hydrogen cyanide (HCN), which inhibit several enzyme systems, depress growth through interference with certain essential amino acids and utilization of associated nutrients (Egbunike, 1992;Okafor, 2004). Cytochrome oxidase, is the primary site of action for ingested cyanide, an effective inhibitor of many metallo-enzymes (Emeking and Wink, 2000).

The enzyme cytochrome oxidase in the mitochondria of cells is inactivated by hydrogen cyanide binding to the Fe^{2+}/ Fe^{3+} contained in the enzyme. This results in a reduction of oxygen usage in the tissues (Vetter, 2000) and oxygen starvation at cellular level, due to the effects of cyanide poisoning, resulting in death. Respiratory failure is therefore the cause of death since the respiratory centre nerve cells are extremely sensitive to hypoxia (Okolie and Osagie, 1999). Other diseases associated with dietary cyanide intake include (i) konzo (Cliff *et al.,* 1997), a paralytic disease; (ii) tropical ataxic neuropathy (TAN) (Onabolu *et al*., 2001), a nerve-damaging disorder that renders a person unsteady and uncoordinated; (iii) goiter and cretinism (Delange *et al.,* 1996). Sheeba and Padmaja (1997), observed that the palatability and shelf-life of cassava products may be prolonged by processing. The levels of cyanogenic glycosides and hydrogen cyanide are also reduced to safer limits by processing (peeling, slicing, boiling, fermentation) before consumption (Sheeba and Padmaja, 1997; Feng *et al.,* 2003).

Phytic acid, which is hexaphosphate of myo-inositol, is very common in the plant kingdom (Chan *et al*., 2007). Phytic acid is the primary storage compound of phosphorus in plants, accounting for up to 80 per cent of the total phosphorus (Raboy, 2001). Phytic acid has been found in cassava root (Panigrahiet *et al*., 1992) and cocoyam tuber (Olajide *et al*., 2011) up to levels of 62.4 and 1.75g/100g, respectively. Josefsen *et al.* (2007) reported that the negatively charged phosphate in phytic acid strongly binds to metallic cations (e.g. Ca, Fe, K, Mg, Mn and Zn) and forms a mixed salt called phytin or phytate.

Phytate forms insoluble complexes because they are negatively charged under physiological conditions. These complexes cannot be digested or absorbed in the gastrointestinal tract of monogastric animals owing to the absence of the intestinal phytase enzyme (Igbal *et al.*, 1994). Deficiencies of phosphorus and nutritionally important minerals in monogastric animals can be a result of cations bound in the phytic acid salt and of low bioavailability of phosphorus (Apata and Ologhobo, 1989; Gibson *et al*., 2006)

The plant oxalis, commonly known as wood sorrel, gave rise to oxalic acid, a strong, organic acid which has been found to be widely distributed in plants (Liebman, 2011). Up to 45.30g/100g has been found in cocoyam tuber (Olajide *et al.*, 2011). Strong bonds are formed between oxalic acid and various other minerals, such as calcium, magnesium, sodium and potassium (Fink, 1991; Noonan and Savage, 1999).

This chemical combination results in the formation of oxalate salts. A salt formed from oxalic acid is known as an oxalate: for example, calcium oxalate. Some oxalate salts, such as sodium and potassium, are soluble, whereas calcium oxalate salts are basically insoluble. The insoluble calcium oxalate has the tendency to precipitate (or solidify) in the kidneys or in the urinary tract, thus forming sharp-edged calcium oxalate crystals when the levels are high enough (Bradbury, 1988). These crystals play a role in the formation of kidney stones (Noonan and Savage, 1999). When oxalic acid is consumed, it irritates the lining of the gut and can prove fatal in large doses. Most taro cultivars have an astringent taste and can cause swelling of lips, mouth and throat if eaten unprocessed. This is caused by closely-packed, needle-like, calcium oxalate crystals, which can penetrate soft skin (Bradbury, 1988). Both the tubers and the leaves can give this reaction (FAO, 1992) but this effect is reduced by cooking (Bradbury, 1988).

Cassava Peels in Rabbit and Snail Feeds

Inclusion of cassava peels in rabbit and snail feeds has been extensively researched and this is one of the reasons why performance level in livestock becomes imperative. It was reported by (Olugbenga *et al.*, 2019) reported the inclusion cassava peels beyond 35% requires a high quantity supplementation of methionine in addition to multi-enzyme to achieve a good performance, (Osakwe and Nwose, 2008) reported that cassava can replace maize at 100% in weaned rabbit without any deleterious effects and the conclusion of (Omoleet al., 1990;Esonu and Udedebie, 1993), (Agunbiade*et al.*, 1999); Olorunsanya *et al.*, 2007) pointed out the inclusion of up to 30% cassava peel in rabbit feeds resulted in no negative effect on growth and organ development.

Furthermore, (Ojebiyi *et al.*, 2009) concluded that young female rabbits can tolerate a mixture of cassava peel and blood meal up to 30% without adverse effect on growth performance. In growing Snails, a previous study by (Kehinde, 2009) showed a 40% reduction in growth and carcass yield of snail's exclusively fed cassava material but recommended in his research work in 2018, a 15% inclusion level of all cassava by products (cassava peel, cassava leaf, cassava seviete and cassava chaff) was recommended without any adverse effect. Also in a preliminary study carried out by (Maduekeh *et al.*, 2021), it was revealed that amending cassava peel meal with 20% blood meal could replace poultry starter feed mash for optimum performance of the snail's.

The Anti Nutritional Factors are also present in yam and require processing in order to enhance the availability of the nutritional content from the yam. Anti-Nutritional Factors present in yam include phenol (0.16 to 0.27%); hydrogen cyanide, (9.62 to 12.00 mg/kg); alkaloids, (0.12 to 0.55%); tannins, (46.50 to 180.25%); phytate, (0.22 to 0.28%); heamagglutinin, (1.22 to 5.75 Hu/g) and trypsin inhibitor,24.02 to 49.51. TI unit/mg. (Udensiet al., 2010)

Inclusion level of peels

According to (Yaqoob *et al.,* 2019; Gamboet al., 2015), growing rabbits showed no adverse effect on performance when maize was replaced up to 100% with yam and Irish potato peel meals. Also there was reduction in cost per kg of feed up to 27% which translates to increase in Return on Investment. This is in line with (Uchewa, 2013) who reported that a 100% replacement of maize with yam peel had no adverse effect on the performance, and carcass characteristics of weaner rabbit so also reduction in the cost of feed/kg weight gain.

The conclusion of (Adeyemi *et al.,* 2014) was that of 25% of dietary maize content of rabbit feed can be replaced with fermented cassava leaf meal and peel meal mixture and can result to superior performance over the diet with 100% maize.

In snail production, it was reported by (Omole *et al.*, 2013) that replacement maize in snail diet with 50% yam peel resulted in relatively increase in weight gain, feed efficiency and dressing percentage without any deleterious effect.

Return on Investment by farm animals with cassava peel

As regards Return on Investment, (Olafadehan, 2011) reported that using retted cassava peel meal resulted in the reduction of cost of feed/kg body weight in rabbits followed by sundried cassava peel meal and ensiled cassava peel meal with a percentage relative cost benefit/kg body weight of 25.98, 23.26 and 16.40 respectively. The conversion rate at the time of the research was #120/$.

It was reported by (Olorunsanya *et al.*, 2007) that replacement of maize with cassava peel resulted to the reduction in producing a unit weight of weaner rabbit. In Snails, (Kehinde, 2018) reported that snails fed different cassava by products (cassava peel, cassava leaf, seviate and chaff) showed a decrease in the cost of production/g weight gain with #0.35/g weight gain recorded for snails fed cassava leaf.The lowest cost per weight gain of N196.56 was recorded in snail fed diet containing 50% Yam Peel (YP) as replacement for maize fraction of the diet according to (Omole *et al.*, 2013)

Cassava in diets of Poultry

Poultry feed constitutes more than 90 percent of all commercial livestock feeds produced. The use of cassava as a substitute for maize will therefore make its greatest impact if it can be incorporated into commercial poultry feeds. Certain precautions need to be taken to achieve satisfactory performance of stock on cassava-based diets. These include removal of cyanide, higher protein supplementation with fish meal, soybean, groundnut cake or methionine in its pure form and the prevention of microbial activity during sun-drying as well as overcoming dustiness. Most of the present studies indicate that satisfactory growth response has been obtained for growing chicken at 10% incorporation of cassava flour (lafun) or cassava peel into the diet; 40% inclusion of cassava flour or 20% inclusion of cassava peel in layer's diet is satisfactory for egg production (Egbunike , 1992). Combination of cassava root and leaves in ratio 4:1 could replace maize in poultry diets and reduce feed cost without a loss in weight gain or egg production (Tewe and Bokanga, 2001) . Feeding cassava chips supplemented with Moringaoleifera leaf meal at 5% and 10% levels showed that cassava chips replacing maize at 55.56 and 83.33% in the diets of broilers had no negative effect on productivity and haematology when 5% Moringaoleifera leaf meal was added (Olugbemi *et al.*, 2010).

Cassava Peels in Poultry Diets

Cassava peel can be used to cut down the cost of production and lead to an active and sustainable development in livestock production (Olorede *et al.*, 2002). Some workers [55 -57] recommended the inclusion of fermented cassava peel up to 15% in broiler diets with no adverse effects. For a reasonable performance of animals fed cassava-based diets, the rations must be nutritionally balanced and with protein source that contain sufficient sulphur-containing amino acids (Tewe, 1991).

In the study on the influence of protein source on the performance and haematology of broiler chicken on cassava peel-based diets using fishmeal and groundnut cake, Egbunike *et al* (Egbunike *et al.*, 2009) reported that broilers could be raised on cassava peel-based diets using groundnut cake as protein source without any adverse effect on performance indices. Also, Sogunle *et al.* (2009) studied the inclusion cashew nut reject and cassava peel meal in the diet of growing pullets and concluded that combination of 10% cassava peel meal and 30% cashew nut reject meal was appropriate for enhanced performance of growing pullets.

Cassava in Diets of Pigs

Cassava can be fed to pigs either fresh or parboiled (as commonly practice in small and medium scale pig farms), or included in the diets as a dried meal. Due to high level of moisture, fresh cassava is not recommended for feeding suckling and weaned pigs. Also, in starter pig diet, cassava meal should be limited because of the potential problems with palatability and its powdery nature which can affect respiratory organs. This can be overcome by pelleting. The use of cassava peels as a partial replacement for maize in young pig diets was cost effective and up to a 57% level of inclusion had no deleterious effect on the pigs (Balogun and Bawa, 1997). Reports on growing-finishing pigs fed diets supplemented with groundnut cake, fish meal and brewer's dried grains in which cassava meal or cassava peel substituted 60% or 100% of the maize respectively, showed no decline/adverse effects on performance and the economics of replacing maize with cassava or its by-product will depend on the price of protein supplementation that can provide an adequate margin of profit (Sonaiya and Omole, 1983). The authors concluded that 40% inclusion of cassava into growing pig diet was economically feasible. Ospina et al. (1995) found that pigs fed cassava root meal ad libitum, combined with 200g/day of crude protein throughout the growing-finishing period gave acceptable growth performance and carcass quality.

Potentials and Limitations of Cassava Leaves as Non-Ruminant Feed

Cassava, one of the world top calorie producers for human consumption, is generally grown without fertilization on soils with poor fertility and can survive prolonged water deficit (Alves and Setter, 2000), tolerant to acid soil and the yield is limited by poor phosphorus supply (Howeler , 1985). Cassava is planted mostly for its tuberous root, leaving the leaves to wither after harvesting the root. However, it is possible to obtain from cassava leaves more than 6 tonnes of crude protein ha^{-1} $year^{-1}$ with proper agronomic practices directed toward foliage harvesting ([5].

Cassava leaf contains high level of crude protein, vitamins and nutritionally valuable minerals (Rogers and Milner, 1963; Aletor and Adeogun, 1995). The nutritional limitations of cassava leave include the HCN content, low digestible energy, bulkiness and possibly the high tannin content (Ravindran, 1986). The inherent cyanogenetic glycosides may limit its use as a non-ruminant feed. The cyanogenetic glycosides, is influenced by the nutritional status and age of the plant (Ravindran and Ravindran, 1986), and higher HCN levels were found in leaves from bitter than in sweeter varieties (Tewe and Iyayi, 1989). However, the HCN concentration and the bitterness associated with high cyanogenetic glycoside contents in leaves (Sundaresanet al., 1987) decreases with the maturity of the leaves.

The two most widely used processing methods are sun drying and ensiling. In the humid tropics, especially in the wet season, sun drying is difficult and may result in the production of low quality product with severe Aspergillus and aflatoxin contamination. Ensiling the leaves entails chopping into small pieces (2-3cm), then mix with additive and add common salt at 0.5% and store in sealed air tight plastic bags for two months could reduce HCN content up to 80% of the original concentrations.

In poultry it is reported that broilers could tolerate diets containing 141 mg total cyanide kg^{-1} without any negative effects on growth performance (Ravindran et al., 1986). According to Fasuyi and Aletor (2005) cassava leaf protein concentrate can replace up to 60% fish meal without any negative effects on growth performance, haematology and serum metabolites of broiler starter. In pigs, the inclusion of 15%

fresh cassava leaves in the diet had no adverse effects on the performance of growing-finishing pigs (Sarwatet al., 1988)]. Dried or ensiled cassava leaves have been used at 16.5% and 20% respectively in the diets without significant effects on performance and carcass traits of growing pigs (Nguyen et al., 2010). However, Ravindran (Ravindran, 1990) reported a depression in weight gain and feed efficiency when cassava leaf meals were included at up to 30% in diets for growing-finishing pigs. KhieuBorin et al., (2005) reported a significant improvement of daily weight gain of crossbred pigs fed a mixture of cassava leaves and water spinach as compared with those fed cassava leaves alone, due to increase intake and possibly the better amino acid balance of the mixture.

Sweet Potato for Non-Ruminant Feeds

The sweet potato (Ipomoea batatas) belongs to the morning-glory family Convolvuceace. It is cultivated primarily in tropical areas and ranked fifth among the most important food crop in the tropics (An, 2004). The cost of production of sweet potato is much lower compared to cereal crops (Huarg, 1982). The carbohydrates of sweet potato are highly available and can be greatly utilized by non-ruminant animals (Oboh, 1987). Also, patatin which accounts for 30-40% of protein in the potato tuber is extremely well balanced, being nutritionally similar to casein (Liedlet al., 1987).

The leave meal has a high protein content of between 26 to 33%, with high amino acid score. It has good mineral profile and rich in vitamins like A, B_2, C and E. Apart from its nutritive values, sweet potato leaves can be harvested many times throughout the year (Hong et al., 2003) thereby making the leaf meal to be abundant. The major factor limiting its use in monogastric animal is the presence of anti-nutritional factors (Tacon, 1993). The antinutritional substances present in the sweet potato leaves, according to Oyenuga (Oyenuga, 1968), are the protease inhibitors and invertase. These substances can be inactivated by various processing methods like oven or sun-drying, boiling or steaming and grinding prior to inclusion in animal feeds.

With regard to non-ruminant feeding, the data on sweet potato are limited. However, reports by Yeh and Bouwkamp (1985) and Nwokolo (1990b), showed that up to 50% of the grain in corn-soybean diets could be replaced with sweet potato chips, without a significant depression in growth or production. With such high levels of replacement, it may be necessary to supplement such sweet potato – based diets with 0.2-0.5% of lysine. The dustiness of the sweet potato and high content of reducing sugars will tend to limit its use at such high levels in poultry and other non-ruminant ruminant diets (Akinmutim and Osuagwu, 2008).

Inclusion of sweet potato leaf meal in the diet of Tilapia zilli showed that levels up to 15% could be added without any negative effects on the growth, feed efficiency and protein digestibility (Adewolu, 2008). In the same vein, Omoregie et al. (2009) revealed that Oreochromisniloticus could tolerate up to 15% level of inclusion of sweet potato peel.

Cocoyam in Poultry and Pig Diets

Cocoyam is recognized as cheaper carbohydrate sources than grains or other tuber crops (Obioha , 1972). It has high caloric yield per hectare, low production cost (Hahn, 1984) and relatively low susceptibility to insect and pest attack. Similarly, it is reported that cocoyam has readily digestible starch content because of its small particle size (Lyonga and Nzetchueng, 1986; Ezedinma, 1987). It is almost competition-free with man in most places as it is eaten only as a last resort when a family can no longer afford garri or yam. It is therefore more likely to be available for use at lower cost. The use of cocoyam as food for man and animal has limiting factors such as storage and presence of antinutritional factors.

Taro is closely related to Xanthosoma and Caladium, plants commonly grown as ornamentals. The antinutritional factors found in taro cocoyam include oxalates, phytates, Tannins and Saponins. (Agwunobiet al., 2002). However, some may serve as defensive mechanism against pests and diseases. Therefore, oxalates have been found to be as defense mechanism and a storage reserve for calcium (Smith , 1982). There is limited reference work on the utilization and inclusion of taro cocoyam as an alternative energy source in poultry production. However, Anigbogu (1997) and Abdulrashid and Agwunobi (2009) reported that taro meal should not exceed 25% replacement of maize in broiler diets.

Tania (Xanthosomasagittifolium) is a high-yielding, disease resistant crop. Its energy content appears moderate when compared with maize. However, like most varieties of cocoyam, the problem with Xanthosomasagittifolium is its content of some antinutritional factors which could be a limitation to its use (Okonet al., 2007). This limiting factors can be removed by boiling or sun-drying (Abdulrashidet al., 2006).

Esonu (2000) reported that starter broilers could tolerate up to 20% inclusion levels of wild variegated cocoyam (Canadiumhortulanum). On the other hand, Uchegbu et al. (2010) showed that raw sun dried cocoyam meal can be used in the diet of finisher broilers up to 15% inclusion level without being detrimental to their performance. However, 10% cocoyam inclusion level is the best in terms of daily weight gain, feed conversion ratio, and cost effectiveness.

Wild cocoyam is a high moisture tuberous rootstock. Presently, it is not directly consumed by man and equally of no industrial use. Available literature on the feeding of wild cocoyam meals to finisher broilers suggests that it is a satisfactory energy ingredient at up to 20 % of the whole ration (Onuet al., 2001; Onu and Madubuike, 2009). However, its liberal use in monogastric animal feeding could be encumbered by the presence of some anti-nutritional factors (tannin and trypsin inhibitor), which adversely affect protein and energy utilization in broilers (Onu and Madubuike, 2009; Huisman, 1995). The use of heat to inactivate these anti-nutritional factors could increase the use of wild cocoyam as a feed component in broiler diets.

Cocoyam corms intended for utilization as pig feed need to be cooked prior to drying and feeding to ensure removal of the toxic substance (oxalic acid) present in the corms, leaves and petiole of the plant. There are few actual experiments conducted on cocoyam utilization. However, it is recommended that cooked dried cocoyam can be fed on sows in gestation and late lactation but not to starter pigs or those in the early grower phase. Cocoyam silage may be fed to pigs in the growing and fattening stages, as well as to gilts in gestation and lactation. At levels of 20 – 40% of dry matter, cocoyam silage supported adequate growth rate in young pigs (Esonu, 2000). Ohaemenyi (1993) reported that Xanthosomasagittifolium corms can be cooked and used to some extent in the diets of growing pigs.

Conclusions

Considering the chemical and nutritional characteristics of available alternative energy supplements of roots, tubers and their by-products, they have potentials for increased use as alternative energy supplements for non-ruminant production. Furthermore, these materials possess readily digestible energy. The comparable growth performance of pigs and poultry fed varying levels of roots, tubers and their by-products with those fed maize showed that they can be used as substitutes in non-ruminants' diet at certain levels without being detrimental to their performance. However, for improved performance of animals, rations containing roots, tubers or their by-products must be formulated to contain good protein source and sufficient sulphur-containing amino acids. In addition, various processing methods (e.g. drying, boiling, frying, fermentation and ensiling) can be employed to eliminate or reduce the anti-nutritional factors present; this will improve the quality and safety of these feed materials. If these findings are diffused and adopted by farmers and livestock feed manufacturers, the amount of roots and tubers used in non-ruminant feed production in Nigeria would increase with consequent reduction in pressure on demand for cereal grains.

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