Chapter

Lesser Known African Indigenous Tree and Fruit Plants: Recent Evidence from Literatures and Regular Cultivation Culture

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Abstract

Indigenous plant species native to Africa have numerous uses. They have a long and rich ethno-medicinal history with well-known native applications in different African countries. The effects of these indigenous underutilized crops in local traditional medicine differ. But they play an important role in enhancing food and nutrition security of the population. Tropical plant species have economic potential as they make great socio-economic impact on the livelihoods of rural dwellers. Despite their economic, food and nutritional values, these plants are still underutilized and have not been brought under regular cultivation culture due to inadequate information about their food values and their agronomic requirements for cultivation. Their potential values to the African food system could be enhanced if they are domesticated and prevented from going into extinction. Thus, the potential implications for long-term sustainable food security of these plants should not be neglected. Therefore, there is the need to recognize and enable indigenous foods from the indigenous plant species to serve as a key resource in ensuring healthy food systems in Africa. The inherent potential of the following tropical indigenous plant species African Walnut (*Plukenetia conophora* Muell Arg.), Saba (*Saba senegalensis* (A. DC.) Pichon), Baobab (*Adansonia digitata* L.) and Kapok (*Ceiba pentandra* (L.) Gaertn.) are discussed in this review.

Keywords: forest resources, nursery management, fertilizer use, nutritional quality, growth and yield

1. Introduction

The extinction of plant species resulting from human activities throughout the world has become a major concern [1]. Forest resources diminish as a result of deforestation, which has negative impact on agriculture, medicine and economic enterprises of man [1, 2]. Forest resources provide numerous goods and services to man such as food, medicine, wood, fiber and energy, they were taken for granted in

the past because they were available almost everywhere but the situation has changed due to adverse effects of human activities [3, 4]. Food insecurity remains a major challenge in developing countries and insufficient nutrient intake causes severe malnutrition affecting the populace [5].

Worldwide, the problem of food security leads to calorie deficit of more than 700,000,000 underfed people [6]. The valuation of edible fruits and vegetables that are underutilized is one of the ways out of this impasse, a few examples of such extinct fruit and vegetable species with potential to address global undernourishment problems particularly those confronting the developing countries are *Plukenetia conophora, Saba senegalensis, Adansonia digitata* and *Ceiba pentandra*. They are potential sources of vitamins, minerals, antioxidants and phenols [7]. Indigenous plant species are outstanding plants due to their numerous benefits. Many of them are richer in protein and other nutrient contents [8]. They are good sources of macro and micronutrients for human consumption; many indigenous fruits and vegetables are characterized by a high nutritional value in comparison with global vegetables like tomato and cabbage [9]. Notably, many are potential sources of vitamins and macro and microelements with the ability to provide them to children and adult at levels higher than those recommended by the World Health Organization (WHO) [10]. Consumption of fruits and vegetables can improve health and prevent the risk of developing chronic diseases including cancer [11]. Consuming adequate quantity of food can be assured by utilizing nutrient-rich fruits and leafy vegetables accompanied with staple food. Generally, indigenous plant species are important as food, medicine and socio-economic value.

In spite of the numerous potentials of these indigenous crops, they have not been cultivated like other tropical plant species in Nigeria as a result of lack of adequate knowledge on their nutritional value, climatic requirement, fertilizer requirement and agronomic practices. Crop yield is to a large extent, associated with its fertilizer requirements, and maintaining the yield and quality of a newly introduced crop involves suitable crop management practices to improve soil productivity [12, 13]. Soil amendment could be done using organic or inorganic fertilizer and may be combined [14]. Therefore, investigating into food, nutritional, medicinal, climatic and fertilizer requirements of these indigenous crops can provide evidence-based information encouraging the cultivation of these wild species in order to remedy food insecurity, improve the diet of the people and prevent the crops from going into extinction. The information will also be useful to the food industries and pharmaceutical companies.

2. African walnut (*P. conophora*)

2.1 Description

P. conophora Muell Arg. known as African walnut belong to Euphorbiaceae family [15]. It is a climber that twines around cocoa and kola nut trees for support [16] (**Figure 1**). *P. conophora* is a small tropical flowering shrub, a woody perennial plant 6 m – 18 m long when it attains maturity stage; the stem can be as wide as 16 cm and turns dark gray as it ages, but it is green and glabrous at tender age [17]. The leaf is simple, crenate and having serrated margin. They are spherical at the base with the leaves arranged alternately [18, 19]. The seeds can be boiled and eaten as snacks [20]. Fruits not yet developed have green color but change from dark brown to black at

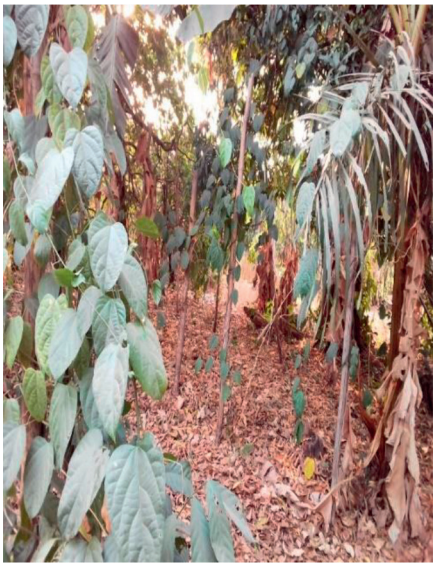

Figure 1.
Staked African walnut plants.

Figure 2.
African walnut capsules.

maturity [21]. The seed is white when cracked upon shell removal with a thin layer between split halves. After eating the nut, the presence of chemical substances such as alkaloids gives a bitter taste upon drinking water [22]. Walnut seeds are housed in a pod having: one seed (single), two seeds (double), three seeds (triple), four seeds (quadruple) and five seeds (quintuple) [23]. The walnut shells are usually black or brown in color (see **Figure 2**).

2.2 Origin and distribution

Plukenetia conophora originated from tropical western and central Africa and it is available in Nigeria, Cameroon, Congo, Central African Republic, Gabon, Niger, and Sierra Leone [18, 24]. The African walnut is cultivated in Western and Eastern regions of Nigeria [18]. It is found in Uyo, Akamkpa, Akpabuyo, Lagos, Akure, Kogi, Ajaawa, Ogbomosho, Ibadan [25, 26], Ife, Ekiti and Osun State. In the South and cocoa producing States in Nigeria, walnut is available [24, 27]. African walnut thrives on loamy soils that are deep, fertile, moist and well drained. Walnut does well on silty clay and loam soils [28, 29] and for optimum growth, walnut requires high solar radiation.

2.3 Food and economic importance

P. conophora Muell Arg. is a multipurpose crop used for food, nutritional and economic purposes in Africa. This plant is grown purposely for its nuts, boiled in water and eaten as a snack [25]. In Nigeria, Sierra Leone and Ghana, the fruits improve the livelihood of the rural people by providing income [30]. Extracted oil from the nut is used in making wood varnishes, vulcanized oil for rubber, stand oil and leather substitutes [31, 32]. Essential oils are usually extracted and used in food, cosmetics, perfumes, soaps and drinks as flavor. It can also be used in treating skin diseases and as remedy for cancer. Walnut peels (shell) combined with other materials are used as filler in dynamite [33]. The shell can be included in catfish meal with no negative effect on the performance and health status of the fish [34].

2.4 Medicinal value

P. conophora have numerous ethno-medicinal uses among the African rural populace. The leaves, root, bark and fruit are known for their medicinal values. Walnut leaves are used to treat venous insufficiency, hypoglycemia, hemorrhoids, indigestion, constipation, dysentery, diarrhea, syphilis, asthma, thrush, prolonged and constant hiccups, pruritus, eczema, fungal and microbial infections, psoriasis and parasitic skin conditions majorly among children, the elderly and immunosuppressed [35, 36]. African walnut can be used to expel worms; it can also treat rheumatism, kidney pain, cold, gout, cleaning of blood and abnormal menstrual bleeding [37]. The succulent leaves are used as vegetable and for treating cancers growing in the neck. They control inflammation of the gums and throat and mouth when used as tea [33]. Brown dye is extracted from the husk and leaf which is used to manage hiccups [38]. The root is effective in the treatment of piles. It lowers the risk of developing cancer and it controls high blood pressure [37] and it can be used as an antidote to snakebite, tonification of kidneys and strengthening of the back and knees [39]. The bark can be used in tea as laxative, chewed to reduce toothache and to treat high blood pressure while the root is used for frost bite and varicose ulcers [40, 41].

2.5 Nutritional qualities

The seed and leaf of *Plukenetia* are good sources of nutrients that can ensure food security and remedy malnutrition of the populace. Olajide *et al.* [42] evaluated the variability in proximate quality traits of 10 accessions of *Plukenetia conophora* from Southwestern Nigeria. They found that the seeds contained proximate contents and established that location of seed collection significantly affected ash, crude fat, crude

fiber, dry matter, moisture content and nitrogen free extract, which suggests the need for selection and also gives way to improvement program. Agbo and Baiyeri [43] also reported variability in proximate and mineral qualities of five accessions of African walnut, which probably suggests genetic diversity or more probably, could be environmentally induced. Olajide *et al.* [42] also found that fresh and boiled walnut is an excellent food material with the ability to combat food insecurity in rural populace. They reported that the proximate composition in the nut include ash (6.40 and 6.34%), crude protein (17.04 and 19.20%) crude fat (40.77 and 39.74%), crude fiber (11.76 and 11.28%), dry matter (90.93 and 90.94%), moisture content (9.07 and 9.06%) and nitrogen free extract (14.97 and 14.40%) for fresh and boiled nuts respectively. Boiling positively influenced proximate qualities of African walnut as it increased protein content and dry matter while it reduced ash, crude fat, crude fiber, moisture content and nitrogen free extract. The proximate composition of *P. conophora* shows that it contains carbohydrate (4.17%), ash (3.32%), protein (29.14%), fat (54.14%) and various vitamin contents [44]. Suara *et al.* [45] reported 6.86% for moisture content, 11.78% for protein, 8.57% for total ash, 20.12% for crude fiber, 1.56% for total fat and 51.8% for total carbohydrate. In addition, Olajide *et al.* [46] evaluated the nutritional differences in 10 accessions of African walnut obtained from Southwestern Nigeria as affected by collection center and processing and the results suggested sufficient genetic variability in seeds of walnut obtained from Southwestern Nigeria, emphasizing the possibility for selection. The nutritional assessment of the seed revealed that the fresh and boiled seed contains iron (16.82 and 24.59 mg/kg), potassium (10781.0 and 10420.0 mg/kg), magnesium (5076.0 and 4621.0 mg/kg), phosphorus (162.7 and 229.7 mg/kg), zinc (65.2 and 54.54 mg/kg) and sodium (729.2 and 718.2 mg/kg). The results showed that processing had positively effect on iron, magnesium, phosphorus and zinc contents. Fresh seeds possessed higher quantity of zinc, potassium, magnesium and sodium compared to the boiled seeds. Conversely, iron and phosphorus were more in boiled seeds. Enujiugha [47] reported that walnut seeds contain mineral (465.95 mg/100 g of phosphorus, 57.37 mg/100 g of magnesium, 1.55 mg/100 g of iron and 6.84 mg/100 g of zinc). Phytochemical contents revealed 0.243 and 0.31% of phenol, 0.0142 and 0.0179% of phytate, 0.0851 and 0.0784% of tannin, 0.5419 and 0.5547% for alkaloid and 0.1396 and 0.1577% of glycoside for fresh and boiled nuts, respectively [48]. Concentration of phytate, alkaloids, phenol and glycosides were more pronounced in boiled seeds in comparison with the fresh nuts. On the other hand, higher value for tannin was obtained in fresh seeds. Ekwe and Ihemeje [19] found tannins of 0.89 mg/100 g, oxalate of 1.28 mg/100 g, phytic acid of 3.105 mg/100 g, trypsin inhibitors of 1.84 mg/100 g, saponin of 985.0 mg/100 g and alkaloid of 40.91 mg/100 g. However, higher concentration of alkaloid of 2.670 mg/kg and lower tannin of 0.56 mg/kg were recorded. Ayoola *et al.* [49] found that nutritional and elemental components are more in the nuts than in the leaves. The phytochemical contents observed in the seeds were also available in walnut leaves. The nut contained oil of 48–50%, the oil color is golden yellow, the taste and odor resembles that of linseed oil [50].

2.6 Climatic requirement

P. conophora is native to West Africa or Central Africa. It is abundant in Nigeria, Congo, Ghana and Cameroon. It occurs in the rain-forest region and plantations found at elevations from 250 to 1400 m [51]. The plant thrives on fertile, well—drained loam soils and can also grow on silt clay loam soils [29]. Generally,

subsistence farmers grow *P. conophora* around gardens and backyards in humid and hot zones of tropical Africa [16]. It is also found in bottomlands, coves, rich woodlands and abandoned agricultural fields [52]. As a climber, the plant twines round the host plant to the apex in order to trap sufficient sunlight.

2.7 Cultivation

The plant thrives on deep, fertile, moist and well-drained loam soils [29]. The African walnut is majorly grown for subsistence consumption in the humid and hot regions of tropical Africa [16]. It does well in rich woodlands, fallow fields, bottomlands and coves [52]. The plant twines round the host plant to settle at the apex to receive more light from the sun, it may join trees to each other and hold a dead tree in position until it decays. Flowering occurs from November to early January and fruiting starts in February till September with the highest yield in July [16]. Walnut seed takes about 4–6 months to reach maturity stage [53].

2.8 Fertilizer requirement

Prior to the introduction of inorganic compounds, soil fertility has been improved through the breakdown of raw natural materials in the environment. This provided the soil with the needed nutrients for crop growth from only organic matter and this was enough in sustaining life [54]. Rob [54] noted that synthetic fertilizers do not add to the humus content of soil nor substitute it. Growth and dry matter yield of *Amaranthus cruentus* as affected by organic manure investigated by Daramola *et al* [55] showed that soil amendment using organic nitrogen sources produced the tallest plants, greater number of leaves, more branches and dry matter yield in comparison with the control. Olajide [23] conducted a study on influence of four poultry manure rates (0, 10, 20 and 30 t ha^{-1}) on early growth of African walnut and reported that morphological traits were positively affected with the application of PM at 10 t ha^{-1}, increase in PM beyond this rate resulted to a decline in growth of African walnut. The decline in growth at 20 t ha^{-1} and 30 t ha^{-1} of PM indicated that adequate amount of nutrients were released by the 10 t ha^{-1} of PM to complement the inherent nutrient in the soil. Sufficient nutrient supply produced high quality and better nutritious plants [56, 57]. As reported by Adebayo *et al*. [58], when manure is supplied at the required quantity, plants tend to grow at their optimal potential.

3. Saba (*Saba senegalensis*)

3.1 Description

S. senegalensis (A. DC.) Pichon is a large woody liana with white latex [59], from the Apocynaceae family [60]. The fruit is known as maad (Senegal), zaban (Mali), malombo (Congo Basin), wèda (Burkina Faso) and côcôta (Côte d'Ivoire) [61]. A climbing plant species that clings on other plants for support and growth (**Figures 3** and **4**). Saba trees are upwardly mobile plant found in tropical West Africa and the Western Sudan [62]. The plant can be grown in different ecological zones with rainfall from 100 mm to 1300 mm per annum and an altitude of 0–800 m [63]. Saba can withstand bush fire and has the ability to suppress

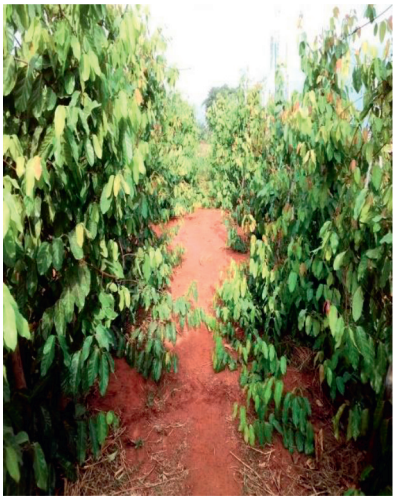

Figure 3.
Saba senegalensis plants.

Figure 4.
Staked Saba senegalensis plants.

weed (**Figure 5**). The bark has a dark gray color [64, 65] and it can reach up to 40 meters with the trunk above 40 cm in diameter [64, 66]. *S. senegalensis* fruit is a globulous envelope which contains seeds coated with yellow juicy pulp [67] (**Figure 6**). Juice from the fruit has become popular in urban areas of Côte d'Ivoire, Mali, Guinée, Burkina Faso, Senegal and the Gambia. *S. senegalensis* fruit has yellow pulp that is acidulous, tasty, sweet–sour when ripe and can be consumed directly or processed into other products [60, 67]. The fruits are often traded in towns and cities in most of the West African countries. In Nigeria, Mali, Burkina Faso, Ghana and Côte d'Ivoire, clusters of the fruits are been sold like oranges along the roadways. In Nigeria, the fruits of Saba are available from April to August.

Figure 5.
Saba senegalensis flower.

Figure 6.
Saba senegalensis fruit.

3.2 Origin and distribution

S. senegalensis is native of Gambia, Ghana, Guinea and other African countries [67]. It can thrive in different ecological zones having rainfall from 100–1300 mm annually, but mainly distributed along the river banks, open woodland and in rocky hills [60, 62, 67]. It is found in the Sudan savannas as well as in the Guinean savannas of Africa. It is a twining plant that normally needs staking. These areas are characterized by maritime trade winds with an average annual temperature range of 26–31°C, a dry climate with considerable variations in humidity. Maximum of precipitation in

these areas occurs in the month of August with rainfall lasting from 2 to 4 months. The average annual rainfall in these locations varied from 400 to 1200 mm [68].

3.3 Food and economic importance

S. senegalensis fruit can be eaten in various ways; fresh or seasoned with sugar, salt or chilled [65, 67]. Saba fruit pulp is tart and pleasant to consume. In local communities, saba can be used to improve the taste of porridge made from cereals [59, 69]. The fruit pulp can also be made into nectar, preserves, jams and jellies [70]. The inner part of the shell is enveloped with superficial skin that can be eaten as chewing gum. The leaves can be made into sauces and condiments [59]. The inner materials that envelop the fruit pulp are dried and used to substitute lemon and tamarind [71]. Mechanical extractor can be used to change the form, making it possible to produce a refined puree that can be converted into different finished products like nectars, concentrated bases, syrups and marmalades. Saba can be included in food products like yoghurt. Saba fruits are highly cherished and highly prized in Africa, are the fruits are openly hawked in cities which results to improvement in the economy of the rural farmers [72]. The plant has the potential to suppress weeds and contributes to soil and water conservation [73].

3.4 Medicinal value

Saba has been used in herbal medicine with pronounced native applications. Ethnobotany alludes that the leaves, roots and fruit have the potential of treating certain diseases [74]. The fruits contained active compounds that could play a vital role in preventing and treating metabolic diseases and certain vitamin deficiencies [75]. Green fruits have the ability to fight against galactagogic, sterility and colic [59]. Ripen fruits are antiscorbutic, anorexic, stimulating and tonic [76]. The green fruits are preferred by the Fulani, which are prepared with salt; it is active in diuretic drug [59]. In cases of food poisoning, the leaves can be used to reduce the effect, and mashed leaves can as well be used in treating injuries [60]. When boiled, the vapor released can be inhaled to reduce coughing and headaches [77]. It can also be used in treating tuberculosis and pulmonary diseases; the leaves can prevent chronic headache and vomiting [78]. The whit latex can be used to treat pulmonary diseases and helps in fighting tuberculosis [68]. The powder from the dry root bark is effective in wound healing [64]. The roots of saba are used in treating infertility in females and skin burns. Root maceration, as a drink, is considered to be anti-hemorrhagic [59]. The latex is used as an adhesive in preparing poison for arrows. Saba leaves are made into sauces and spices as an appetizer having salty taste.

3.5 Nutritional qualities

The nutritional contents of the pulp are subject to very large variations, which are obviously linked to the differences in climate, nature of the soil and various analytical methods employed [59]. *S. senegalensis* fruit have high nutritional composition such as proximate, mineral, phytochemical and vitamin contents as established by previous studies. It can improve nutrition and health of the household. Olajide [23] evaluated the impact of four accessions on proximate, mineral, vitamin and phytochemical contents of *S. senegalensis* fruit pulp from Kogi State, Nigeria. He reported that ash content varied from 1.0–1.4%, percent carbohydrate values ranged

from 11.60–34.90%, fat content ranged from 0.2–0.3%, fiber was in trace amount, moisture ranges from 63.6–86.5% and protein 0.09–0.18%. Oxalate value varied from 14.0–18.4 mg 100 ml^{-1}, phenol ranged from 11.2–13.4 mg 100 ml^{-1}, saponin varied from 0.4–2.5 mg 100 ml^{-1} and tannin ranges from 0.6–1.5 mg 100 ml^{-1}. The results also indicated that calcium ranged from 12.7–19.2 mg 100 ml^{-1}, iron varied from 0.02–0.08 mg 100 ml^{-1}, potassium ranges from 0.1–0.3, phosphorus ranged from 10.1–15.9 mg 100 ml^{-1} and zinc varied from 1.90–2.1 mg 100 ml^{-1}. He also found that vitamin B_{12} ranged from 0.05–0.07 mg 100 ml^{-1}, vitamin B_2 ranged from 0.7–4.8 mg 100 ml^{-1}, vitamin B_6 varied from 2.7–14.4 mg 100 ml^{-1}, vitamin C ranged from 34.3–66.9 mg 100 ml^{-1}, while β-Carotene and vitamin E contents were 0.5 and 0.01 mg 100 ml^{-1}, respectively. Like other fruits, saba has high amount of carbohydrates but the values varied widely (11–74.23 g/100 g) [60, 63, 70–72, 79, 80]. The oil content is 0.2 g/100 g [81] and the crude protein values range from 0.8 to 0.3 g/100 g [70, 79]. Boamponsem *et al*. [72] reported that *S. senegalensis* contains 47.5 ppm of magnesium, 810 ppm of calcium and 357.5 ppm of phosphorus. It also possessed phenol (264.76 mg/100 g), phytate (31.18 mg/100 g), oxalic acid (381.33 mg/100 g) and tannin (198.94 mg/100 g) [67].

Minerals such as calcium (51 ppm), phosphorus (357.5 ppm), magnesium (47.5 ppm) and potassium (152 ppm) were present in saba fruit pulp [72] but very low sodium content of <5 ppm. Nafan *et al.* [62] documented that the fruit is a potential source of vitamin C ranging from 34.8 to 67.5 mg/100 g. With acidity varying from 30 to 78.5 meq/100 ml; the acid taste of the fruit is high, hence the malic acid of 47.2 mg/100 g [72]. According to Kini *et al.* [77] the fruit contains β-carotene (1.559 mg 100 mg/100 g). Saba fruit has high water content of 80% [79]. All these components suggested that the fruits could supply the required nutrients and improve the health of consumers.

3.6 Climatic requirement

S. senegalensis can be found in West African countries and South Sudan [65, 72]. It can be seen growing along riverbanks [65], in woody savanna region and rocky areas [61, 77]. These locations have maritime trade winds, annual temperature of about 25–30°C and a dry climatic condition which varies in relative humidity. Maximum rainfall occurs in August and lasts for 2 to 4 months [70]. The species survives in different ecological conditions having rainfall between 100 mm to 1300 mm per annum with an altitude of 0–800 m [64, 65]. The plant is hardy and it resists bush fire.

3.7 Cultivation

Sales revenue for *S. senegalensis* fruits in Senegal are significant, accounting for 1/3 to 2/3 of farmers' income [80]. Programs meant at increasing *S. senegalensis* production and domestication are in place. Grafting of saba vine to encourage the domestication and reduce the time of fruiting has been carried out [82]. There is limited information or research work on fertilizer requirement for favorable growth of the seedlings in the nursery and field for its domestication [83]. *S. senegalensis* is predominant in regions that have sandy-loam to sandy-clay-loam soils [84]. It is not known whether physical and chemical properties of the soils are linked to the geographical distribution of Saba.

3.8 Fertilizer requirement of *S. senegalensis*

Food security, malnutrition and environmental degradation are being influenced by low soil fertility, inappropriate use and poor nutrient management strategies. Currently, there is dearth of information on the nutritional requirement and domestication of Saba in Nigeria. In maintaining the yield and quality of new crops, soil fertility management is of paramount importance [12]. The low fertility status of most tropical soils results in low crop production as most crops are nutrient demanding. Inorganic fertilizer such as NPK has strong effect on plant growth, development and yield [85]. Excessive use of NPK will result to loss of soil fertility, which has adverse effect on agricultural productivity, soil degradation and even cause water pollution. Conversely, regular use of organic fertilizers can improve organic matter content, water-holding capacity, enhance structure, nutrient cycling, helps in soil conservation, increase cation exchange capacity and encourage the activities of soil living organisms. Olajide *et al.* [86] evaluated early growth pattern of four accessions of Saba (*S. senegalensis*) in response to seven fertilizer rates (0 t ha^{-1}, 20 t ha^{-1} of PM + 200 kg ha^{-1} of NPK (20:10:10), 30 t ha^{-1} of PM, 30 t ha^{-1} of PM + 100 kg ha^{-1} of NPK, 30 t ha^{-1} of PM + 150 kg ha^{-1} of NPK, 40 t ha^{-1} of PM and 50 t ha^{-1} of PM) in the nursery and found that fertilizer application increased the growth traits measured compared to the control with no fertilizer application. This could be linked to sufficient nutrient released by the fertilizer that enhanced Saba growth. He further stressed that soil amendment with 50 t ha^{-1} of PM enhanced better growth of Saba seedling which indicates that this amount is sufficient for plant growth and development. Olajide [23] examined the effect of four PM rates (0, 10, 20 and 30 t ha^{-1}) on early growth of Saba in the field. He reported that soil amendment with PM at 20 t ha^{-1} positively influenced all the growth attributes measured. When nutrients are supplied optimally, high quality and better nutritious plants are produced [57]. Ndukwe and Baiyeri [13] found that application of PM at 20 t ha^{-1} was optimum for the production of yellow passion fruit in either the nursery or field.

4. Baobab (*Adansonia digitata*)

4.1 Description

Baobab *(A. digitata* Linn.) is a deciduous tree of the family Bombacaceae [87]. It grows up to 20 to 30 m tall with a diameter of 2–10 m at adult age. The trunk is soft, it has vast girth, reddish brown to gray smooth bark and possesses fibers used in making rope and fish net [88]. The plant produces numerous branches, the lateral root system can be up to 50 m from the trunk (see **Figures 7** and **8**). The root end is tubular while the taproot of the tree is shallow which does not grow beyond 2 m depth making them susceptible to storms [88]. The mature tree begins each season with the production of simple leaves having 2 or 3 leaflets. The plant produces white, large, pendulous flowers, and they appeared singly or paired in the leaf axils. The plant bears flower towards the end of dry or prior to the commencement of rains usually after shedding of leaves [89]. The fruit possesses outer shell, pulp and seeds (see **Figure 9**). The life span of baobab trees ranges from 200 to 300 years and some can live beyond 1000 years [89]. *A. digitata* has numerous uses, hence the name 'tree of life and small

Figure 7.
Baobab plants at 4 months after transplanting.

Figure 8.
Baobab plants pruned after 6 months of transplanting.

pharmacy' as a results of its benefits including food, clothing, medicine, protection, fiber, seeds, leaves and roots [90].

4.2 Origin and distribution

Adansonia digitata is a tree originating from African savannah, Madagascar, Australia and Arabia, of the family Malvaceae [90]. It is distributed in arid regions of most countries of the Sahara. The trees are normally found in the thorn woodlands of

Figure 9.
Baobab seed extraction.

African savannahs having low altitudes and 4 to 10 dry months yearly [90]. The tree may grow alone, although it occurs in small groups, which depends on the nature of the soil. Wherever baobab is found, it is majorly in the arid or semi-arid regions of the world [91]. Baobab tree is seen in both settlements and in the wild. In Nigeria, the baobab trees are widely found in North central States (Kogi, Benue, Niger and Kwara) and Sudano-Sahelian parts of the country like Kano, Katsina, Sokoto, Zamfara, Kebi and Jigawa States (Northwestern) and in the Northeastern (Yobe, Borno, Gombe, Bauchi and Adamawa States) [91].

4.3 Food and economic importance

Baobab is an important tree for the African countries [92]. Traditionally, the plants have been used in many ways by people occupying the areas where they are available. The fruit pulp plays a vital role in contributing to the diets of the local populace, and it serves as seasoning material as well as appetizer [93]. When the pulp is soaked in water, the liquid derived from it can be used in making drinks, it can also serve as sauce for food, it can be fermented and used in local brewing [88, 93]. Recently, the pulp has gained popularity and used as ingredient in making ice and other products in urban centers [94–96], the pulp is made into juices and jams. The baobab fruit pods can be burnt and the potash-rich salt obtained can be used for making soap [91]. The European Commission has permitted the importation of baobab fruit pulp as new type food for human use [97] which was approved as a food ingredient by the Food and Drug Administration of the United States of America [98].

The seeds can be consumed fresh or dried, it can also be made into powder which can be used to thicken soup, or roasted and made into a paste, or boiled, fermented and then dried for use [87, 99]. The seeds can be pounded for the extraction of

vegetable oil used in soup preparation and it can be fermented into seasoning [94]. The oil extracted can also be used as fuel, cosmetic, medicine and for treating muscle spasms, swollen veins, injuries and dandruff [100–102]. The seed is a potential source of protein, and the roasted seeds are used to substitute coffee in Sudan and North Africa [103].

Baobab leaves are important in traditional diets of the rural people as leafy vegetables are rich in iron and vitamins. Young leaves are harvested, dried, made into powder and used in making soup [87]. Fibers from the bark are used for weaving bags, hats and mats [87]. The wood is light and whitish when dried and used for fuel [104]. The tree provides shelter, clothing and material for hunting and fishing [94]. It is a good source of dye and fuel. The roots, leaves, seeds and pulp are consumed and it serves as a basic source of livelihood. Baobab trees provide shelter and it can store water [94], with capacities of 1000 to 9000 liters per tree [105]. The products were traded centuries ago being popular in Cairo markets in the sixteenth century [87].

4.4 Medicinal value

Baobab possesses a lot of substances used for treating various diseases in African traditional medicine [106]. In many medicinal uses the stem bark is ground for internal use and it is effective as a result of the presence of soluble and insoluble tannin [107]. The plant parts are used treating diseases and specific uses that were documented includes the treatment of microbial infections, tuberculosis, malaria, anemia, fever, diarrhea, toothache and dysentery [108]. The leaves and fruit pulp are used as febrifuge and boosts the immune system [97, 109]. It is reported that baobab pulp is used externally with buttermilk for relief from diarrhea and dysentery in India, and also the fresh leaves are crushed and used to treat painful bruises [89]. In some West African countries, the seeds, leaves, fruit pulp are major ingredients in beverages, sauces and porridges [97, 107, 110].

4.5 Nutritional qualities

Previous studies showed that baobab leaves are good sources of nutrients. Study [23] that evaluated the effect of poultry manure application rates on nutritional qualities of two accessions of baobab grown in Nsukka, Enugu State, Nigeria revealed that ash ranges between 7.68–8.44%, carbohydrate varied from 51.70–58.50%, fat ranged from 2.90–6.10%, fiber varied from 4.73–5.39%, moisture ranges from 7.40–14.10% and protein ranged from 14.25–18.29%. This author reported that cyanogenic glycosides content obtained was 0.02 mg/100 g while flavonoids ranged from 19.22–25.33 mg/100 g, oxalate varied from 36.70–66.70 mg/100 g, phenol ranges from 50.00–146.00 mg/100 g, phytate ranged from 1.56–2.54 mg/100 g, saponin varied from 0.09–0.10 mg/100 g and tannin ranged from 5.35–5.66 mg/100 g. The concentration of phytate was within the tolerable limit of 5.72–9.22% [111] but oxalate, phenol, saponin and tannin were above the tolerable limits of 5% [112], 2% [113], 0.2% [114] and 3.3% [115], respectively. Since the leaves are not consumed raw, the anti-nutrient contents may be significantly reduced by heat during the cooking process. When plant parts are boiled in water, effects of poisonous anti-nutrients are reduced, hence increasing their palatability [116]. Olajide [23] reported that calcium, iron, iodine and zinc contents ranged from 89.70–98.10, 7.78–8.00, 7.83–8.44 and 0.90–0.93 mg/100 g, respectively. Value for vitamin B_{12} was 0.04 mg/100 g while vitamin B_6 varied from 0.54–2.28 mg/100 g, vitamin E ranged from 8.89–12.33 mg/100 g

and carotenoids ranges from 81.10–124.40 mg/100 g. The study also found that poultry manure application rates significantly influenced moisture, iron, iodine, zinc, vitamin B_6, carotenoids and phenol contents in Baobab leaves. Baobab leaves contain protein (13.6%), fat (2.71%), ash (4.08%), crude fiber (2.45%), (0.01%), moisture (78.2%) and vitamin C (14.98 mg/100 g) [117]. Osman [118] observed that the seeds possessed high quantities of fat, fiber, crude protein but low carbohydrate contents. Consuming 20 g can provide 15 to 34% recommended daily allowance of protein for children; 60 g can meet 27% of the recommended daily allowance for pregnant women. Also, consuming 100 g can supply about 22% recommended daily intake of the energy for pregnant women and 29.4% recommended daily allowance of energy for children [110]. Previous work of Arowora *et al.* [119] revealed 31.43 mg/100 g of tannins, 124.36 mg/100 g of phenolics, 9.35 mg/100 g of alkaloids, 63.43 mg/100 g of flavonoids and 14.63 mg/100 g of glycosides. Enoch *et al.* [120] reported that baobab leaf contains sodium (0.870 mg/l), magnesium (1.260 mg/l), potassium (4.118 mg/l), calcium (0.780 mg/l), iron (3.640 mg/l) molybdenum (0.409 mg/l) aluminum (0.006 mg/l), nitrogen (0.278 mg/l) and phosphorus (0.162 mg/l). Baobab fruit contains α-carotene (0.17 μg/g) and lutein (1.53 μg/g) in dry weight [121]. Becker [122] found riboflavin, thiamine and niacin content with respective values of 0.07, 0.04 and 2.16 mg/100 g dry weight.

4.6 Climatic requirement

A. digitata is an enormous evergreen tree distributed across subtropical regions of Africa such as South Africa, Botswana, Nigeria, Tanzania and Madagascar. The baobab is also considered to be one of the oldest forms of life in Africa, some estimated to be up to 3000 years old [123]. The tree is restricted to hot, dry regions but lives in various environments outside both the northern and southern edges of tropical regions of Africa, more specifically outside latitude lines 16° N and 26° S [124]. Its semi diverse stretch reaches biomes like scrub, woodlands, wooded savannah and even semi-arid/semi humid tropical regions. *A. digitata* tree is usually seen in regions with annual rainfall of 500 to 800 m [125].

4.7 Cultivation

Due to the medicinal, nutritional and cosmetic applications of baobab, it has gained popularity and attracted the interest of a lot of pharmaceutical companies and researchers in the past decade. As a result of the high demand for baobab products in European Union and United States of America, the tree ought to be conserved, treasured and domesticated in other parts of the world [126]. The plant is found in hot, semi-arid regions, dry woodland and stony areas with low rainfall of 1500 mm per annum [94], it thrives on marginal soils but does well on well-drained, clays to sandy soils, but not on deep sands, where it will be difficult for the plant to obtain sufficient moisture and support [89]. In Africa, baobab is found at latitude 16° N and 26° S, these areas do not have more than one day of frost in a year. It has slow growth which could be as a result of low rainfall and low soil fertility. Assogbadjo *et al.* [127] determined the perception and preferences of baobab products in Burkina Faso, Benin, Senegal and Ghana, the study included women and men of different ages. According to the survey, if the bark is easier to harvest, then the pulp and leaves will be tastier; slimier pulp are less tasty; when the fruit capsules are longitudinally marked, the tastier the pulp will be. The study indicated that farmers can use selected

combinations of attributes as a guide in germplasm collection. This knowledge could be employed during the selection of a suitable planting material and a guide for a domestication. Commercialization of baobab seed oil and fruit pulp is on the rise, in addition, exportation worldwide has led to mounting pressure on this resource [87].

4.8 Fertilizer requirement

In order to increase productivity to meet the nutritional requirements of human population and to increase the household income, enhancement of soil health is a critical factor. Soil fertility can be improved using organic or inorganic fertilizers and may be combined [14]. Frequent utilization of inorganic fertilizers solely cannot increase crop yield on poor soils [128]. Therefore, the need for organic soil amendments to increase soil fertility and enhance the physicochemical and biological properties for continuous production of crops. It was noted that amending the soil with organic and inorganic fertilizers support the best crop performance [129, 130]. Olajide [23] who worked on the influence of three rates of PM (0, 15 and 30 t ha^{-1}) on early growth of baobab in Nsukka, Enugu State, Nigeria found that plots amended with poultry manure performed better in terms of the growth attributes measured compared to the control. The higher values of the morphological traits obtained with poultry manure application suggests that baobab plants are highly responsive to manure application. Poultry manure is the richest out of the animal manures, and it is a valuable source of nitrogen and potassium as well as organic matter [12]. Organic manure as soil amendment is highly important in order to sustain crop production systems since it is a reliable source of nitrogen and carbon [131, 132] and it also moderates soil pH [133]. Olajide [23] reported that application of 15 t ha^{-1} of PM increased all the growth parameters evaluated than other poultry manure rates. Adebayo *et al.* [58] reported that when manure is available in adequate quantity, plants tend to grow at their optimal potential.

5. Kapok (*Ceiba pentandra*)

5.1 Description

C. pentandra is a tree belonging to Malvaceae family. It is a plant that is found in the wild. The plant is called Kapok or white Silk-Cotton tree in English. It is known as "Araba" in Yoruba, "Akpu-ogwu" in Igbo and "Rimi" in Hausa tribes of Nigeria [134, 135]. *C. pentandra* is a fast-growing tree and can grow up to 24–70 m high, having a diameter of 100–300 cm. Universally, kapok is known to be among the largest trees. The stem and large branches are usually crowded with conical spines (**Figures 10** and **11**). The palmate leaves consist of 5 to 9 leaflets and can be up to 20 cm (7.9 in) in length. The tree produces hundreds of pods measuring 15 cm (5.9in) with seeds surrounded by a fluffy fiber which combines lignin and cellulose (**Figure 12**). In Miami, Florida, one of the oldest known trees lives at 200 years [136]. Kapok fiber is light, water resistant, but it is highly flammable. The harvesting, processing and separating the fiber is done manually and is labor-intensive. Although it is difficult to spin, it is used alternatively to down for filling in mattresses, pillows, upholstery, zafus and stuffed toys like teddy bears and for insulation. Earlier, it was used in making life jackets and similar devices until synthetic materials largely substituted the fiber. Oil extracted from the seeds is used locally in soap and fertilizer production [137].

Figure 10.
Kapok plants at 5 months after transplanting.

Figure 11.
Kapok plants at 11 months after transplanting.

5.2 Origin and distribution

Ceiba pentandra is native primarily in West Africa where it is found in rainforests typically at elevations of 900 to 1200 meters [138]. It is widely distributed in South America—Brazil, Venezuela, Ecuador, Peru, Bolivia, Colombia, the Guyanas; North through Central America to Mexico; Caribbean; West tropical Africa [75]. Kapok is a multipurpose tree with numerous uses for the local populace where it is grown. It is highly valued for its fiber, and it also provides food, medicines and other products.

Figure 12.
Kapok pods.

Kapok is widely grown in the tropics for its medicinal value and fiber, the plant exists naturally in many areas [139]. It has long been planted around buildings in villages for food, medicine, beautification purpose and other uses. However, the floss is harmful as it causes irritation to the eye and nose, so the tree is not suitable for town planting. Commercially, kapok is grown for the fiber from the pod in Java [75].

5.3 Food and economic importance

The succulent leaves of kapok are used in soup preparation, which is comparable to Okra, and it is used for eating starchy balls made from millet, cassava and yam [140, 141]. The leaves are dried and made into powder used to prepare delicious soup known as 'kuka' during dry periods [23]. Fresh and dry leaves made into powder are hawked in the villages, which contributes to the rural farmer's economy. Vegetable oil extracted from the seeds can be used for bio fuel, soap making, paint preparation and can also be used in manufacturing fertilizer [130]. The plant provides fiber and timber. The whitish cotton (floss) can be used for making mattresses, absorbent material, pillows and tinder [141]. The wood is widely used in plywood manufacturing and in making canoes. It is also used for musical instruments, mortars, carvings, lightweight furniture and other items [130]. The foliage can be used in feeding ruminant animals, trunk for plywood and wood pulp for paper. The fiber is used while dressing injuries; applying the oil can treat rheumatism [130]. *C. pentandra* is known in folktale, it is noted to be a sacred plant and its image is used as the national emblem of Guatemala, Puerto-Rico and Equatorial Guinea. It appears on the coat of arms and flag of Equatorial Guinea.

5.4 Medicinal value

Leafy vegetables play a vital role in maintaining health of the populations and diseases prevention. Large quantities of micro-minerals are obtained from dark green

leafy vegetables which are essential in nutrient metabolism and slow down degenerative diseases [142]. Gropper *et al.* [143] emphasized the importance of consuming vegetable based meals to prevent colon cancer. Ball [144] found high vitamin, dietary fiber and mineral contents in vegetables and the role they play in keeping up alkalinity in the body. The high amount of fibers in green leafy vegetables assists in regulating the digestive system, improving bowel health and weight management [145, 146]. The leaves are recognized as having emollient and sedative contents. In Senegal, Kapok leaves are mashed in water, which is drunk for general fatigue, stiffness of the limbs, headache and bleeding of pregnant women. Young leaves are warmed, mixed with palm oil and eaten against heart diseases. Leaf sap is used in treating skin infections and mental illness. Leaf decoction is used by veterinary doctors in the treatment of trypanosomiasis among others [137]. The bark contains a blackish mucilaginous gum; it is astringent and is used in India and Malaya for bowel complaint and West Africa for diarrhea [66]. It is also used for treating skin infection and tooth troubles in Senegal. Bark macerations are credited with stimulant and antihelminthic properties. It is also a cure for heart trouble and hypertension [130]. The root forms part of preparations to treat leprosy. The flowers are eaten to treat constipation and fruits taken with water against intestinal parasites and stomach problem.

5.5 Nutritional qualities

Many of the local vegetables are underutilized due to inadequate information on their potentials to nourish the body with nutrients [147]. High utilization and consumption of vegetables is crucial in alleviating universal incidence of nutritional deficiencies [148]. Chemical analysis has shown that the leaves of *C. pentandra* contain anti-nutrient, proximate, mineral and vitamin contents. Olajide [23] reported that the succulent leaves of *C. pentandra* contain ash (8.59%), carbohydrate (55.60%), fat (1.50%), fiber (18.80%), moisture (3.34%) and protein (12.34). As reported by Osuntokun *et al.* [137], it has protein (16.25%), fat (5.34%), fiber (8.53%) ash (8.72%), moisture (7.32%) and carbohydrate (53.72%). Enechi *et al.* [149] found 47.37% for moisture, 16.81% for protein, 25.23% for carbohydrate, 4.47% for fiber, 2.23% for fats and 2.14% for ash. According to Olajide *et al.* [150], succulent leaf of *C. pentandra* possess calcium (9.93 mg/100 g), iron (19.05 mg/100 g), potassium (35.80 mg/100 g), magnesium (60.79 mg/100 g), phosphorus (78.50) and zinc (0.59 mg/100 g). Shahin *et al*. [151] reported that the leaf contains 177.0 mg/100 g of calcium, 153.66 mg/100 g of potassium, 48.15 mg/100 g of magnesium, 27.09 mg/100 g of zinc and 1.54 mg/100 g of iron. Olajide [23] obtained 0.012 mg/100 g for vitamin B_{12}, 0.59 mg/100 g for vitamin B_2 and 0.97 mg/100 g for vitamin C in succulent leaves of Kapok from Kogi State, Nigeria. Earlier report of Adepoju and Ugochukwu [141] found that Kapok leaves contain vitamin B_2 (0.19 mg/100 g) and B_{12} (0.24 mg/100 g). Friday *et al*. [140] found that it contains phenol (173.94 mg/100 g), oxalate (0.10 mg/100 g), tannin (0.48 mg/100 g) and saponin (1.55 mg/100 g). Olajide *et al.* [150] also reported 0.19 mg/100 g of saponin, 107.10 mg/100 g of oxalate, 18.20 mg/100 g of phenol, 2.60 mg/100 g of phytate, 4.55 mg/100 g of tannin and 3.96 mg/100 g cyanide in succulent leaves of *C. pentandra* sourced from Kogi State, Nigeria. The concentration of saponin content was within the tolerable limits of 0.2% reported by Codex [152], but oxalate, phenol, phytate and tannin contents of succulent leaves of *C. pentandra* were above the tolerable limits of 5% [112], 2% [113], 9.22–5.72% [114] and 3.3% [115], respectively. Since the leaves are not eaten raw, the anti-nutrient contents may be significantly

reduced by heat during the cooking process. Boiling significantly reduced the poisonous effects of anti-nutrients and increased the leaf consumption [116, 153]. Olajide [23] conducted a study on the impact of integrated application of poultry manure and inorganic fertilizer on mineral and vitamin constituents of *C. pentandra* leaves grown in Nsukka, Enugu State, Nigeria. The results indicated that fertilizer application rates only influenced zinc and calcium with 20 t ha^{-1} of PM having the highest concentration of Zinc (0.45 mg/100 g) and integrated application of 5 t ha^{-1} of PM + 200 kg ha^{-1} of NPK recorded the highest value for calcium (145.00 mg/100 g). Protein consumption is necessary due to role carried out by its essential and non-essential amino acids as building blocks for protein biosynthesis not only for the growth of infants and children, but also for the steady replacement and turnover of body protein in adults [147]. Flavonoids have antiviral, antibacterial, antineoplastic, anti-inflammatory and anti-allergic properties [148]. Tannins possess antioxidant, antimicrobial and anti-inflammatory properties. Phenols are known as powerful antioxidants, preventing oxidative damage to biomolecules such as DNA, lipids and proteins which are active in chronic diseases such as cancer and cardiovascular diseases [137]. Ascorbic acid/vitamin C empowers the body's immunity against infection, helps in collagen and thyroxin synthesis and improves absorption of iron [147]. In living organisms, ascorbate (anion of ascorbic acid) is an antioxidant that protects the body against oxidative stress and is a co-factor in several vital enzymatic reactions [154]. These constituents give the leaves their protective, preventive and therapeutic properties thus improving the gains that can be obtained by consuming these leaves.

5.6 Climatic requirement

C. pentandra needs abundant rainfall but requires drier period for flower and fruit production. It grows at altitudes as high as 4000 m [155]. Night temperature less than 17°C decreases the germination of pollen grains. This reduces areas where the plant can be found. It thrives in latitudes of 20°N and 20°S and requires annual rainfall of 1500 mm. Where kapok is naturally distributed, the average rainfall is 750 to 3000 mm per annum. The dry season should not exceed 4 months. In drier regions, water requirement by the plant can be met by providing irrigation [23]. For optimum production, the tree is grown on deep, fertile well drained soils. Kapok is prone to heavy winds and cannot survive bush fire. The plant is usually found in rainforest and drier zones. Kapok is dominant in secondary forest and along the riverbanks and is hardly found in primary forest. It is a fast growing plant with canopy developing within few months if left undisturbed [156]. The tree may occur in large numbers in humid to semi-arid regions. Kapok can be grown or self-sown; the seedlings should be protected from fire and livestock [23].

5.7 Cultivation

Kapok is a tropical plant found at height of 1200 meters, however, productivity declines beyond 460 meters [144]. Optimal growth is achieved in locations with yearly daytime temperatures range of 17–38°C, and kapok can withstand 12–40°C. The plant could die at −1°C or less [72]. Fruit production could be delayed at nocturnal temperature of 20°C. Kapok enjoys a mean rainfall of 1500 to 2500 mm per annum, although it withstands 750 to 5700 mm [72]. It tolerates long dry period range of about 0–6 months [157]. Kapok is the tallest indigenous plant in Africa [158]. It thrives in a fertile, deep, moisture-retentive but well-drained loamy soil is preferred

[139, 159]. It does well at a pH range of 5.5–6.5 and it can also tolerate 5–7.5 [74]. Kapok is prone to wind; it prefers wind break for protection against strong winds [139]. The tree may start bearing fruit at 4–5 years, with increased production till 8 years. The economic or production life of kapok tree can last for almost 60 years [74]. Leaf and flower production season are stable in drier regions where the plant is distributed; in wet regions, production of leaf and flower are not regular. Anthesis occurs in the night and ended at midday. The flower releases strong scent and secretes nectar at the flower base, which is large and bisexual. Ripening of fruits occurs at 80–100 days after flowering, the dehiscent types splits with loosely fixed seeds released and dispersed [74]. The light seeds are spread widely and find ideal germination conditions in abandoned agricultural land [74]. A single tree can produce over 300 pods yearly with an output of 20 kg of fiber from 5 years to 50 years [139]. The tree responds positively to coppicing. It has vigorous root system causing damage to buildings and roads [160].

5.8 Fertilizer requirement

Soil degradation as a result of deforestation, nutrients lost through leaching and erosion has led to depleting fertility and caused decline in soil organic matter levels [161, 162]. Soil amendment using organic manure is vital in increasing crop yield. A fertile soil should possess an organic matter content of more than 3%. Soil amendment could be in form of organic or inorganic or combined [14]. Previous studies confirmed that combined application of organic and synthetic fertilizers supports the best crop performance [129, 130]. Olajide and Baiyeri [163] who worked on the effect of these rates (No fertilizer, 5 t ha^{-1} PM + 200 kg ha^{-1} NPK, 10 t ha^{-1} PM, 20 t ha^{-1} PM, 450 kg ha^{-1} NPK and 20 t ha^{-1} PM + 100 kg ha^{-1} NPK) on growth of kapok in the field reported that 20 t ha^{-1} of PM applied solely increased the performance of kapok plants. Olajide and Baiyeri [163] also found that soil amendment using 450 kg ha^{-1} of NPK and other treatments combined with NPK reduced the growth of kapok when compared with the plants in plots where no fertilizer was applied. Inability of NPK fertilizer in increasing kapok might be associated with acidification of the rhizosphere. It has been established that application of NPK reduces soil pH and boosts soil acidification but addition of organic manure improves soil acidification [164].

6. Conclusion

It is quite evident from this review that tropical plant species provide a lot of benefits to ensure food security, improve the health and socio-economic status of the populations. These crops have nutritional, economic, medicinal and industrial potential and can ensure healthy food system for the people. They can also play an important role in climate resilience for sustainable environment. Their full potential should be harnessed as it has been established that these crops are highly responsive to fertilizer. They can be brought under regular cultivation culture and the fruits and leaves accessed without the traditional search for them. This information could encourage the domestication of these indigenous plant species and guide the utility of these crops. Empirical studies [23] copiously quoted in this review supports the possibility of adapting these forest species to regular cultivation culture.

Furthermore, in harnessing the potential of these tropical plant species to the fullest, this review outlined some key factors that could unlock their vast potential.

- *Awareness*: It is crucial to supply the stakeholders with knowledge with respect to their nutritional, economic, industrial and medicinal values in order to increase their acceptability and domestication.

- *Domestication*: No effort has been made to specifically cultivate these crops for food. Most of these tropical plant species have been neglected for long; farmers should be encouraged to grow them commercially. Government and the scientific community should work alongside the farmers.

- *Intervention of government*: Production, harvesting, processing and marketing of these crops require the support of government. Incentives can be made available to farmers to boost their morale.

Conflict of interest

The authors declare no conflict of interest.

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