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# The traditional and medicinal use of African breadfruit (*Treculia africana* Decne): an underutilized ethnic food of the Ibo tribe of South East, Nigeria

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## Abstract

African breadfruit is an underutilized food security crop which is a delicacy for the Ibo ethnic group of South East Nigeria. It is commonly found in West and Central Africa. It is an evergreen large tree that bears about 20–30 pods containing edible seeds, annually. The edible seeds are used as specialty dishes by the Ibo tribe of South East Nigeria. African breadfruit meals have high dietetic value. The pods, leaves and roots are used in traditional medicine. The leaves are particularly rich in carbohydrates, phytochemicals (flavonoids, phenols, cardiac glycosides and anthraquinones) and minerals. These constituents contribute to its antioxidant, antimicrobial and wound healing properties. The stem bark extract is used as a cough remedy and has antimicrobial properties. The water and ethanolic extracts of the root possess antihyperglycaemic properties and also discourage the development of secondary complications of type 2 diabetes. Many of the perceived medicinal and chemical properties have not been scientifically investigated. Although other members of the mulberry family (especially the *Artocarpus* species) have received some research attention, *Treculia africana* remains underutilized despite its great potentials as a food security and medicinal crop.

**Keywords:** African breadfruit, *Treculia Africana*, Composition, Phytochemicals, Nutritional quality, Processing, Ethnobotanical uses, Medicinal properties, Underutilized

## Introduction

### *Treculia africana* (Decne)

The African breadfruit (*Treculia africana* Decne) is large evergreen tree found in tropical and sub-tropical humid forests. It is widely distributed in West and Central Africa. It belongs to the family Moraceae and can grow to a height of 30 m while the stem can be up to 6 m wide. The stem bark is grey in colour and produces a white latex. The leaves are large and dark green on the surface and lighter underneath. The tree may be monoecious or

dioecious. The male flowers are club-shaped while the female inflorescence form globose heads on a receptacle [1]. It produces big round greenish brown fruits when mature which turns greenish yellow when ripe [2]. The fruit has a hard and spongy texture and contains numerous oval shaped seeds randomly embedded in the spongy mesocarp [3, 4]. A brown coloured seed coat covers the milk white cotyledon (inner edible endosperm). While Breadfruit and jackfruit (*Artocarpus* species) are now popularly grown in other countries with tropical climates like Ghana, West Indies, Jamaica, and Sierra Leone, *Treculia africana* has not received good research attention. The seeds are the edible part of this fruit. Under good environmental conditions, the yield from one tree is 200 kg of dried seeds. However, its yield is not statistically

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measured and it is not found in the agricultural census of Africa. A mature tree can produce up to 30 fruits in a year and each fruit can yield up to 10 kg seeds after pulp removal [5]. *Treculia africana* is presently considered an endangered species [6, 7]. This legume needs to be conserved as a matter of urgency [7] (Table 1).

### History, origin and distribution of breadfruit varieties

Breadfruit (*Artocarpus altilis*) (also belongs to the mulberry family but is different from African breadfruit) has been a staple food in the Pacific Islands for over 3000 years. Jackfruit (*Artocarpus heterophyllus*) is grown India, Myanmar, China, Sri Lanka, Malaysia, Indonesia, the Philippines, Brazil, Caribbean islands, the US, Australia and some African countries [10]. They were distributed by sea travels between 1790s through 1840s. While a seedless Caribbean breadfruit variety spread from Tahiti to the West African coast (from Senegal to Southeastern Nigeria), a Samoan variety spread to Ghana, Kenya and Liberia. There are at least 120 breadfruit varieties in Asia and the Pacific. A Pacific Island breadfruit variety is now common in southwest Nigeria and has both seeded and seedless types [11]. In the 1980s, Dr Ragone started a collection of 120 breadfruit varieties which eventually led to the establishment of the breadfruit Institute at the United States' National Tropical Botanical Gardens (Hawaii) [12]. Using tissues from the most productive ones, Dr Susan Murch of British Columbia University developed an in vitro propagation method that led to easy multiplication of the seedless breadfruit varieties. The Global Breadfruit Initiative distributes the *Artocarpus* varieties worldwide [13, 14].

There is a sustained use of African breadfruit (*Treculia africana*, Decne) from Sierra Leone to southwestern Nigeria, as well as the use of Pacific Island seedless

varieties. The use of African breadfruit in southern Nigeria, extends to Cameroon and the Congo Basin. The seedless varieties now used in southwest Nigeria and coastal regions up to Senegal are believed to be more recent than the indigenous African variety [15]. In West Africa, African breadfruit trees are found around homes and in the forest, suggesting that they were not purposely planted. Howbeit, they are owned by individuals. In South East Nigeria, personally owned trees are intensively utilized. The African custom is that trees are owned by individuals and this practice is not peculiar to breadfruit. The importance of African breadfruit cannot be overemphasized. It saved Ghanaians from death and wasting during 1983 famine. Breadfruit was the *only* crop that did not fail completely when Southern Ghana experienced drought in 1983; most of the grain crops and trees failed [16].

The Global breadfruit initiative makes available at the International level, improved crops mainly seedless varieties of *Artocarpus altilis* and *Artocarpus heterophyllus* but *Treculia africana* is not yet in the picture. They produce “plugs” from sterile growth media which sprout up and start fruiting within 2–3 years, while cuttings will take 4–9 years to fruit. Alternatively, they may be grown hydroponically. Scientific methods have been developed for large-scale propagation and mass production of breadfruit plants for worldwide distribution but African breadfruit remains underutilized [13, 16].

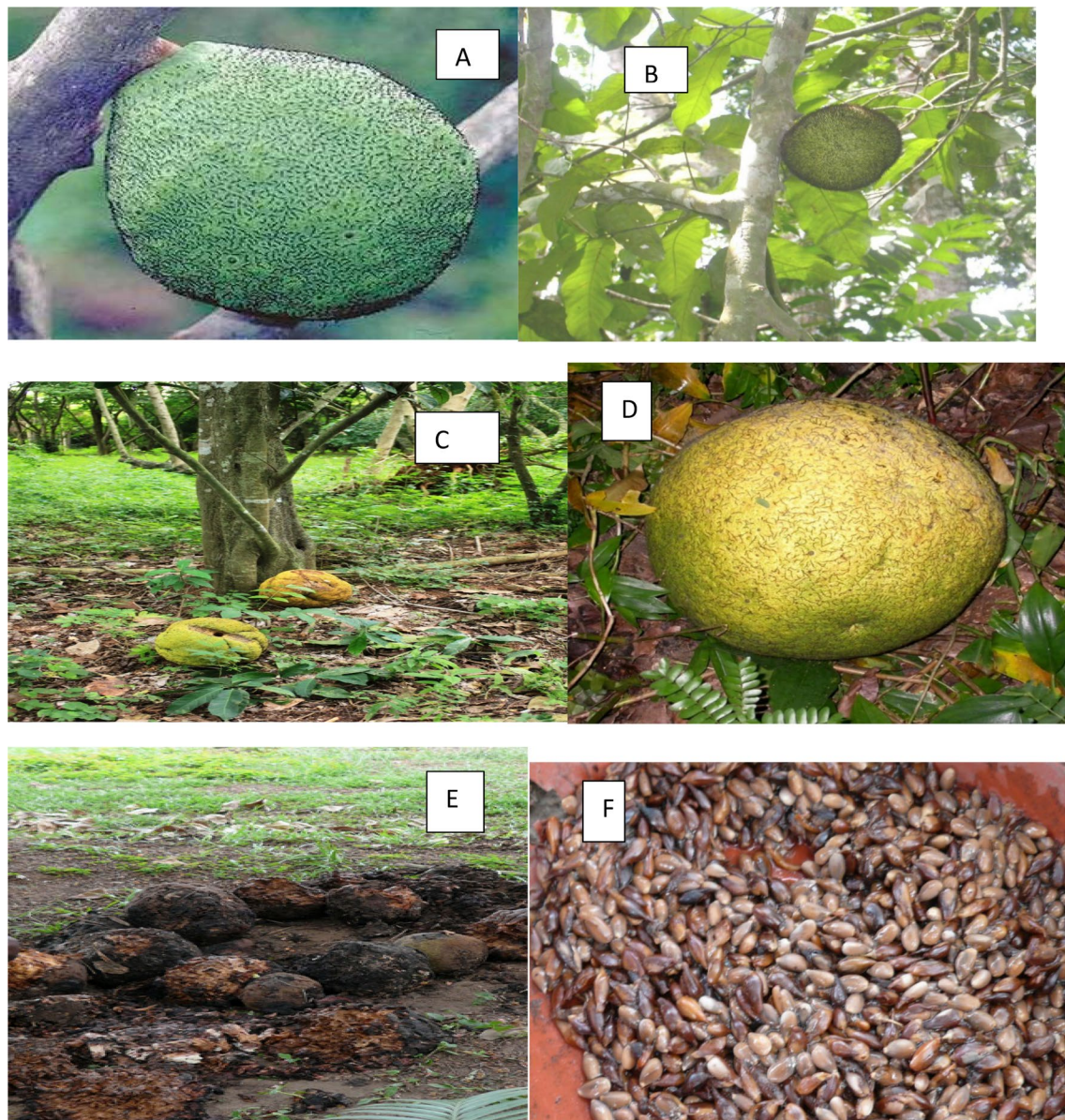
### Morphological characteristics of varieties of breadfruit

The African breadfruit is indigenous to West and Central Africa [17] (Fig. 1). Three varieties can be easily distinguished within the subspecies: *T. africana*. Var. *africana* (which is found in Senegal, Southern Sudan, Angola, central Mozambique and Sao Tomé and Principe Islands), *T. africana*. Var. *inversa* (found in

**Table 1** Common/vernacular names for *Treculia africana*

Location	Common/vernacular names
Nigeria	Breadfruit; Afou or “bere – foo-foo (Yoruba); Barafuta (Hausa); Ize (Bini); Eyo (Igalala); Edikang (Efik); Ukwaa (Ibo)
Tanzania, Uganda	Wild jackfruit; Ezeya
Tanzania; Zambia; Uganda; USA	African breadfruit, African breadnut
South Africa	“mwaya” in Swahili
Uganda, Tanzania, Kenya, Republic of Congo	muzinda (Lugada)
Mali; Mauritania; Senegal	brebretim (Wolof)
France	Abre a Pain D’Afrique
Germany	Okwabaum
Malawi	African boxwood

[8, 9]



**Fig. 1** African breadfruit (*Treculia africana*). <http://tropical.theferns.info/image.php?id=Treculia+africana> Photograph by: Scamperdale. A = Mature breadfruit pod; B = Ripe breadfruit pod; C/D = Breadfruit pod that has detached from the tree; E = decayed breadfruit pod; F = breadfruit seeds after extraction from the pod. Source: Adapted from en:User:Gachet—English Wikipedia ([http://en.wikipedia.org/wiki/Image:Breadfruit\\_Tree.jpg](http://en.wikipedia.org/wiki/Image:Breadfruit_Tree.jpg)), CC BY-SA 3.0,

Anambra State, Edo and Delta States, very abundant in the eastern states of Nigeria), and *T. africana*. Var. *mollis* (found in isolated locations in Edo and Delta states of Nigeria, Cameroun, Congo, Gabon, and Cabinda) [4, 18]. They are distinguished based on the size of the fruit head (infructence), the hairiness of branchlets and the leaves [5]. *T. africana* var. *africana* has large fruit heads and more seeds. *T. africana* var. *inversa* is more branched; has smaller fruit heads, but more fruits. *T. africana* var.

*mollis* has dull elliptic leaves, small fruit heads and wrinkled small, rounded or elongated seeds.

The common names Breadfruit (Fig. 2), jackfruit (Fig. 3) and “African breadfruit” actually refer to members of the mulberry family which are different from one another. *Artocarpus altilis* (breadfruit); *Artocarpus heterophyllus* (jackfruit) and *Treculia africana* (African breadfruit). *Artocarpus altilis* is seedless and may be processed like sweet potatoes and yams [16]. Jackfruit leaves



**Fig. 2** (*Artocarpus altilis*) Parkinson (Breadfruit). By C. Hans Hillewaert, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=7893338>



**Fig. 3** *Artocarpus heterophyllus* Lam (Jackfruit). Source: Wikipaedia

(*Artocarpus heterophyllus*) are without lobes and are smaller than breadfruit leaves. Jackfruit male flowers and the fruits are borne on stems on the tree trunk or branches. Breadfruit leaves are large with indents and is believed to have originated in New Guinea and the Indo-Malaysia [11, 16]. Breadfruit is closely related to the jackfruit (*Artocarpus heterophyllus*), from which it might have been naturally selected. It is similar in outward appearance and they belong to the same genus [19].

### African breadfruit in the Nigerian food culture

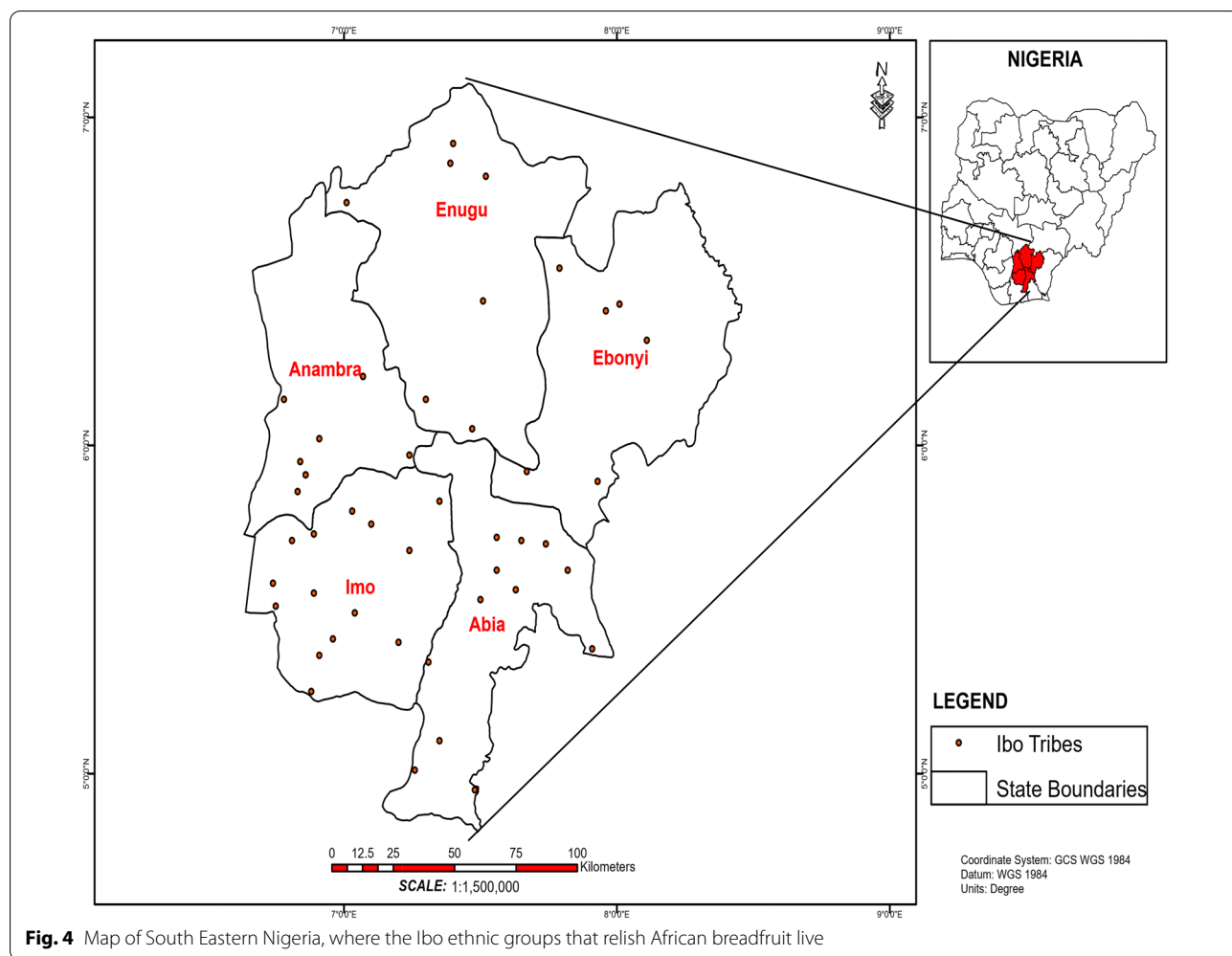
The African breadfruit seed is a delicacy which is relished in South East Nigeria. The un-decorticated seeds may be roasted, de-hulled and eaten with palm kernel (*Elais guineensis* seed) or coconut (*Cocus nucifera*) as snack. The roasted dehulled seeds are often hawked on roadsides in South East, Nigeria. The fresh un-dehulled seeds may be blanched in hot water for 5–10 min, drained and dehulled. The seed coat is winnowed off,

while the milk-coloured cotyledon is used in food preparations. It may be boiled to a soft consistency and eaten as porridge. It may be mixed with cereals such as rice yam, sorghum and maize or with tubers such as shredded cassava. It may be dried, ground into flour and used as a composite with wheat flour for baked foods. The flour from the decorticated seeds may be used for thickening soups. In the South East and South West Nigeria where the consumption of African breadfruit is common, it is very important in alleviating rural poverty because it can serve as a substitute for yam and is eaten in combination with many other foods. The cooked seeds are a valuable food among the “Igbos” in particular; the Efiks, Kalabaris, Edos and the Ika Igbos in Delta State and most tribes of the Southern part of Nigeria [20]. The extracts from the sprouted seeds have been supplemented with kunun-zaki at various concentrations and improved the protein content of the gruel. The cooked mashed porridge can be used as complementary foods for children. It may be used

for oil extraction and as a flavoring for alcoholic drinks (Fig. 4).

In some Ibo traditional settings in Nigeria, *T. africana* grows in the wild and the fruit head is picked on first come first served basis for consumption once it falls down from the tree. The first person to hear the sound of the falling fruit head, usually runs to carry the fruit for subsequent processing and preparation as food. No one is allowed to pluck it. Recently because of its commercially increasing importance it is owned and planted by individuals. However, it is seldom planted very near the houses because of the very large pods that can cause damages as they fall down when ripe.

African breadfruit (ukwa) has a well- liked flavor. The food can be cooked in different ways: The decorticated seeds Fig. 5a) may be sun-dried and later reconstituted in water (Fig. 5b). It might be cooked with palm oil salt and pepper as porridge (Fig. 5c) or with additives like fish, scent leaf or bitter leaf, palm oil and condiments (Fig. 5d). It may be cooked and served with rice (Fig. 5e). It is sometimes



**Fig. 4** Map of South Eastern Nigeria, where the Ibo ethnic groups that relish African breadfruit live



**Fig. 5** a–f Dehulled African breadfruit; Boiled African breadfruit porridge; Roasted African breadfruit. Source: Eleazu et al. [21]

roasted and eaten as snacks (Fig. 5f). Whichever method of preparation, ukwa usually comes out delicious and appetizing. Freshly processed (washed) African breadfruit (ukwa) or dried ones can be used for preparing this dish. If it is dried, it should be soaked overnight in cold water to reduce the cooking time. Some people also add potash to shorten the softening time during cooking. In some parts of South East Nigeria (Anambra), fermented legume condiment (Ogiri) is added to give some aroma and flavour. It may be fried with or without the bran.

#### Preparation of African breadfruit meal

The decorticated African breadfruit seed (ukwa) is rinsed in a clean water and put in a cooking pot. Water is added to be slightly above the ukwa. The pot is placed over fire (made with wood, kerosene stove or gas cooker). Potash may be added to tenderize the African breadfruit. Cooking in a pressure cooker will achieve the same purpose. When the “ukwa” is tender, some “ukwa” juice is decanted and set aside as a side dish. De-boned dry fish is washed with warm water and added to the pot. Other ingredients viz: palm oil, vegetables, legume condiment (Ogiri) may be added as, flavorings at the appropriate cooking time. The mixture is stirred periodically and allowed to simmer until the ingredients are thoroughly

blended with the ukwa. One of the popular traditional method of preparing the “ukwa” is with scent leaf (*Ocimum gratissimum*) or bitter leaf (*Vernonia amygdalina*), dried fish and palm oil and eaten as a porridge. The cooked porridge is served with the decanted juice as side dish. *Artocarpus altilis* is used in Southwest Nigeria to make a type of pounded yam known as “Iyan Jaloke” and may be cooked and eaten as yam. It should not be confused with *Treculia Africana* [22, 23].

Among the Igbos of Nigeria, *Treculia* has been recognized as one of the choice foods for special occasions. It is a delicacy served during social outings like weddings, traditional title taking, initiation of persons into age grades, burials etc. *Treculia africana* seeds play vital roles in improving people’s socio-economic life. Inter State trade on the species seeds generates substantial revenue to the resource-poor rural dwellers and the intermediary traders. Within the South Eastern States, hawkers on *Treculia* snacks earn revenue that sustains their families [6, 24].

#### Ethnobotanical uses of *Treculia Africana* (African breadfruit)

*T Africana* is used in traditional settings for food and medicinal purposes. Crude extracts from the leaves, stem bark, and roots are used in folk medicine to treat

various ailments. Crude extracts from different parts of the plant are used either singly or in combination with other herbs to treat various diseases. Crushed leaves are applied on the tongue as a treatment for throat infections and for thrush in children. The latex is applied as an antibacterial agent in eardrops. Juice from the leaves can also be used locally as ear drops. It is used for the treatment of cough, rheumatism, rashes, malaria, stomach disorders, mouth yaw and the regeneration of damaged spleen and liver cells. The leaf ash is used as a remedy for enlarged spleen. Decoctions from different plant parts are used as an anti-inflammatory agent and in the treatment of whooping cough and is used also in some communities as an effective treatment in stomach upset and other gastro intestinal infections. A decoction of the breadfruit leaf (*A. altilis* not *T. africana*) is believed to lower blood pressure and may relieve asthma. It is apparently *A. altilis* whose leaf decoctions were reportedly used in Trinidad and Bahamas to lower blood pressure [25]. Most of these claimed uses are yet to be scientifically verified and evaluated.

### Other uses

*T. Africana* is a nutritious feed for livestock. Farm and wild animals feed on the fruit head, the unfermented pod, the seed, the bran and the leaves [26]. The wood may be used for making furniture, pulp, paper, firewood, building; as well as fibre-board. The fruits can serve as fodder. Chimpanzees break the fruits into small pieces and eat it. In Malawi, blue monkeys are very fond of the fruits while in Tanzania the leaves are used as fodder [18]. It may be used as a brewing adjunct to provide fermentable sugars. It is used for erosion control and for reforestation. The fresh pulp can be utilized as fodder [3, 14]. African breadfruit is a food security that helps meet the nutrient needs of people and also provides income to rural poor households that produce, process and/or preserve this crop. Uluocha et al. [27] investigated the income generation, processing and sales of African breadfruit in Imo State, Nigeria. Their findings was that AFB was an underutilized food security crop and the major challenges to its economic development were; seasonal scarcity; labour input during processing and transportation.

### Processing of *Treculia Africana*

The heavy, large fruit of *T africana* is not traditionally harvested but allowed to ripen and drop from the tree. Ugwu and Iwuchukwu [28] studied the method of processing and preservation of AFB by women in Enugu State, Nigeria. The women employed both fresh extraction method and fermentation method for removing the

seeds from the pulp. In the fresh extraction method, the seeds inside the spongy pulp is removed with kitchen knife. The fermentation method involves allowing the fruit to decay, removing the pulp which becomes slimy as fermentation progresses and extracting the seeds, using water.

Onweluzo and Odume [29] observed that mucilage constitutes about 30% of the decaying *T. africana* pods on a wet basis. Fermented fruits are extracted from the retted pods and washed with water to remove the slime. Removing the mucilage using trona (1–5%) was more effective than applying wood ash (for 5–25 min [29]). Treatment with trona during the demucilagination process facilitated the dehulling process to separate the bran from the edible portion. This suggests that trona loosened the non-starchy polysaccharide layer that attach the bran to the endosperm. Gums and non-starchy polysaccharides are responsible for the tight adherence of the hulls of seeds to the cotyledon. Allowing the pods to ferment naturally to release the seeds reduces labour but elicits deteriorative changes in the edible portion. The crude fat extracted from the edible portion of seeds from the unfermented pods had a peroxide value of 1.20% and a free fatty acid content of 1.35 mg/KOH; while the peroxide value of crude fat from the fermented pod sample was 5.28% and its free fatty acid content was 20.20 mg/KOH [29]. Peroxide value and free fatty acid content are indices of fat deterioration and their values are directly proportional to the level of fat deterioration.

The cleaned seeds are parboiled before decortication [5]. Obi and Akubuo [30] found a paraboiling time of 5 min ideal for the optimal dehulled kernels outturn (DKO) for African breadfruit using a mechanical dehuller. Threshing is used to remove the hulls from the seeds before winnowing and separating them. Some people use mechanical means (grinding and milling machines), while others use the manual method. The manual method involves threshing on a hard board, using mortar and pestle; or concrete floor using bottle. After threshing, the separated husk is winnowed and hand-picked, leaving the cleaned milk-colored edible portion. Research efforts are on-going for improving the dehulling of African breadfruit using mechanical means [31, 32]. Addition of trona in the water used for parboiling at a concentration of up to 1.5% to cooking water was found to impart better colour, texture, taste, aroma, mouth feel and overall acceptability [8]. Steeping of African breadfruit in alum enhanced dehulling but hardened the seed. Storage of seeds at 5 °C reduced spoilage by 100%. Pre-treatment of seeds with 15% NaCl reduced spoilage by 95% [33]. Dried *T. africana* seeds can be stored using nutmeg oil [34]. Novel food products are also being developed from African breadfruit [35, 36].

### Microorganisms associated with the fermentation of African breadfruit during processing

The natural fermentation process degrades the pods, which becomes slimy and darkened but allows the seeds to be more easily extracted. It may last for 8–10 days. When it is unduly prolonged, the quality of the seeds become poor. Nwaiwu et al. [33], identified the organisms associated with the deterioration of *Treculia africana* pods as mainly fungi (*Aspergillus niger*; *Rhizopus stolonifer*; *Botrydiploia theobromae*) and *Erwinia* sp. Uzo et al. [37], observed both bacteria and fungi during the retting of the African breadfruit pulp. A mixed bacteria flora of seven isolates were observed and most of them were gram positive rods and clustered cocci that were in chains. *Microrococcus* sp. and *Streptococcus* sp. were found only during the first two fermentation days. *Bacillus subtilis* was dominant throughout the fermentation period. Yeasts were also found to be associated with the fermentation process. During fermentation, there was a remarkable increase in the yeast counts (up to  $4.5 \times 10^5$  CFU/g) by the 10th day. The mold count increased to a maximum of  $2.8 \times 10^3$  CFU/g by the 12th fermentation day, but it was not isolated on subsequent fermentation days. *Bacillus* sp. can initiate fermentation singly or in combination [37]. *Bacillus* is capable of secreting hydrolytic enzymes such as amylases, proteases and pectinases. Pectinases may be actively involved in the liquefaction of the spongy pulp to release the seeds. Pectinolytic enzymes are also released by yeasts. Uzoh et al. [37] observed complete softening in African breadfruit pulp during retting, on the 10th fermentation day. The highest titratable acidity was observed on the 6th fermentation day (0.86). Other microorganisms that have been associated with the fermentation of *Treculia africana* include: *Bacillus pumilus*; *Staphylococcus aureus*; *Lactobacillus plantarum*; *Laeuconostoc esenteroides*; *Aspergillus niger*; and *Aspegillus flavus* [8, 37–41].

### Effects of processing on nutrient composition and quality

Obiakor-Okeke and Nnadi [42] investigated the effects of cooking and roasting on the nutrient composition of African breadfruit (AFB) seeds. The two processing methods improved the nutrient composition of African breadfruit seeds and eliminated the tannin and phytates in the seed. Nwaigwe and Adejumo investigated the effects of boiling autoclaving and roasting on AFB. The boiled and autoclaved samples were further oven-dried at 60 °C for 15 min. Boiling or autoclaving of breadfruit seed prior consumption or conversion into flour is recommended, since it will increase the nutrient density and reduce the antinutrients. Olapade and Umeonuorah [8] investigated the effects of steeping in alum (1–2%) and cooking with trona (1–2%) on the proximate composition

of *T. africana* seeds. Soaking in alum followed by cooking in trona progressively increased moisture, ash and crude fibre, while the crude protein content, crude fat, carbohydrates and energy decreased. Osabor et al. [41] evaluated the chemical and nutrient composition of AFB (Table 2). They found very low levels of HCN, cyanide and oxalate. Adumanya et al. [43] investigated the effects of traditional preparation methods on selected minerals of AFB. Roasting increased the iron and copper contents of the sample, while boiling decreased them. Un-dehulled toasted breadfruit (UTB) sample had significantly ( $p < 0.05$ ) higher amounts of calcium, phosphorous, sodium and zinc than dehulled toasted breadfruit (DTB). The DTB sample had significantly ( $p < 0.05$ ) higher potassium, magnesium and iron than UTB. The results show that toasting AFB before de-hulling is a better processing treatment than dehulling them before toasting.

The sun-dried, blanched and fried samples were firstly blanched for 10 min at 100 °C, peeled and de-hulled before further processing (oven-drying, boiling to softness and oven drying at 105 °C) (Table 3).

### Composition of African breadfruit (*Treculia africana*)

African breadfruit seeds are highly nutritious and constitute a relatively cheap source of vitamins, minerals, proteins, carbohydrates and fats. The nutrient composition of African bread fruit is 14.23% protein; 0.22% ash; 91.25% moisture. 12.5% crude protein; 4.2% fat; 2.3% ash; 1.6% fibre; 73.0% carbohydrates [45]. The leaves of *T. africana* were found to contain 9.4% moisture, 2.0% fibre and 61.8% carbohydrate. The zinc content was quite high ( $837.00 \pm 0.10$  mg/100 g) [45]. The fruits contain polyphenols. Phyllocoumarin, catechin and 6, 9-dihydroxy-megastigmane-3-one are phytochemicals isolated from *T. africana*. The raw sample contained 1.49 mg/100 g, 1.30TUI/mg, 32.03 mg/100 g, 2.07 mg/100 g, 4.00% and 3.24 mg/100 g of hydrogen cyanide (HCN), trypsin inhibitors, tannin, phytate, alkaloids

**Table 2** Proximate and micronutrient content of *Treculia africana* (African breadfruit)

Proximate parameter	%	Micronutrient	Quantity (mg/100 g)
Carbohydrate	73.26	Sodium (Na)	7.10
Crude protein	12.47	Potassium (K)	587
Fat	4.23	Calcium (Ca)	165
Ash	2.26	Magnesium (Mg)	186
Crude fibre	1.62	Iron (Fe)	1.66
Moisture content	8.01	Zinc (Zn)	8.50
		Copper (Cu)	3.67

Osabor et al. [41]



**Table 3** Mineral content of *Treculia africana* (African breadfruit) seeds processed in different ways

Mineral	Processing method			
	Control (Raw and undeveloped)	Boiled	Fried	Dried
Calcium (Ca)	4300	4100	4200	4200
Copper (Cu)	16	14	15	15
Iron (Fe)	70	63	64	62
Potassium (K)	1600	1400	1500	1500
Magnesium (Mg)	760	730	740	760
Sodium (Na)	850	820	810	840
Zinc (Zn)	35	31	31	31

Adapted from Nnorom et al. [44]

and oxalate respectively. The fruit head consisting of pulp and bran were found to contain 9.4% protein (pulp) and 5.7% protein (bran). The hexane extract from the seeds contains a stearin solid fat fraction similar to palm kernel oil and an olein fraction. Nnorom et al. [44] observed that *T. africana* is a rich dietary source of minerals (Zn, Mn, Fe, Cu, Ca, Co, Cr, Mg, K, and Na) (Table 4).

There are wide variations in the values recorded for the proximate and mineral composition of *Treculia africana* by various researchers and most researches on the chemical composition have been carried out on the seeds (Table 2) [29, 47]. The methods of analysis, environmental conditions and level of accuracy could account for these variations. Oduro et al. [49] observed an oil yield of 11.82% for *T. africana* seeds. Specific gravity of the oil was 0.89; refractive index 1.47 and an iodine value of less than 100 (35.66). The peroxide value was 2.67 and the saponification value was 128.33. *T. africana* is rich in polyunsaturated fatty acids (60.37%) [50]. This suggests that the edible portion of *T. africana* will be susceptible to rancidity. Sixteen (16) constituents were found in the essential oil from the leaves of *T. africana*; 11 from the stem bark and 35 from the root bark. They were all rich in monoterpenoids. While alpha-pinene was the most abundant in the leaf and root bark, limonene was the most abundant phytochemical in the stem bark [51]. Glutamic acid, aspartic acid and glycine were the most abundant amino acids, found in African breadfruit [48, 52]. This seed also contains a lot of minerals [53]. *Treculia africana* may be ranked as carbohydrate rich leaf (61.82 g/100 g) [41]. When compared with other leaves, it is rich in fats and minerals [41, 53].

### Nutritional quality of African breadfruit (*Treculia africana*)

A study showed that consumption of ethanol extract of boiled *T. africana* seed increased the body weights of experimental animals. The extract at 100 mg/kg increased

**Table 4** Composition of African breadfruit (*Treculia africana* Decne)

Parameters	Leaves	Seed (Edible portion)	Seed coat
<i>Proximate (%)</i>			
Moisture	9.43	3.33–8.81	15.3
Protein	14.67	12.47–25.62	6.1
Carbohydrate	61.82	46.74–73.26	2.4
Fat	8.31	4.23–15.67	
Ash	1.47	2.26–5.20	5.2
Crude fibre		1.62–4.64	3.6
<i>Vitamins</i>			
Vitamin C	1.43		
<i>Minerals (mg/100 g)</i>			
Potassium	586.11	587.00	0.53
Magnesium	186.00	186.00	0.17
Zinc	837.00	0.10–8.50	34.59
Copper	3.48	0.033–3.67	53.0
Sodium	7.10	7.10	40.79
Iron	2.18	0.257–1.66	561.94
<i>Phytochemicals</i>			
Phenols	0.12		
Tannins	0.84	0.06–32.03	
Flavonoids	0.88		
Alkaloids	0.91	2.40–2.94	
Saponins	0.69	0.47–4.42	
Cardiac glycosides	0.87		
Anthraquinones	1.84		
Oxalate	2.94	0.21–3.23	
Phytate	0.78	0.76–6.59	
Hydrogen cyanide		0.06–1.49	

[41, 43–47]

their LDL cholesterol, Atherogenic Index (AI), and Coronary Risk Index (CRI), suggesting that consumption of boiled African breadfruit may expose an individual to the risk of developing cardiovascular diseases. The study suggests that consumption of *T. Africana* seed by a nondiabetic subject may have no effect on the glucose tolerance of the individual, while it will negatively impact on the glycemic status of a diabetic subject [21]. Chinedu et al. [55] investigated the effect of processing on starch digestibility, polyphenol content and alpha amylase inhibition of *Treculia Africana* seeds. Resistant starch was found only in the fried legume. Boiled breadfruit had intermediate glycaemic index and its aqueous extract had weak alpha-amylase inhibitory activity. Whole breadfruit consumption may lead to increase in sodium serum level. It is known that in some diseases that affect the heart, liver and kidney, a train of events that set in often manifest clinical features of hypervolaemia [54].

### Dietetic value

*T. africana* seed has an excellent dietetic value. Its biological value has been reported to exceed that of soybeans. This nutritive value indicates the contribution of a food to the nutrient content of the diet and depends on the quantity of a food which is digested and absorbed, including the amounts of the essential nutrients (protein, fat, carbohydrate, minerals, and vitamins) which it contains. *T. africana* is recommended for the alleviation of protein-energy-malnutrition [42].

### Medicinal uses of *T. Africana*

In Ghana, a root decoction of *T. africana* is used as an anthelmintic, febrifuge, verbrifuge, vermifuge, galactagogue and laxative [56]. The caustic sap of male AFB is applied on carious teeth; a bark decoction is used for cough and whooping cough, and ground bark with oil and other plant parts for swellings, leprosy and as a laxative.

### Diabetes

In Nigeria, some medical experts recommend African breadfruit as one of the foods for managing type 2 diabetes. Reports by Eleazu et al. [57] showed that consumption of ethanol extract of boiled *T. Africana* seed increased body weights. Moreover, the extract at 100 mg/kg increased LDL cholesterol, Atherogenic index (AI), and Coronary Risk Index (CRI), indicating that the usage of boiled African breadfruit may expose diabetic individuals to the risk of cardiovascular diseases. Consumption of *T. africana* seed by non-diabetic subjects is unlikely to affect their glucose tolerance [21].

Water extract from the root of *T. africana*, appears to be more relevant to the regulation of blood glucose levels. Administration of the aqueous root extract of *T. Africana* (200 mg/kg body weight) for 21 days to test animals decreased their blood glucose level. It also decreased the levels of aspartate amino transferase (AST) and alanine aminotransferase (ALT) (two diagnostic enzymes whose elevated levels indicate cell damage or trauma due to disease. In normal metabolic conditions, these enzymes are found in low amounts in the blood, but under disease conditions and organ damage, they leak into the blood increasing their concentrations to abnormal levels. *T. africana* root extract induced a reduction in the blood level of these enzymes [1]. Lactate Dehydrogenase activity (LDH) of the animals was not affected. LDH activity normally increases when the tissues like the liver, heart and muscles are not functioning normally. The result therefore implies that the extract possessed antihyperglycaemic effects without complications. The diethyl-ether extract of the root bark was more effective than the water extract [58].

### Wound healing properties

The high zinc content of *A. africana* leaves (837 mg/100 g) explains its ethnobotanical use in boosting immunity and in wound healing. Magnesium helps muscles and nerves to function well and keeps bones strong. Potassium was also very high in this sample (586.11 + 0.09 mg/100 g) [45]. The leaves also contain substantial amounts of phytochemicals which are secondary metabolites indicative of its medicinal properties. Wound healing requires nutrients such as vitamin C and zinc as well as phytochemicals [59]. Mouth sores and some problems of the digestive system are associated with internal wounds and are alleviated by *T. africana*.

### Antioxidant capacity

Antioxidant capacity of *Treculia africana* leaves was fairly high (84.73 + 0.07mgVCE). Antioxidants scavenge free radicals which harm the cells and strengthen the immune system to fight diseases, thus promoting good health and longevity [60]. Phenols have antioxidant properties and are involved in providing the body with protection against oxidative stress or injury arising from free radicals [61, 62]. Phenols prevent the deteriorative oxidation of fatty acids in the human body [63]. The secondary metabolites examined and detected in the leaf include tannins, flavanoids, alkaloids, saponin, cardiac glycoside, anthraquinone and phenols. The mineral elements content of the leaves (K, Mg, Zn, Cu, Na and Fe) will boost the antioxidant potentials improving both muscle and nerve functions of humans.

### Antimicrobial property

The ethanol (70%) extracts of the stem bark powder of *T. africana* inhibited *S. dysenteriae* and *P. aeruginosa* at the minimal bactericidal concentration of 50 mg/ml. *Salmonella typhi* (ATCC24682), *Shigella dysenteriae* (ATCC23513), *Escherichia coli*, *Pseudomonas aeruginosa* (ATCC12462) and *Staphylococcus aureus* (ATCC23815) required higher concentrations for effective inhibition. The Minimum Inhibition Concentration (MIC) of the extract ranged from 3.125 to 25 mg/ml for different organisms tested. The extract contained steroidal saponins, glycosides, polyphenols and anthraquinone glycosides. The ethanolic extract of *T. africana* stem bark was inhibitory to gastrointestinal bacteria pathogens and could serve as a potential antibacterial [56]. Phyllocoumarin; Catechin and 6, 9-dihydroxymegastigmane-3-one which are phytochemicals found in *T. africana* leaves have antimicrobial properties, with catechin being the strongest antimicrobial compound comparatively.

### Safety

The anti-nutrients in *Treculia africana* seed is easily detoxified by processing methods thereby making the products safe for consumption [28, 64, 65]. Olatoye and Arueye [66] fed extruded *T. africana* to experimental rats and investigated toxicological parameters. The extruded *T. africana* products were found to be safe.

### Historical, anthropological and cultural perspectives on *Treculia africana*

The origin of *Treculia Africana* is not clear. It is found in riverine forests (streams and swampy areas of West Africa, Central Africa, Southern Sudan, the Islands of Principe and Sao-Tome and other areas with the tropical climate [39]. It grows in many types of soils and climatic conditions. It is in high demand for both food and non-food uses [67]. African breadfruit has a long gestation period (up to 10 years) and bears heavy fruits which fall down from a height when ripe. This constitutes a hazard and may cause accidental death for unfortunate victims. There is a belief that those who are killed by the fruit fall are witches in Ibo tribes of South East Nigeria. Developing dwarf varieties that mature early could handle this problem. The tree may be used to indicate landmarks because of its resilience. The dead trunk may be used to grow mushrooms.

There is an alarming rate of decline in the population of African breadfruit trees due to increased population pressure; high rate of de-forestation; non improvement and non-cultivation of the species; generally and in the areas of abundance (Southern Nigeria) of the species [68]. Forests are being converted to agricultural lands, home buildings and industrial estates as the population increases. Only very limited efforts are being made to propagate the plant. African breadfruit needs urgent conservation. Novel conservation strategies should include; mass propagation and establishment of plantations and the development of early-maturing and dwarf varieties.

### Conclusion

*Treculia africana* is an underutilized legume with a high dietetic value and medicinal properties. It is very rich in micronutrients which contribute to its wound healing and antioxidant properties. The leaves and stem bark have antimicrobial properties. The roots have anti-hyperglycaemic properties and do not promote secondary complications of diabetes. Challenges of seasonal scarcity, and tedious methods of processing deterring the enterprise face *T. Africana*. Appropriate conservation approaches are required for this plant. Early maturing dwarf varieties that can fruit all year round are required. Presently the demand for this food crop outweighs its availability. Appropriate conservation methods should

be put in place using organized sustainable policy framework that will ensure availability and abundance.

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### Authors' contributions

PC and FU conducted literature searches, compiled and analyzed information. Philippa C Ojimekwe wrote up the manuscript for publication. The two authors read and approved the final manuscript.

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All data generated or analyzed during this study are included in this published article [and its supplementary information files].

### Declaration

### Competing interest

The authors have no conflict of interest to declare.

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