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Review Article

# Oilseeds of Indigenous Fruit Bearing Trees as Alternative Feedstuffs or Supplements in Livestock Diets

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## Abstract

In Africa, commercial and smallholder livestock production enterprises are growing, thereby increasing the demand for livestock feeds. Convectional ingredients mainly maize and soybeans have been and still are the main sources of energy and protein in livestock diets respectively. But with the growth of the livestock sector, the world's population and increased demand for convectional sources, alternative ingredient sources have to be taken into consideration. The high cost and, sometimes, the lack of availability of the known convectional sources is known as one of the main limitations to efficient animal production. This makes the prospects of utilizing oilseeds of indigenous fruit bearing trees as alternative feed ingredient sources feasible because of their ease of propagation and availability. This review article will explore the options to reconsider oilseeds of indigenous fruit bearing trees found in the African ecosystem as alternative plant based feedstuffs or supplements for soybean and maize in livestock diets. This review will also highlight some of the potential oilseeds of indigenous fruit bearing trees found on the African continent, in order to reduce farmers' dependence on conventional sources.

## Introduction

As indicated by projections of the FAO [1], by 2050 the world's populace is estimated to reach 9.1 billion, 24% higher than the present populace. According to *Alexandratos & Bruinsma* [2], internationally the total consumption of meat and dairy products is expected to raise by 102% and 82% respectively by 2050. Worldwide interest for poultry meat will increase by up to 85% and there will be an expected 30% increase in egg production [3]. As far as possible to creating sustenance for a growing global populace have been a source of debate and preoccupations for a very long time [2]. The general interest for agricultural products is expected to rise at 1.1 percent per year from 2005/2007-2050 [2,3]. The global population growth has been noted to increase in per capita consumption and changes in diets leading to the consumption of more animal products are the known main drivers of such expected changes [3]. Traditional protein sources for livestock diets explicitly soybean meal and fishmeal are anticipated to be in scarcity and not meet the increasing demands in the future [4,5]. The prices for fishmeal and soybean fluctuate, consequently for farmers, this suggests that fishmeal and soybean meal tend to be less available [6,7]. In particular, soybean has been a very significant plant protein source of choice for the livestock feed industry. In livestock feed formulation, protein is of fundamental importance but costly feed nutrient and its quality and amount assumes an imperative part in promoting the growth of livestock [8]. A possible way to reduce livestock feed costs and alleviating the feed ingredient shortage is by replacing or finding alternative supplements to conventional feed ingredients with cheaper, efficient and locally available sources [9].

Research findings have proven that multipurpose trees can be used as cheap protein supplements which can improve voluntary intake, digestibility and general performance of animals [10,11]. Various studies have noted that seed and leaf meals from multipurpose trees can function as energy or protein sources and also aid in providing some essential vitamins, minerals, oxycaretenoids as well as bio-active compounds that function at cellular level [12,13]. At hand a great necessity is required to search for and develop non-conventional dietary energy and protein sources in order to increase livestock production [14]. On the other hand, the utilization of such feedstuffs demands having a good knowledge of the nutrient composition as well as appropriate inclusion levels [15]. Even though, the protein and energy levels in some of these non-conventional ingredients; suggests that they can be utilized to an advantage at low inclusion levels to reduce the costs of livestock diets [16]. This review attempts to iron out some of the factors that might positively aid the African animal feed industry and a summary of some oilseeds from indigenous fruit bearing trees that can be utilized to supplement protein or energy in livestock diets.

## Global Supply and Demand

Global livestock production has substantially increased ever since the 1960s. Beef production has more than doubled, despite the fact that over the same time production of chicken meat has increased by a factor of nearly 10, made up of increases in both number of animals and productivity [17]. Domesticated animals continue to make significant contributions to food supply across the globe and, consequently, livestock feeds have grown to be an increasingly essential component of the integrated food chain. Not just is the interest for livestock products markedly increasing owing to the growing population, feed suppliers additionally need to adapt to increasing safety and welfare concerns [2]. For the greater part in livestock production feed accounts for the largest single cost of about 60%-80% of the total cost. The use of non-conventional feed ingredients (leaf meals, legume seed meals, tree seed cakes and oilseeds of indigenous fruit bearing trees) that are not highly edible for human nutrition but readily accessible has proven to reduce feed costs and maximize production returns in the livestock enterprise [18]. The availability of an optimum crude protein content and availability of essential amino acid in parts of multipurpose trees can be taken to an advantage at low inclusion levels in livestock diets and cut down costs and minimize demands for soybean and maize [15]. Below is Figure 1. showing the current production trends of some of the commonly used ingredients in livestock feeds.

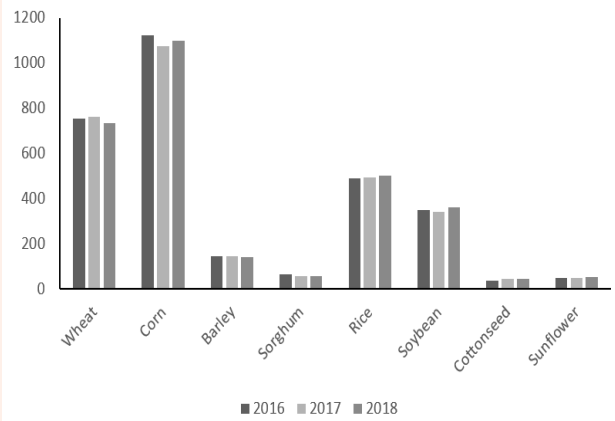


**Figure 1:** Trend in the production of some of the commonly grown and used commodities as ingredients in livestock feed. These values are in millions of metric tonnes of total production in the world [19].

Accordingly, this increasing demand for livestock products and excepted limited supply of convectional energy and/or protein sources for livestock diets has prompted an urgent need for new, safe supplies for energy or protein from sustainable resources for incorporation in livestock diets [20]. The utilization of oilseeds from indigenous fruit bearing trees specifically with the aim of being fed to livestock species has been the subject of evaluations for several decades, but has not yet arrived at a stage that has led to any noteworthy substitution of convectional protein sources currently used for livestock production [1]. Livestock nutrition is a vital part of animal production not just on the grounds that the cost of feeding amounts to approximately 60-75% of all the costs incurred in livestock production, additionally in light of the fact that nutrition impacts animal growth, health, reproduction and the quality of the products derived from them [21]. Oilseeds from various indigenous fruit bearing trees in the African woodlands have been shown to be excellent energy and/or protein sources with most of the essential and non-essential amino acids.

In sub-Saharan Africa, the low dietary intake of animal protein has been noted to result in a high prevalence of protein malnutrition [22]. Soybean, a noteworthy protein source in monogastric and ruminate nutrition, likewise serves as a human food ingredient. Hence, livestock production relatively competes vigorously with man for soybean for sustenance [23]. The utilization of fishmeal as a protein source in animal diets especially in monogastric animals is restricted by its high cost and the odour tainting it impacts to animal products if utilized as a part of finisher rations [24]. Likewise, cereal grains, the major energy sources in intensive livestock production are in limited supply for human consumption in the sub-Saharan African region resulting in substandard and to some extent contaminated cereal grains being fed to livestock [25]. Competition and drought-induced soybean scarcity, the restrictions to the use of fishmeal and lack in cereal grain impose a great necessity to search for non-conventional livestock feed sources of protein and energy that are adaptable to harsh climates and edaphic environments of the sub-Saharan African region and elsewhere [16]. Various studies have noted that a practical approach in cutting down nutrition costs for livestock nutrition is by the supplementation or replacement of conventional feed ingredients by high protein and energy products such as oilseeds of indigenous fruit bearing trees.

## Sustainable Agriculture

Over the past decade, there has been a convergence of concern on the global farm and food system and its contributions to feeding the world's population as well as to ensuring the environmental stability of the planet. The soybean industry is the star amongst all the oilseed industry. It plays a key role in all the links of the value chain, especially with regard to animal feeds, but even more in human nutrition. However, as a result of the global concerns of 2050, alternative ways or sources for soybean have to be searched for to reduce the demand for soybean [3]. Alternative protein sources are truly a smart thought considering the anticipated growth of the global population and livestock sector. In view of the fact that the total requirement for meat will most likely double by 2050, to supply such a huge increment in livestock production there will be need for supplementary implementation of unconventional feed ingredients to produce the appropriate feed amounts so as to meet the animal needs and maintain livestock production [26]. In addition taking into consideration the implementation of the ban on the use of meat and bonemeal together with the predicted demise of fishmeal in feed, there is the realization that a bigger market will be created for alternative protein feed sources [22]. In addition, more noteworthy concerns comprehensively for a more reasonable agriculture, with a lower ecological effect, are having a huge influence on the current farming systems and future prospects and approaches to food production [27]. For this reason, the necessity to look for alternative protein and/or energy sources that can be utilized in livestock production to lessen land expansion for soybean and cereal production and utilization of animal protein sources that are considered as pests. Bearing in mind as well political support, or otherwise they continue to have key influence on protein supply issues and the international realities of the animal feed industry [28]. For example, continuing support for 'home-produced protein cropping', assimilated crop management, organic farming and non-adoption of GM crops, have considerable influence for the exploration and utilization of alternative sources of protein in livestock diets [29].

## Oilseeds of Indigenous Fruit Bearing Trees

Forests have offered shelter and food to man ever since ages. Approximately 20% of the plants occurring in the forests are accounted for to have direct utility to humankind [30]. In sub-Saharan Africa around 600 plant species or more are enumerated to have food value. Most of these plant species that have feed value are noted to be tolerant to the arid regions of sub-Saharan Africa [31]. Indigenous fruit trees even though in their natural habitat play various crucial roles to the livelihoods of people in African societies. They are noted to be important sources of traditional foods such as nuts, fruits, spices, leafy Vegetables, edible oil and beverages [32]. These plant species play a pivotal role in the nutrition of children in rural and urban areas alike and are relished by them. According to *Saka* [33] indigenous fruit bearing trees provide essential vitamins and minerals for the proper maintenance of human health and animals. *Maghembe* [34] also noted that the nutritional value of these tree species point out that many are rich in sugars, vital vitamins and minerals whereas others are high in vegetable oil and proteins. Aside to the fruit production and cash provision, the broad list of merits incorporates provision of firewood, fodder, building material, shade and medicine to rural communities [35]. The growing of trees implies that there will be less dependence on arable agriculture, which in turn reduces environmental degradation. However, they are often undervalued and underutilized as more fruits that are exotic become available [30]. In addition, most of these are not cultivated and there is only scarce and scattered knowledge about them [31,34]. Production and consumption of some of these species provides a dietary supplement as well as commercial opportunity for the animal feed industry. Some of the potential oilseeds of indigenous fruit species are discussed below.

### a) Baobab *(Adansonia digitata)* seeds

The baobab is a fruit-producing tree which belongs to the family *Bombacaceae* [36]. This tree has an outstandingly wide variety of uses which range from food, beverages and medicinal uses [37]. The baobab is a gigantic, deciduous, majestic tree which reaches heights of up to 25m high and can live for up to a 1000 years [36]. Baobab fruits are very inconsistent, usually they are globose to ovoid but at times oblong-cylindrical, often asymmetrical in shape, apex pointed, or obtuse, covered with velvety greenish or yellowish hairs [37]. Baobab trees are widespread all over the hot, drier regions of tropical Africa and are prevalent south of the Sahara except Djibouti, Liberia, Burundi, Uganda, and the Central African Republic [38]. Looking at the nutrient composition on dry matter basis the none dehulled seeds contain approximately 13-18% crude protein (CP), 26% crude fibre (CF) and 10-13% oil [39,40]. Dehulling the seeds, results in an increase of the CP (26-38%), lessened CF (17%) and richer oil content of 23-24% on dry matter basis [41].

According to Osman [39], the seeds are processed for their oil; on the other hand, the by-product, which is the oilseed meal, is characteristically under-utilised. On dry matter basis it contains approximately 17-36% CP, 15-25% CF and 5-14% residual oil [44]. Madzimure [44], additionally, noted that the oilseed cake is unused in spite of its potential importance as a livestock feed ingredient. The baobab seeds/oilcake if incorporated in livestock diets can provide some of the necessary minerals, vitamins, fibre and amino acids, in particular, methionine and lysine which are usually the limiting amino acids in most cereals but vital for livestock production [39,46]. See Table 1. for the potential use and merits of using the baobab seeds and oilcake in livestock diets.

### b) Red Sour Plum *(Ximenia caffra)* Seed

The big Sourplum, (family; *Olacaceae*) is a common indigenous fruit bearing tree extensively distributed across southern Africa that is known to withstand moderate frost and also drought resistant [16]. The flesh *Ximenia caffra* fruit just around the fruit stone is known for its high protein value and richness in Vitamin C (ascorbic acid) at

**Table 1:** Studies on the potential use of Baobab *(A. digitata)* seeds and oilcake as an alternative protein supplement in livestock diets.

| Animal | Results and Conclusions |
|---|---|
| Grower Rabbits | - Inclusion of baobab pulp and seed meal up to 15% in diets has no detrimental effects on the health and growth status of grower rabbits and also results in reduced production costs [42]. |
| Broilers Chicks | - Inclusion of the baobab seed oilcake in broiler diets up to 10% had no compromising effects on the feed intake, growth, carcass characteristics and also resulted in reduced feed and production costs [43]. |
| Dairy Cows | - Supplementing soybean meal with baobab oilcake at 5-10% decreased milk butterfat content and yield but result in an increase in milk total solids and protein content [44]. |
| Young Guinea Fowls | - No detrimental effects on growth and feed intake were noted at 5% inclusion rate, with a considerable reduction in body weight of 9% at 6 weeks of age at 10% and 15% inclusion rates of the oilcake in the diet [15]. |
| African Sharptooth Catfish | - Inclusion of up to 25% of boiled baobab seeds in the experimental diets had no detrimental effects on the growth of the fish. This was attributed to the fact that the boiling process of the seeds had inactivated the antinutritive factors in the seeds [45]. |

**Table 2:** Brief detail of the proximate, mineral and amino acid composition of Red Sour Plum *(Ximenia caffra)* Seed. Adapted from: *Chivandi et al.* [16].

| Parameter | Mean±SD |
|---|---|
| Proximate component (g/kg DM) | |
| Dry matter | 955.13±0.78 |
| Organic matter | 934.69±1.97 |
| Crude protein | 182.55±0.52 |
| Mineral (mg/100g DM) | |
| Calcium | 17.85±0.74 |
| Magnesium | 207.90±5.94 |
| Phosphorus | 345.45±5.94 |
| Amino acid (g /100g) | |
| Lysine | 1.03±0.09 |
| Methionine | 0.16±0.02 |
| Tyrosine | 0.75±0.13 |
| Glutamic acid | 2.34±0.18 |
| Isoleucine | 0.62±0.02 |
| Leucine | 1.03±0.05 |

approx. 27mg 100mg$^{-1}$. Generally, the fresh *Ximenia caffra* fruit juice and also the dried fruit flesh is usually used in adding flavour to porridge by the indigenous people in the communities where the tree is found. According to Chivandi [16], the indigenous people also use the *Ximenia caffra* fruit jelly as an ingredient when making tarts. Kernels of Red sour plum seeds (RSP) contain a high oil yield of approximately 48% of which 62.8% of the oil yield is oleic acid. They also contain a CP content of 18.3% which is alike the reported 18.8% CP by FAO [3] for undefatted sunflower seed. The key protein sources in livestock diets are sunflower seed and soybean. Considering the competition for these ingredients with humans and the price increases for these key sources RSP seed could be used to supplement protein in animal feeds. Most groundnut *(Arachis hypogaea)* varieties, full-fat kernels contain approx. 44-56% lipid/oil with a CP range of 23-30%, but with solvent extraction groundnut meal has a CP content of about 54% [14,47]. Despite the fact that the amino acid content of full-fat RSP seed being lower than that of the FAO reference protein, oil extraction from RSP seed (48% oil) potentially could result in increased CP and amino acid (AA) content of the residual meal [48]. Implying that applying such a technique to RSP seeds could greatly increase their CP value and make them more valuable by making the values high enough for use as a protein concentrate or supplement in livestock feeds. Even though the essential AA concentration of full-fat RSP seed is low relative to that of soybean, if RSP seeds are deffattened prior to use as a livestock feed ingredient over and above increasing the concentration of AAs would reduce the likely problem of rancidity due to the seed's high oil content [14,16]. See Table 2. for a short detailed description of the proximate, mineral and AA composition of RSP seed.

### c) Silver leaf tree *(Terminalia sericea)* Seeds

The silver leaf tree (SLT, *Terminalia sericea*), family; *Combretaceae*, are trees extensively distributed along the tropical Africa savannah where they are found scattered in most of the east, central and southern Africa woodlands occurring as a dominant or co-dominant specie in the mixed forests and also in some of the warm temperate African regions [49]. The tree is known to be moderately adapted to saline soils, drought tolerant and tolerates some degree of frost. In sub-Saharan Africa SLT contributes to both wildlife and domestic production through the provision of browse especially during the hot dry season [50]. Previous research on SLT tended to focus mostly on the phytochemical composition of its leaf extracts, bark and root that are used in ethnomedicine neglecting its seed potential. According to a study by *Chivandi* [49] found that, the nutritive value of 78.8% of SLT seed to have a CP content of 46.2% and lipid content of 32.6%. With this CP and lipid value SLT seed could be easily utilized as a protein supplement in most livestock feeds and foods and could also be exploited as a non-conventional plant oil source of oleic acid and linoleic acid [49,50]. In livestock feed formulations soybean meal (SBM), sunflower seed cake (SSC) and cotton seed cake (CSC), are the major plant based protein sources [43,48]. The CP content of SSC and CSC highly depends on the degree of dehulling. Dehulled SSC meal has a CP content range of around 24-40%, while the CP values of non-dehulled and dehulled CSCs are 21.3% and 45%, respectively [49]. Solvent extracted SBM has a CP value of 45% whilst full-fat SLT seed's CP value of 46.2% (Table 3) is similar to that of solvent extracted SBM (45% CP) and quite higher than that of SSC and CSC [27]. Implying that defatting or dehulling SLT seeds could result in a seed meal that contains a CP value much higher than that of SBM, mainly when taking into account the higher oil content of SLT seed (Table 3). SLT seed meal could potentially then be used to completely or partially replace SBM as a plant protein source in livestock feed and human food.

**Table 3:** Brief detail of the proximate, mineral, amino acid and fatty acid composition of Silver leaf tree *(Terminalia sericea)* seeds. Adapted from: Chivandi et al. [49].

| Parameter | Mean±SD |
|---|---|
| Proximate component (g/kg DM) | |
| Dry matter | 953.03±0.92 |
| Organic matter | 884.08±3.22 |
| Crude protein | 462.32±5.49 |
| Mineral (mg/100g DM) | |
| Calcium | 795.20±17.82 |
| Magnesium | 560.70±6.68 |
| Phosphorus | 1121.75±10.39 |
| Amino acid (g/100g) | |
| Lysine | 1.60±0.21 |
| Methionine | 0.65±0.11 |
| Threonine | 1.76±0.26 |
| Arginine | 7.56±0.21 |
| Isoleucine | 1.59±0.23 |
| Fatty acid % | |
| C18:2n6 (linoleic acid) | 68.63 |
| C18:3n3 (α-linolenic acid) | 0.41 |
| C20:2n6 (all cis-11, 14-eicosadienoci acid) | 0.06 |
| Omega-3 | 0.41 |
| Omega-6 | 68.63 |
| Omega-9 | 14.05 |

## Conclusion

In conclusion, within the vast African biodiversity, there are a vast number of plant resources that can supplement of replace partially some of the commonly used feed ingredients in livestock diets. Theirs need for more research in the short and medium term in agronomy and the further development of alternative and novel energy and protein supply cropping. More meaningful and greater co-operation is advocated between policy-makers; the feed industry; farmers and researchers to better deliver the future energy and protein supply potential for animal feeds. Also the association between agriculture, the livestock sector and indigenous trees in African communities needs to be understood and supported, rather than ignoring the extensive local knowledge and technology change that has occurred across these areas.

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## Authors' Contributions

All the authors were directly involved in the preparation and design of the manuscript. TTN reviewed, corrected and contributed the publication costs.

## References

1. FAO (2012) The contribution of insects to food security, livelihoods and the environment. Italy.
2. Alexandratos N, Bruinsma J (2012) World Agriculture towards 2030/2050.
3. Food and Agriculture Organisation (2013) World Livestock 2013- Livestock in food security. Rome, FAO, Italy. pp. 44-99.
4. Chimvuramahwe J, Musara JP, Mujuru L, Gadzirayi CT, Nyakudya IW (2011) Effect of feeding graded levels of *Adansonia digitata* (baobab) seed cake on the performance of broilers. Journal of Animal and Plant Science 11: 1442-1449.
5. Sebola N, Mlambo V, Mokoboki H, Muchenje V (2015) Growth performance and carcass characteristics of three chicken strains in response to incremental levels of dietary *Moringa oleifera* leaf meal. Livestock Science 178: 202-208.
6. Anastasiou S, Nengas I (2005) A general review on the use of alternative protein sources in diets for Mediterranean fish. Cahiers Options Mediterraneennes 63: 121-126.
7. Archimède H, Régnier C, Marie MCC, Gourdine JL, Rodriguez L, et al. (2011) The alternatives to soybeans for animal feed in the tropics. In: Ng PTB (Ed). Soybean-applications and technology. Guadeloupe French West Indies, France. pp. 276-286.
8. Tabinda AB, Ghazala R, Yasar A, Ashraf M (2013) Utilization of chicken intenstine as an alternative protein source in the diet for fingerlings of *Cirrhinus Mirigala*. Journal of Animal and Plant Science 23(6).
9. Zanu HK, Asiedu P, Tampuori M, Abada M, Asante I (2012) Possibilities of using moringa *(Moringa oleifera)* leaf meal as a partial substitute for fishmeal in broiler chicken diets. Online Journal of Animal and Feed Research 2: 70-75.
10. Melesse A, Tiruneh W, Negesse T (2011) Effects of feeding *Moringa stenopetala* leaf meal on nutrient intake and growth performance of Rhode Island red chicks under tropical climate. Tropical and Subtropical Agroecosystems 14: 485-492.
11. Nkukwana TT, Muchenje V, Pieterse E, Masika PJ, Mabusela TP, et al. (2014) Effect of *Moringa oleifera* leaf meal on growth performance, apparent digestibility, digestive organ size and carcass yield in broiler chickens. Livestock Science 161: 139-146.
12. Melesse A, Getye Y, Berihun K, Banerjee S (2013) Effect of feeding graded levels of *Moringa stenopetala* leaf meal on growth performance, carcass traits and some serum biochemical parameters of Koekoek chickens. Livestock Science 157: 498-505.
13. Nkukwana TT, Muchenje V, Masika PJ, Mushonga B (2015) Intestinal morphology, digestive organ size and digesta pH of broiler chickens fed diets supplemented with or without *Moringa oleifera* leaf meal. South African Journal of Animal Sciences 45: 362-371.
14. Moyo D, Erlwanger K, Chivandi E (2012a) Effect of graded dietary substitution of soyabean meal with large sour plum effect of graded dietary substitution of soyabean meal with large sour plum *(Ximenia caffra)* seed meal on erythrocyte osmotic fragility and the packed cell volume of growing male sprague dawley rats.
15. Mwale M, Mupangwa JF, Mapiye C, Saina H, Chimvuramahwe J (2008) Growth performance of guinea fowl keets fed graded levels of baobab seed cake diets. International Journal of Poultry Science 7: 429-432.
16. Chivandi E, Davidson B, Erlwanger K (2012) Red sour plum *(Ximenia caffra)* seed: A potential non-conventional energy and protein source for livestock feeds. International Journal of Agriculture & Biology 14: 540-544.
17. Thornton PK (2010) Livestock production: recent trends, future prospects. Philosophical Transactions of The Royal Society 365: 2853-2867.
18. Olugbemi T, Mutayoba S, Lekule F (2010) Effect of moringa *(Moringa oleifera)* inclusion in cassava based diets fed to broiler chickens. International Journal of Poultry Science 9: 363-367.
19. USDA (2019) World Agricultural Production. Foreign Agricultural Service/USDA Office of Global Analysis. pp. 1-28.
20. Bale JS, Mancha YP, Sanusi M, Doma UD (2013) Effect of graded levels of baobab *(Adansonia digitata)* seed meal on the growth performance and production economic analysis of broiler chickens. International Journal of Poultry Science 12: 273-276.
21. Mukumbo FE, Maphosa V, Hugo A, Nkukwana TT, Mabusela TP, et al. (2014) Effect of *Moringa oleifera* leaf meal on finisher pig growth performance, meat quality, shelf life and fatty acid composition of pork. South African Journal of Animal Sciences 44: 388-400.
22. Chivandi E, Mukonowenzou N, Nyakudya T, Erlwanger KH (2015) Potential of indigenous fruit-bearing trees to curb malnutrition, improve household food security, income and community health in Sub-Saharan Africa: A review. Food Research International 76: 980-985.
23. Gadzirayi CT, Masamha B, Mupangwa JF, Washaya S (2012) Performance of broiler

chickens fed on mature *Moringa oleifera* leaf meal as a protein supplement to soyabean meal. International Journal of Poultry Science 11: 5-10.

24. Chivandi E, Erlwanger KH (2011) Potential usage of african ebony *(Diospyros mespiliformis)* seeds in human health. Nuts and Seeds in Health and Disease Prevention. Elsevier Inc, Netherlands.

25. Moyo D, Erlwanger KH, Chivandi E (2012b) Effect of graded dietary substitution of soyabean meal with large sour plum *(Ximenia caffra)* seed meal on erythrocyte osmotic fragility and the packed cell volume of growing male sprague dawley rats. International Journal Of Agriculture & Biology 14: 671-674.

26. Martens SD, Tiemann TT, Bindelle J, Peters M, Lascano CE (2012) Alternative plant protein sources for pigs and chickens in the tropics-nutritional value and constraints: A review. Journal of Agriculture and Rural Development in the Tropics and Subtropics 113: 101-123.

27. Feedipedia (2014) Animal feed resources information system.

28. Berhan T, Wude T (2010) Effects of different levels of dried sweet potato *(Ipomoea batatas)* leaves inclusion in finisher ration on feed intake, growth, and carcass yield performance of Ross broiler chicks. Tropical Animal Health and Production 42: 687-695.

29. Abdel halim HA (2009) Effect of partial replacement of soybean meal protein with dehydrated alfalfa meal. Egypt Journal of Aquatic Biology and Fish 13: 35-51.

30. Rathore M (2009) Nutrient content of important fruit trees from arid zone of Rajasthan. Journal of Horticulture and Forestry 1: 103-108.

31. Mojeremane W, Tshwenyane SO (2004) *Azanza garckeana*: A valuable edible indigenous fruit tree of botswana. Pakistan Journal of Nutrition 3: 264-267.

32. Okafor JC (1985) Selection and improvement of indigenous topical trees. Journal of Tropical Resources 1: 87-95.

33. Saka J, Msothi JD, Maghembe JA (1994) The Nutritional value of edible fruits of indigenous wild trees of Malawi. Forest Ecology and Management 64: 245-248.

34. Maghembe JA, Kwesiga F, Ngulube M, Prins H, Malaya FM (1994) Domestication potential of indigenous trees of the miombo of southern Africa. In: Leakey RRB and Newton AC (Eds.) Tropical trees: The potential for domestication and rebuilding of forest resources, HMSO, London.

35. Campbell BM (1987) The use of wild fruits in Zimbabwe. Food and Nutrition 12: 38-44.

36. Gebauer J, El Siddig K, Ebert G (2002) Baobab *(Adansonia digitata L.)*: A review on a multipurpose tree with promising future in the Sudan. Gartenbauwissenschaft 67: 155-160.

37. Sidibe M, Williams JT (2002) Baobab *(Adansonia digitata L.)*. Fruits for the future 4. Southampton, International Centre for Underutilised Crops, UK.

38. Assogbadjo AE, Glèlè Kakaï R, Chadare FJ, Thomson L, Kyndt T, et al. (2008) Folk classification, perception, and preferences of baobab products in West Africa: Consequences for species conservation. Economic Botany 62: 74-84.

39. Osman M (2004) Chemical and nutrient analysis of baobab *(Adansonia digitata)* fruit and seed protein solubility. Plant foods for human nutrition (Dordrecht, Netherlands) 59: 29-33.

40. Anjos FR dos (2005) Effect of three different diets (baobab, cowpea and papaya) on the dynamic of the gastrointestinal helminths and on weight in chickens. In: Effect of scavenging feed resource base on the prevalence of parasites and performance of chickens in Sussundenga D. University Maputo, Mozambique.

41. Igboeli LC, Addy EOH, Salami LI (1997) Effects of some processing techniques on the antinutrient contents of baobab seeds *(Adansonia digitata)*. Bioresource Technology 59: 29-31.

42. Oladunjoye IO, Akinlade M, Lawal Z (2014) Perfomance, Digestibility, carcass and blood profile of grower rabbits fed baobab *(Adansonia digitata)* pulp and seed meal. Indian Journal of Fundamental and Applied Life Sciences 4: 234-240.

43. Chisoro P, Nkukwana TT, Mupangwa JF, Mabusela TP (2018) Feed intake, growth performance and carcass traits of broilers fed diets with various inclusion levels of baobab seed oilcake. South African Journal of Animal Science 48: 284-294.

44. Madzimure J, Musimurimwa C, Chivandi E, Gwiriri L, Mamhare E (2011) Milk yield and quality in Guernsey cows fed cottonseed cake-based diets partially substituted with baobab *(Adansonia digitata L.)* seed cake. Tropical animal health and production 43: 77-82.

45. Anene A, Olivia C, Anene A, Onyekachi C (2012) Nutritive value and utilization of baobab *(Adansonia digitata)* seed meal as plant protein source in the diet of juveniles of *Clarias gariepinus*. Journal of Research in Biology 2: 348-354.

46. Glew RH, Vanderjagt DJ, Lockett C, Grivetti LE, Smith GC, et al. (1997) Amino Acid, fatty acid, and mineral composition of 24 indigenous plants of Burkina Faso. Journal of Food Composition and Analysis 10: 205-217.

47. Goosen NJ, Stander MA, Ibrahim AD, Pedavoah M (2018) Phenolics, organic acids and minerals in the fruit juice of the indigenous African sourplum *(Ximenia caffra, Olacaceae)*. South African Journal of Botany 119: 11-16.

48. Chisoro P, Kaguru T, Assan N (2017) Baobab seeds as an alternative protein source in poultry feed. Scientific Journal of Review 6: 509-518.

49. Chivandi E, Davidson B, Erlwanger KH (2013) Proximate, mineral, fibre, phytate-phosphate, vitamin E, amino acid and fatty acid composition of *Terminalia sericea*. South African Journal of Botany 88: 96-100.

50. Bigirimana C, Omujal F, Isubikalu P, Bizuru E, Obaa B, et al. (2016) Utilisation of Indigenous fruit tree species within the Lake Victroria basin, Rwanda. Agricultural Science: An International Journal (AGRIJ) 1: 1-13.