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A review of explored uses and study of nutritional potential of tamarind (*Tamarindus indica* L.) in Northern Ghana

Chimsah F. A.*, Nyarko G. and Abubakari A-H.

Department of Horticulture, Faculty of Agriculture, University for Development Studies, Tamale, Ghana.

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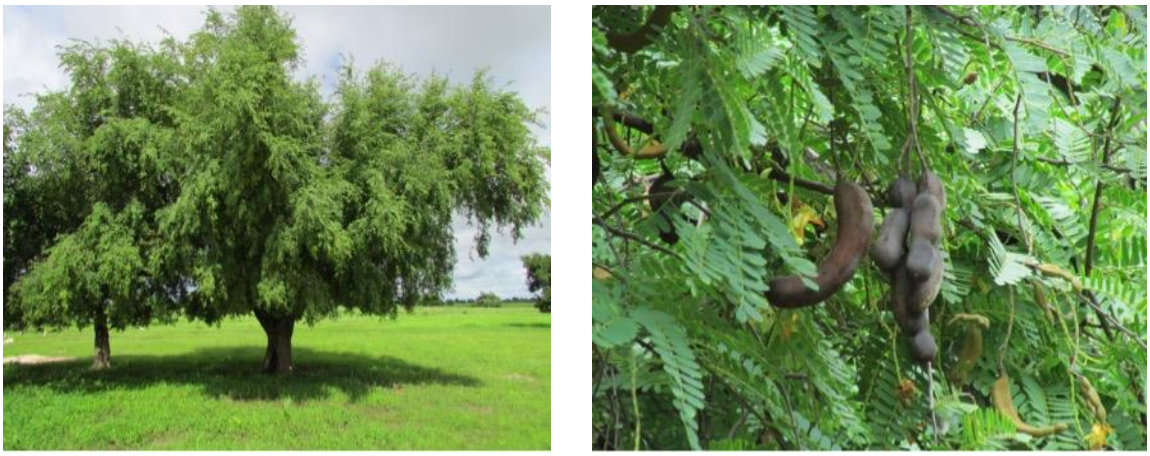
Tamarind (*Tamarindus indica*) is increasingly becoming a commercially important underutilized tree crop worldwide. Due to its multi-purpose use and market demand the tree and its processed products are been traded in many towns and villages. Despite its potential, major setbacks are the lack of knowledge on its uses and nutritional potential within the Ghanaian context. This study reviews and exposes the beneficial potential of tamarind whiles studying with empirical data its nutritional composition for proximate analysis. Indigenous to tropical Africa and naturalized to many regions of the world, the tree is seen in over 50 countries. Within Ghana and other parts of the world, tamarind is distinctively called by different vernacular names either referring to the tree or its product. Almost every part of the tree is used in one way or the other from food including beverage drinks, jams, and curries, to pharmaceutical, textile, timber, fodder, and as a fuel source. It is rich in vitamins, minerals and other proximate elements. Proximate composition of locally sourced fruit pulp showed high levels of fats and oils 51.39% and fibre 15.10% while other parameters like protein, ash, vitamin C and moisture were similar to test results from other countries. The tamarind plant has undoubtedly great potential based on its benefits, and uses.

Key words: Tamarind, *Tamarindus indica*, Ghana, multipurpose, benefits, nutritional potential, medicinal, proximate composition.

INTRODUCTION

Tamarind (*Tamarindus indica*) is a leguminous tree that belongs to the family Fabaceae with Subfamily Caesalpiniaceae (Stege et al., 2011). The plant is believed to be indigenous to tropical Africa and also described by some botanist as a pan-tropical species which stretches from Senegal to Eritrea, from Sierra Leone to Cameroon, from Ethiopia and Somalia to Mozambique (Bhadoriya et al., 2011). According to Abubakari and Muhammad (2013), the tamarind tree was long ago introduced into and adapted to India such that it has often been reported been indigenous from there. They added that, it was apparently from this Asiatic country that it reached the Persians and the Arabs who called it “Tamar Hindi” (Indian date, from the date-like

*Corresponding author. E-mail: fachimsah@uds.edu.gh.



A B

Figure 1. (A) The tamarind tree; (B) Tamarind shoot with hanging fruit pods and leaves.
Source: Field survey (2019).

appearance of the dried pulp) traded in it, and thus giving rise to both its common and generic name. Unfortunately, the specific name “indica” also perpetuates the illusion of Indian origin. The genus, *Tamarindus* is monotypic in its taxon, and therefore has only one species (*indica*).

According to El-Siddig et al. (2006) the major production centres of tamarind are in the Asian countries like India, Sri Lanka, Thailand, Bangladesh, Indonesia and Thailand. Whiles in the Americas, Mexico and Costa Rica are the biggest producers. India is the major country that has broadly utilized the tree, with more than 250,000 tons of the fruit harvested each year. Of this, about 3,000 tons is exported into Europe and North America for use in the food and beverage industries (Abdelrahman and Mariod, 2019). Africa on the other hand does not produce tamarind on large scale basis, although it is widely utilized by locals in some minor producing countries mostly in West African.

The tamarind tree is well adapted to semi-arid regions of the tropics and can withstand drought conditions relatively well. It can tolerate a great diversity of soil types but does best in deep, well-drained soils, which are slightly acid or saline. The tree will not tolerate cold and continuous wet soils (Bhadoriya et al., 2011). The tree is fairly large in size (Figure 1A and B) and can produce up to 175 kg as fruit yield per year (Dassanayake and Fosberg, 1991).

Generally, there are sweet and sour types and this differ significantly in their morphological characteristics. Hailay et al. (2020) in a study in Ethiopia found that the sweet tamarind trees produced significantly more fruit pulp, seed, seed size and weight than the sour trees. They also observed that tamarind fruit vary from curved to straight. The colour of the sour variety pods and fresh pulp are a light brown, while the sweet variety pods and fresh pulp are usually deep brown. Ripe fruits are filled with a yellowish or brown pulp, fibrous with an acid like but pleasant taste. The seeds are hard and shiny with the bark of pod been fragile and easily broken by hand (Okello et al., 2018).

As indicated by Shankaracharya (1998), the fruit pulp of tamarind comprises 30-50% of the ripe fruit while its shell and fibre account for 11-30% and the seed about 25-40%. The most outstanding characteristic of tamarind as indicated by El-Siddig et al. (2006) is its sweet acidic taste due to the presence of tartaric acid (10%). The author describes tamarind to be simultaneously the most acidic and sweetest fruit. According the World Health Organization (WHO) tamarind can be considered a source of all essential amino acids, with the exclusion of tryptophan. It contains also other organic acids as tartaric, succinic and malic acid (Ferrara, 2019).

The tree plays major and important roles in many aspects of life from food, pharmaceutical, and textile industries, to being used as timber, fodder, and as a source of fuel (Pugalenthi et al., 2004). The fruit pulp of tamarind is edible and is considered more appealing and palatable, as it becomes sweeter and less sour (acidic) as the fruit matures. It is rich in vitamins, minerals and other proximate elements (Emmy et al., 2010). According to El-Siddiq et al. (2006) in most growing areas, processed tamarind beverage drink is among the most popular flavoured drinks and the brand name “Jarritos” is a well-known tamarind export traded soda drink. As described by Arbonnier (2004), the tree’s morphological features are distinct;

(i) Stems are more or less pubescent, fissured and scaly. Bark Scaly, with longitudinal and transverse fissures. Some pale brown-grey patches showing between the rectangular scales. Slash with yellow outer layer, pale red beneath.

(ii) Leaves, are alternate compound, 7-15 cm long, pubescent, becoming glabrous, with 8-10 (-15) pairs of opposite leaflets, narrowly oblong, 2-3 cm long and 0.6-1 cm across. Leaf blade is rounded or notched apex and rounded asymmetrical base appearing glaucous green with the petiole channeled at the base.
(iii) Flowers are pedicellate and appear attractive as pale yellow with red stripes, 2.5 cm in diameter, with 4 ovate sepals, green and yellow inside and brown outside, and 3 finely denticulate petals.
(iv) Fruit appears as a sub-cylindrical pod, 10-18 cm long and 1.5-2.5 cm across, somewhat curved, more or less constricted and torulose, puberulous, brown-russet, persistent and turning blackish. Pulp is brownish, containing an astringent which sweet tasting and sticky. The shell of the fruit-pod is brittle and the seeds are embedded in the edible pulp.
(v) Seeds are 3 to 10 per pod, approximately 1.6 cm long, unevenly shaped, with a hard, shiny, and smooth testa.

In Ghana, the tree is commonly found growing within the Savannah ecological zones. The tree starts flowering during the dry season and fruiting starts from January and stretches through to the beginning of rains (March/April). Its fruit is mainly used for food purposes with local beverage drink products being the major processed form that is seen marketed across towns and villages within Ghana. The tree is evergreen and mainly provides shade all year round. The tamarind tree in parts of northern Ghana is claimed to be a special tree for the elephant because of its constant shade and strength to lean on as a form of support when it is in labour. Locals claim, that in order to be safe from an attacking elephant, run to the tamarind tree, and you will be spared.

There are many published works about this multipurpose fruit, El-Siddiq et al. (2006) and De Caluwé et al. (2009) has published a review on the traditional uses of tamarind with reference to sub-saharan Africa. However, very little is known of the local potential from the Ghanaian context as the tree plays major roles in local economies and landscapes where it is grown. Within Ghana, despite the wide usage of the tamarind tree, the tree can be termed as under-utilized since there is virtually no major industrial exploration of the potential of this important tree. There is also limited information on the nutrient content of the edible portions of many indigenous and underutilized fruits including tamarind in Ghana and this makes it difficult to make any substantial claim for their optimal use as a source of nutrients (WHO, 2005; Abebrese et al., 2007).

With emphasis on comparing and exploring the tree's nutritional potential and uses with already established facts, this study seeks to bring to bear from both primary and secondary data sources the potential of the tamarind tree. As a traditional food source plant in Africa, tamarind has a great potential to improve human nutrition, boost food security, promote rural development, enhance revenue and support sustainable land care.

MATERIALS AND METHODS

Primary data for this study was solicited from personal interviews and interactions with local users, marketers and traders of tamarind within Northern Ghana. Secondary data was also compiled from an array of information search without time limitation in the World Wide Web across a wide range of search engines and databases using the main search keys; 'tamarind' and *'T. indica'*. Data gathered was screened and synthesized for qualitative and quantitative outputs. Results from both primary and secondary sources are presented in a descriptive and narrative form and where applicable, tables used to compare data with previous work.

Study on proximate analysis for nutritional composition was done by randomly sampling ripe tamarind fruit pulps from a major local market (Aboabo market) in Tamale the capital of the northern region of Ghana. Each test parameter was replicated 3 times. Sampled pulps were tested using the methodologies as described in the Association of Official Analytic Chemistry (AOAC), International, 19th Edition.

As is conventional and ethical in reviews, authors respected originality of results as presented though very much aware that results presented are the views from respondents and also acknowledges the limitations in variation of results collated from other authors. And this could be based on test location, techniques and types of instruments used in the different laboratories. This paper does not in any way claim full proof of any responses as presented by respondents except in the case of analytical results obtained from the primary data from the study's laboratory test. All presented laboratory test parameter results are presented in same SI units to ensure homogeneity. Further details on analytical methodologies of reviewed work presented, could be obtained from the original articles as cited.

Vernacular names of tamarind tree within Ghana

The tamarind tree species though the same botanically across all growing areas in the world, it is known and called differently within the different spoken languages where it is grown or traded. Within northern Ghana it is known in some local dialects as shown in Tables 1 and 2.

POTENTIAL BENEFITS OF TAMARIND WITHIN THE GHANAIAN CONTEXT

Fruit pulp

Within the Ghanaian context, the fruit pulp of tamarind is

Table 1. Local names of tamarind in various spoken languages in northern Ghana.

Tribe (language spoken)	Vernacular name	Tribe (language spoken)	Vernacular name
Builsa (Builli)	Pusik	Mamprusi (Mampruli)	Pussa
Kasena (Kasim)	Saana	Dagbani (Dagbanli)	Puhugu
Nankana (Nankam)	Pusika	Gonja	Kapaaleri/ Kapaluo
Frafra (Gurune)	Pusa/Pusiga	Waala (Waali)	Puhee
Kusasi (Kusaal)	Pussa	Dagaaba (Dagare)	Puree
Dagati (Dagao)	Putiye	Sissala (Sissali)	Sunsuing
Bissa (Busanga)	Heeri/ Fiiri	Hausa	Samiya
Bimoba (Moar)	Poses	Moshie (Moa)	Pussa
Talensi (Talen)	Puah		

Source: Field survey (2020).

undoubtedly the most important part of the tree, as it is considered useful as a food source and traded in most local markets. The fruit pulp can be eaten raw to boost appetite, and the in most parts of northern Ghana the pulp is becoming increasingly popular in its use as a beverage drink commonly known in Hausa as “tankua beer” or within the Dagbon area (northern Ghana) as “poha”. As suggested by Sadik (2010), the consumption of this drink could help reduce the prevalence of iron deficiency anaemia because of the vitamin C rich content of the pulp which enhances bioavailability of non-haem iron. Saha et al. (2010) and Abhijit et al. (2010) reported that tamarind fruit shell can be utilized as a low-cost biosorbent for the removal of malachite green from aqueous solutions.

The fruit pulp is processed into balls (Figure 1A), the extracted pulp is commonly and commercially marketed across Ghana. It is mainly processed by soaking it in water and straining out the extract which is mixed-up with sugar and other spices to make tamarind flavoured beverage drink. Among most tribes in the upper regions of Ghana, the pulp of tamarind is mixed with floor or water and used as flavouring in the preparation of “Tuo Zafe” (TZ) a traditional stable local food common in northern Ghana. It is also fermented and used in the preparation of porridge. The fruit pulp is also a good ingredient in making skin care products like soaps, as it enhances skin lightening or skin toning and treats skin irritation.

Seed

This has less uses in many processing areas within Ghana as it is often discarded as a by-product after extraction of the pulp from the fruit. However, some processors gather it and use as feed for animals especially pigs while in some parts of northern Ghana, the seeds are added during brewing of a local alcoholic beverage beer called “pito”. Is has been shown in recent times, that the almond composition of tamarind seeds is very similar to that of cereal seeds and is a good source of food (Okello et al., 2017).

Leaves, flower, and pods

Among some tribes in northern Ghana, women use the leaves in preparing vegetable soups though this practice is not very common in recent times. The flowers, tinder leaves and dry pods after processing are very palatable and liked by ruminants including cattle, sheep and goats. The flowers are also attractive to bees and the honey produced from the tree is very tasteful and sweet. Within northern Ghana, tamarind tree comes with some useful non-food benefits in many societies. Some parts of the plant including the leaves, the bark, shoots and roots have various form of uses such as fuelwood, timber, charcoal making, chewing sticks among others (Figures 2 and 3).

OTHER POTENTIAL BENEFITS OF TAMARIND ACROSS THE WORLD

Fruit pulp

This is used for a variety of domestic and industrial purposes (Kulkarni et al., 1993). It is an important source ingredient in the making of marinades, curry, chutney, vindaloos and Worcestershire sauce (Fararra, 2019). In India, the pulp is eaten raw or sweetened with sugar and also used to make sweet meats mixed with sugar, commonly called tamarind balls. Commercially, it is used as a raw material for the manufacture of numerous industrial food products, such as tamarind juice concentrate, curries, tartaric acid, tamarind pulp powder, sauces, pectin, ice cream, and alcoholic beverages (Lotschert and Beese, 1994). The fruit pulp is also used as a fixative in dyeing when mixed with turmeric

Table 2. Local names of tamarind in various languages in other countries and regions.

Country/region	Language	Vernacular name (s)
Africa		
	Bemba	Mushishi
	Fula	Jammeth, Dabe, Jammi
	Jola	Budahar
	Mandinka	Timbingo, Tombi, Timbimb, Tomi
	Tigrina	Humer
	Wolof	Daharg, Dakhar, Dakah, Nclakhar
Ethiopia	Amharic	Hemor, Humar, Komar, Homor, Tommar
	Tigrina	Arabeb
	Gamo/Oromo	B'roka, Dereho, Racahu, Dindie,
Kenya	Swahili	Mkwaju
	Masai	Ol-masamburai
Malawi	Chewa	Ukwaju, Bwemba
	Yao	Mkwesu
Nigeria		Tsamiya
Somalia	Somali	Hamar
South Africa	Afrikaans	Tamarinde
Sudan	Arabic	Aradeib, Tamarihindi
	Nuba	Kuashi, Shekere, Danufi
Tanzania	Swahili	Ukwaju
Uganda	Teso	Esukuru, Esuguguru (leaves)
	Teso/Karamojong	E/apedyra (fruits)
Zambia	Bemba	Mushishi
	Nyanja	Mwemba
Asia		
China	Sino-Tibetan	Khaam, Mak kham
India	Hindi	Ambli, Amli, Imli
	Sanskrit	Amalika
	Bengali	Tintul, Tintiri, Tetul
	Marathi	Chinci, Chitz, Amli
Indonesia		Asam jawa, Tambaring, Assam
Malaysia		Asam jawa
Philippines	Tagalog	Sampalok
Sri Lanka	Sinhala	Makham
Elsewhere		
	Dutch	Tamarenn
	French	Tamarainer, Tamarin, Tamarindier
	German	Tamarinde
	Italian	Tamarindizio
	Portuguese	Tamarindo
	Spanish	Tamrin, Tamarindo

Source: Bhadoriya et al. (2011).

(*Curcuma longa*) and annatto (*Bixa orellana*), and it also serves to coagulate rubber latex (El-Siddig et al., 2006). It can also be used in the production of ethanol (Menon et al., 2010).

Processed tamarind pulp has several food uses, in some western cuisines, In parts of China, it is used in the manufacture of jams, syrups or chilled drink. In Mexico, tamarind is used in sauces or sold in various snack

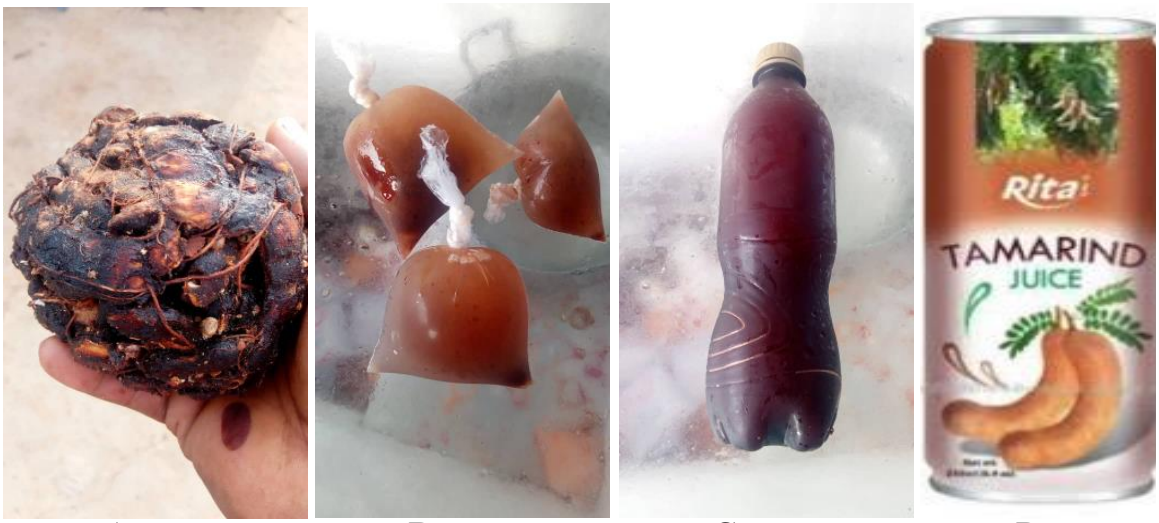


Figure 2. Different locally processed forms of the tamarind fruit pulp; (A) Fruit pulp ball, (B) Drink in polythene package, (C) Drink in plastic bottled container, and (D) Drink in canned container.
Source: Field survey (2019).

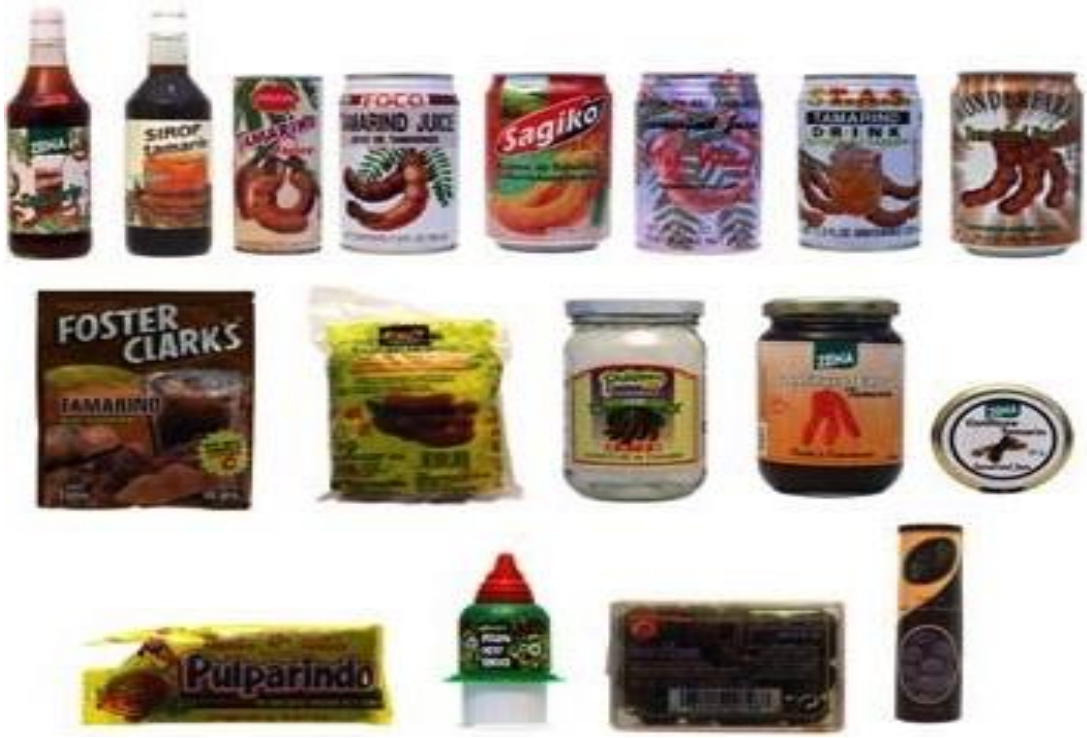


Figure 3. Different kind of tamarind products across the world; syrup, juices, drinks, jam, candies, Sweets etc.
Source: Emmy et al. (2010).

forms: usually dried and salted. In northern Nigeria, tamarind pulp is used with millet grain powder to prepare a traditional pap mostly used in breakfast and commonly eaten with bean cake (Sadiq et al., 2016). In other countries like in Jamaica, Trinidad and Tobago, Grenada, Colombia, Mexico and other Latin American countries tamarind fruit pulp is made into rolled balls (around 5 cm in diameter) with white granulated sugar and blended with spices to create “tambran” balls. In southern Kenya, the Swahili’s use it to garnish their legumes and also

make juices. In Somalia, it is used in cooking to give rice some sour flavour (El-Siddig et al., 2006).

Seeds and pods

Tamarind seed is considered a by-product of the commercial utilization of the fruit pulp. The seed comprises the seed coat or testa (20-30%) and the kernel or endosperm (70-75%) (Shankaracharya, 1998). The seed testa contains tannin, which is used in the preparation of ink and for fixing dyes (Storrs, 1995). In parts of India, the immature seed pod of tamarind is used to flavour foods ranging from meals and snacks with the flowers also pickled and used as side dishes. Tamarind is commercially marketed as a food additive for improving the viscosity and texture of processed foods (Sone and Sato, 1994). El-Siddiq et al. (2006), explains that the name “jellose” has been recommended for the seed as it describes both its jelly forming properties and the carbohydrate character of the seed. Tamarind has also been recommended for use as a stabilizer in making ice cream, mayonnaise and cheese and as an ingredient in a number of pharmaceutical products whiles the seed oil is said to be palatable and of culinary quality (Morton, 1987). The oil is used for making varnish to paint idols, and light lamps (Salim et al., 1998). Krithika and Radhai (2007) reported in India, that the seeds are used as cattle feed due to its high protein content. Rosted seeds from the tamarind fruit are ground and used as substitutes for coffee and its flour is commonly used as animal feed for some ruminants and pigs (Khairunnuur et al., 2009). Among the numerous uses of the tamarind seed, Mokashi and Parlikar (2018) concluded that the tamarind seed powder could be a cheap bio-adsorbent for removal of fluoride in water.

Leaves and flowers

These are edible, characterized by a sour taste and are used to make salads, curries, stews and soups, especially in times of food scarcity. Coronel (1991) added that they are used in some Thai food recipes because of their sourness and definite aroma. Whilst Sozolnoki (1985), states that children in Gambia mix leaves with the acid leaves from the fig trees to make chewing gum. The leaves and flowers are useful as a mordant in dyeing. Yellow dye can be derived from the leaves and used to colour wool and can also turn indigo dyed silk to green (Salim et al., 1998).

Benefits derived from other parts of tamarind plant

The wood from the tamarind tree has many uses, in North America, it has been marketed under the name "Madeira mahogany" and is used in the furniture and timber industry (Bhadoriya et al., 2011). It is valued for making gun-powder and the ash obtained from burning the bark or wood is used to remove hair from animal hides and can also be mixed with the fruit pulp for cleansing and brightening copper and brass vessels (Salim et al., 1998).

Coates-Palgrave (1988) listed a number of these uses from the hardwood of the tamarind tree which include making furniture, mortars, mallets, pestle, rice pounders, ploughs, tent pegs, canoes, side planks for boats, carts shafts and axles and naves of wheels, toys, oil pressers, printing blocks, sugar pressers, tools and tool handles, turnery and others. According to Storrs (1995) during a leather tanning test, tamarind tannins gave harsh and highly coloured leather, which can be used in making heavy soles, suitcases, ink and dyes.

MEDICINAL BENEFITS OF THE TAMARIND PLANT

The tamarind tree plays a major role in traditional medicine in Ghana. Also, it is reported in literature to be used in parts of Asia and Africa in the treatment and prevention of many human ailments and conditions ranging from internal disease conditions to external body wounds. Bhadoriya et al. (2011) concluded that many parts of the tamarind tree have been used in traditional medicines to treat diseases and other ailment conditions. The fruit pulp of tamarind has a laxative action due to the presence of malic and tartaric acid. It helps in relief of abdominal pain and diarrhea. It is digestive, acting on bile secretion and preventing liver disease (Rodriguez-Amado et al., 2016; De Caluwè 2009).

Havinga et al. (2009) widely reviewed in Africa, the ethno-pharmacology of tamarind tree and suggested differences in its use in local medicine. In detailing the medicinal uses of tamarind, Anon (2008) outlines the different medical properties of this tree. These include; anti-microbial, antiviral, anthelminthic (expels worms), antiseptic, sunscreen and astringent. Others are treatment of asthma, cholesterol metabolism disorders, boils, bacterial skin infections, chest pain, colds, colic, conjunctivitis, diabetes, constipation (chronic or acute), dry eyes, diarrhoea, dysentery, indigestion, eye inflammation, fever, gallbladder disorders, gastrointestinal disorders, gingivitis, haemorrhoids, jaundice, keratitis, leprosy, liver disorders, nausea and vomiting (pregnancy-related), sore throat, sores, swelling (joints), sprains, and urinary stones.

Fruit pulp

In Ghana, the fruit when eaten raw helps relieve constipation and other stomach pains. It is a bilious substance and therefore stimulates the activity of the bile and aids in the faster dissolution of foods and fibre to

speed up digestion (Razali et al., 2015). Nacoulma (1999) indicated that the tamarind pulp is valued for its medicinal properties, mainly for constipation, bowel obstruction, abdominal pains, pregnancy vomiting and intestinal disorders among many others. The fruit is used traditionally as a laxative, due to its high amounts of tartaric acids, malic and potassium acid. It is commonly used as a poultice in most parts of South Eastern Asia. To overcome constipation the whole tamarind fruit is eaten during breakfast in Madagascar while in Senegal, it is taken in the form of a sweet meat mixed with lime juice or honey, called Bengal by the Wolof people (Bhadoriya et al., 2011).

Tamarind fruit pulp helps with relief of abdominal pain and diarrhea and acts on bile secretion and preventing liver disease (Rodriguez et al., 2016). The tamarind pulp with lemon is used to treat diarrhea, and to relieve constipation and abdominal pains. The pulp in Mali is prepared as drinks, and in Burkina Faso and across rural Fulanis in Nigeria, it is crushed and soaked for half a day in water with a little salt before consumption (Lockett and Grivetti, 2000).

Leaves, roots and seeds

In most parts of Ghana, the leaves of tamarind is mainly added to other plant parts of the tree to treat malaria and also relieves body pains, weakness and the treatment of wounds (Asase et al., 2005). In some parts of Tanzania, the leaves have been known to be laxative whiles the root is used to treat dysentery and ankylostomiasis that is, hookworm (Bhat et al., 1990). The fiber-rich seed from the fruits, aids regulating the intestinal function and lower the level of cholesterol in the blood (Lim et al., 2013). A decoction of tamarind leaves are used in the extraction of Guinea worms and is one of the most important agents to clean wounds caused by Guinea worm infections (Fabiyi et al., 1993). The seed and pericarp contains phenolic antioxidant compound whiles the roots, prepared as an extract, is used in the treatment of stomach ache or abdominal pains, largely in East Africa, and also in Burkina Faso (Kristensen and Balslev, 2003). An extract of the seed pericarp is shown to provide anti-arthritic activity, counteracting bone degeneration and degeneration of articular cartilage through the inhibition of the proteolytic enzymes (Sundaram et al., 2015).

Bark

In northern Ghana and among many tribes, the bark of the tree is mixed with the leaves and used to bath sick or weak children, or to treat chicken pox disease. According to Tignokpa et al. (1986) the fresh bark of young stems in Benin, is macerated for 24 h and taken orally as a purgative or for relieve of abdominal pains and in the medicinal plant market in Dakar, Senegal, tamarind bark is mainly sold and used for wound healing purposes.

NUTRITIONAL BENEFITS OF TAMARIND

Currently, consumers choose diets based on the associated nutritional and health benefits instead of taste (Katan and De Roos, 2004). This current study shows a good nutritional potential in tamarind pulps especially in fats, fibre and protein as compared to other test results. This could be attributed to the locations and maturity age of the tamarind trees selected for this study. Vitamin C content was however low in this current study as compared to a higher value obtained in a study in Nigeria by Sadiq et al. (2016). Most studies considered in this review did not test for Vitamin C content in the tamarind pulps. It has earlier been reported by Adekunle and Adenike (2012) that the content of vitamin C in tamarind pulps is very low.

Comparative analysis of the proximate composition of tamarind pulps

Table 3 compares the test results of this present study with others. Test results from Sokoto and Kaduna states in Nigeria by Adekunle and Adenike (2012), Sadiq et al. (2016), and Yusuf et al. (2007). From Sudan by El-Siddig et al. (2006) and from Bangolore in India by Shlini and Siddalinga (2015) were reviewed for various proximate analysis and Vitamin C.

According to an earlier study by El-Siddig et al. (2006) tamarind fruit pulp typically contains 20.6% water, 3.1% protein, 0.4% fat, 70.8% carbohydrates, 3.0% fibre and 2.1% ash. Nonetheless, the proximate composition of the tamarind pulp depends on locality of the plant. Tamarind pulps are a major source of sugars, vitamin C, minerals and exhibit high antioxidant capacity (Ajayi et al., 2006). From this study, proximate values obtained from the locally sourced tamarind pulps were 51.39% for fat/oils, 15.10% for fibre, 16.93% for moisture, 15.03% for protein and 2.71% for ash content while ascorbic acid (Vit. C) content was 2.42 g/100 mg (Table 3).

Due to tamarind's rich nutrient and chemical composition as reported in many studies, it could be adopted as a less expensive alternate protein source that can alleviate protein malnutrition among traditional people living in developing countries (Siddhuraju et al., 1995). Currently, most industries are interested in the development of nutraceutical products from waste products during the processing of tamarind, this includes the seeds, peels, stems, and leaves, generated by the food and agricultural processing industries. These waste products contain considerable quantities of phenols, flavonoids, anthocyanins, vitamin C and carotenoids which can be used as economic sources of natural

Table 3. Proximate composition of tamarind pulp from different studies.

Sources of pulps	Fats/oils (%)	Fibre (%)	Moisture (%)	Protein (%)	Ash (%)	Vit. C (mg/100 ml)
Present study, Ghana	51.4	15.1	16.9	15.1	2.7	2.4
Sadiq et al. (2016) Nigeria	1.4	0.5	1.9	4.1	1.8	37.6
Shlini and Siddalinga (2015) India	3.7	3.7	4.2	15.0	3.7	N/A
Adekunle and Adenke (2012) Nigeria	1.0	17.5	13.8	7.1	1.5	N/A
Yusuf et al. (2007) Nigeria	10.7	3.6	10.9	20.7	6.8	N/A
El-Siddig et al. (2006) Sudan	0.4	3.0	20.0	3.1	2.1	N/A

antioxidants for pharmaceutical, cosmetic and food applications (Natukunda et al., 2016; Ferrara 2019).

CONCLUSION

Many authors have recognized the tamarind tree as an underutilized crop with a high potential. The benefits derived from this tree and its products are promising and numerous as evident in this study. The tamarind plant is an all-round, beneficial and nutritious fruit with a great potential. Almost every part of plant (fruit pulp, leaves, bark, root, stems, and seeds) has either some nutritional benefit or medicinal value, and it widely used domestically in Ghana with a number of industrial and commercial applications across the world. This study has exposed in different ways through the collection and reviewing of primary and secondary data, that the tamarind tree comes with enormous benefits, uses and has a great potential.

From this study, it is clear that several authors have reported the use of this fruit tree for both local and industrial purposes. It can also be a very important remedy in parts of the world where malnutrition is a prevalent problem. From its use in local food, drinks and medicinal purposes across northern Ghana and other countries stretching from Africa through Asia and some Latin American countries, it can serve a source of low-cost nutrient supplement. Industrially, the pulp is commonly used in the making of chilled drinks, jams, syrups, juices and other localized products. In its non-food use potential, this study has shown that tamarind non-fruit parts such as leaves, bark and roots have various uses such as a source of fuelwood, charcoal making, source of timber and as fodder for animals. Based on the high levels of fats and oils in sourced pulps in this study, it could be explored as an alternative source. The potential of the tamarind tree, its products and utilization forms should be further investigated to enhance human nutritional and medicinal needs.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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