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Analyses of the Leaf, Fruit and Seed of *Thaumatococcus daniellii* (Benth.): Exploring Potential Uses

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Abstract: *Thaumatococcus daniellii* is an economic plant with versatile uses in Southern Nigeria. The arils attached to the seeds contain thaumatin, a non-sugar sweetener and taste modifier. This study examined the chemical constituents of the leaf, fruit and seed of *T. daniellii*. The fresh fruit, on weight basis, consists of 4.8% aril, 22.8% seed and 72.4% fleshy part. The leaf contained (per 100 g): 10.67 g moisture, 8.95 g ash, 17.21 g fat, 21.06 g protein, 24.61 g crude fiber 17.50 g carbohydrate, 0.10 g calcium, 0.08 g magnesium, 0.01 g iron and 0.37 g phosphorus. The fruit (fleshy part) contained 10.04 g moisture, 21.08 g ash, 0.93 g fat, 11.53 g protein, 18.43 g crude fiber, 37.27 g carbohydrate, 0.34 g calcium, 0.30 g magnesium, 0.01 g iron and 0.21 g phosphorus. The seed contained 15.15 g moisture, 11.30 g ash, 0.21 g fat, 10.36 g protein, 20.52 g crude fiber and 42.46 g carbohydrate. Terpenoids, flavonoids, alkaloids and cardiac glycosides were significantly present in both the leaf and fruit whereas phlobatanin, saponin, steroids, anthraquinones and ascorbic acid were absent. Tannin was present only in the leaf. The leaf and fruit of *T. daniellii* have significant nutritional and medicinal benefits. The leaf is rich in protein and fat. The fruit is a good source of minerals, particularly, calcium and magnesium; the leaf is also rich in phosphorus.

Key words: *Thaumatococcus daniellii* benth, proximate composition, phytochemical screening

INTRODUCTION

The 'sweet prayers' plant (katemfe), *Thaumatococcus daniellii* (Benn.) Benth, is a rhizomatous plant found in the tropical rain forests and coastal areas of West Africa, particularly, Nigeria, Ghana and Cote d'Ivoire (Yeboah *et al.*, 2003). The perennial, monocotyledonous herb propagates itself by rhizomes and forms an undergrowth of trees in its natural habitat (Onwueme *et al.*, 1979). It has long, slender stalks that can grow up to two or three meters high, each bearing a single tough, ovoid shaped leaf of varying sizes depending on the plant's age and habitat (Makinde and Taiwo, 2004). Three leaf forms, morphologically distinct in size, texture and usage, are recognized by local users in Nigeria (Nwodo-Chinedu *et al.*, 2008). The fruit is pyramidal or trigonal in shape and crimson or bright-red in colour when fully ripe and may weigh 6 to 30 g depending on the number of seeds, usually one to three, within it. The seed is black, hard and impervious and look like stone when dried. It is covered by a thin layer of sticky, transparent

gel and has a soft, fleshy and juicy cap called an aril which contains the sweet substances (Onwueme *et al.*, 1979).

Thaumatococcus daniellii, whether cultivated or in the wild, contributes to the economy of the rural people in most parts of Southern Nigeria through its stalks, leaves, fruits and rhizomes (Arowosoge and Popoola, 2006; Osemeobo, 2005). Its local uses include mat weaving (stalks), roof thatching (stalks and leaves), food wrapping (leaves), as potherbs (leaves and rhizomes) and for sweetening drinks and foods (fruits). However, the most exiting use of *T. daniellii*, for which it has earned global interest, is its use as a sweetener or taste modifier. The arils contain thaumatin, a group of intensely sweet proteins, about 3000 times sweeter than sucrose on weight basis (Van der Wel and Loeve, 1972). It has wide applications in foods and drinks, particularly in the area of taste modification and flavour enhancement. Thaumatin is a 'natural protein' sweetener and readily decomposes into a normal distribution of amino acids upon hydrolysis. It is non-caloric, non-toxic and widely accepted as safe by regulatory authorities (Zemanek and Wasserman, 1995).

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The economic prospects of the fruits is currently engaging the attention of researchers, farmers and industrialists in the West African region (Arowosoge and Popoola, 2006; Osemeobo, 2005; Yeboah *et al.*, 2003). Its integration by local farmers into the cropping systems has been recommended as a way to boost crop production and income generation and ensure sustainable fruit supply (Yeboah *et al.*, 2003). Presently, vendors collect the fruits from the natural habitat and sell to companies which extract and purify the thaumatin. The seeds and the fleshy part which constitute the bulk of the fruit are discarded as wastes after thaumatin has been extracted by the processing plants. The leaves of the plant often used for wrapping foods are also discarded indiscriminately by the consumers of the food. The study objective is to determine the nutritional and phytochemical benefits of the leaf, seed and fruit (fleshy part) of *T. daniellii* with a view to finding other uses for these wastes.

MATERIALS AND METHODS

Preparation of samples: *T. danielli* leaf: Broad, large sized leaves, about 45 cm long and 30 cm broad, were obtained from a local market in Ota, Southwest Nigeria and sundried. The dried leaves were ground to powder and passed through a 0.05 mm pore sized sieve. An aqueous extract of the sample was prepared by soaking 100 g of the powdered samples in 200 mL of distilled water for 12 h. The extracts were filtered using Whatman filter paper No. 42 (125 mm). The sieved powdered sample or the aqueous extract was used for the subsequent tests.

***T. danielli* fruit:** Fresh fruits were obtained from a local cocoa farm in Ekiti State, Southwest Nigeria and store in the freezer at -4°C until use. The fruits were washed and weighed. The fleshy fruit part, seeds and arils were carefully separated and weighed. The fleshy part and the seeds were separately sundried and ground into powder. The respective powder was passed through a 0.05 mm pore sized sieve. Aqueous extract of each sample was prepared by soaking 100 g of the powdered samples in 200 mL of distilled water for 12 h. The extracts were filtered using Whatman filter paper No 42 (125 mm). The subsequent analyses were carried out with the powdered samples or the aqueous extracts.

Proximate analysis: The proximate composition of the leaf, fruit and seed of *T. daniellii* was determined by the official method of the Association of Official Analytical Chemists (AOAC, 1990) as follows: Moisture (section 926.08 and 925.09), Protein (section 955.04C and 979.09), Fat (section 922.06 and 954.02), ash (section 923.03) and crude fibre (section 962.09). Carbohydrate was calculated by difference.

Analysis of mineral content: Five grams of the sample was dry-ashed in an electric furnace at 550°C for 24 h. The resulting ash was cooled in a desiccator and weighed. The ash was dissolved in 2 mL of concentrated HCl and few drops of concentrated HNO₃ were added. The solution was placed in boiling water bath and evaporated almost to dryness. The content was then transferred to 100 mL volumetric flask and diluted to 100 mL mark with deionized water. Appropriate dilutions were made for each element before analysis. Calcium, magnesium and iron contents were quantified using S series atomic absorption spectrophotometer as described in the official method of the Association of Official Analytical Chemists (AOAC, 1990). Phosphorous was quantified with a spectrophotometer as follows: 10 mL of the sample solution was placed into a 100 mL volumetric flask; 5 drops of conc. HNO₃ was added to the flask and made up to 100 mL. The absorbance was read at 490 nm wavelength.

Phytochemical screening: The phytochemical constituents of the leaf, fruit and seed of *T. daniellii* were identified using the methods of Harborne (1973), Sofowora (1993) and Trease and Evans (1989).

Test for tannins: The powdered sample (0.5 g) was boiled in 20 mL of water tube and filtered. Few drops of 0.1% ferric chloride was added to the filtrate. Brownish-green or blue-black coloration indicates a positive result for tannins.

Test for phlobatanins: The powdered sample (0.5 g) was boiled in 20 mL of water and filtered. The extract was boiled with 1% aqueous HCl and observed for deposition of red precipitate.

Test for saponins: The powdered sample (2.0 g) in 20 mL of distilled water was boiled in a water bath and filtered. Ten millimetres (10 mL) of the filtrate was mixed with 5 mL of distilled water and shaken vigorously for a stable persistent froth. The frothing was mixed with 3 drops of olive oil and shaken vigorously and observed for the formation of emulsion.

Test for steroids: Acetic anhydride (2.0 mL) was added to 0.5 g ethanolic extract of each sample with 2 mL H₂SO₄. A colour change from violet to blue or green indicates the presence of steroids.

Test for terpenoids (Salkowski test): Five millilitres (5 mL) of the extract was mixed in 2 mL of chloroform and

3 mL concentrated H₂SO₄ was carefully added to form a layer. A reddish brown coloration of the inter face indicate positive result for the presence of terpenoids.

Test for flavonoids: The presence of flavonoids in the plant sample was determined by the methods described by Sofowara and Harborne. Five millimetres (5 mL) of dilute ammonia solution was added to a portion of the aqueous filtrate of the plant extract followed by addition of concentrated H₂SO₄. A yellow coloration observed in each extract indicated the presence of flavonoids. The yellow coloration disappeared on standing. Few drops of 1% aluminium solution were added to a portion of each filtrate. A yellow coloration was observed indicating the presence of flavonoids. A portion of the powdered plant sample was in each case heated with 10 mL of ethyl acetate over a steam bath for 3 min. The mixture was filtered and 4 mL of the filtrate was shaken with 1 mL of dilute ammonia solution. A yellow coloration is positive for flavonoids.

Test for anthraquinones: The powdered sample (0.5 g) was mixed with 10.0 mL of benzene and filtered; 0.5 mL of 10% ammonia solution was added to the filtrate and the mixture was shaken. A violet colour in the layer phase indicates the presence of anthraquinones.

Test for alkaloids: The powdered sample (0.5 g) was defatted with 5% ethyl ether for 15 min. The defatted sample was extracted for 20 min with 5 mL of aqueous HCl on a boiling water bath. The resulting mixture was centrifuged for 10 min at 3000 rpm. One millimetre (1 mL) of the filtrate was treated with few drops of Mayer's reagent and another 1 mL with Dragendroff's reagent and turbidity was observed.

Test for ascorbic acid: Iodine solution consisting of 0.5 g of iodine dissolved in 100 mL of 1% potassium iodide solution was freshly prepared. One drop of the iodine solution was added into 1 mL of 0.1% starch solution placed in a suitable receptacle. Aqueous extract of the sample was added drop by drop until the blue-black colour of the starch iodine complex disappears leaving a colourless solution. The colourless solution indicates the presence of ascorbic acid.

Test for cardiac glycosides (Keller-Killani test): Five millilitres (5 mL) of the extracts was treated with 2 mL of glacial acetic acid containing one drop of ferric chloride solution. This was under-layered with 1 mL of concentrated sulphuric acid. A brown ring of the interface indicates a deoxysugar characteristic of cardenolides. A

violet ring may appear below the brown ring, while in the acetic acid layer, a greenish ring may form just gradually throughout thin layer.

RESULTS

Figure 1a-d show (a) the fresh leaf, (b) the fresh fruits, (c) the dried seeds and (d) the aril attached to seeds of *T. daniellii*. The percentage content (w/w) of the fleshy part, seed and aril in the *T. daniellii* fruit was 72.4, 22.8 and 4.8%, respectively.

The proximate composition of the leaf, fruit and seed of *T. daniellii* is contained in Table 1. The dried leaf sample contained per 100 g: 10.67±0.03 g moisture, 8.95±0.05 g ash, 17.21±0.03 g fat, 21.06±0.12 g protein, 24.61±0.42 g crude fiber and 17.50±0.06 g carbohydrate (NFE). The content of the dried fruit (fleshy part) per 100 g was 10.04±0.03 g moisture, 21.08±0.12 g ash, 0.93±0.02 g fat, 11.53±0.11 g protein, 18.43±0.18 g and 37.27±1.14 g carbohydrate (NFE). The dried seed contained per 100 g: 15.15±0.04 g moisture, 11.30±0.07 g 0.21±0.00 g fat, 10.36±0.04 protein, 10.36±0.04 crude fiber and 42.46±1.15 carbohydrate (NFE).

Table 2 show the iron, magnesium, calcium and phosphorus content in the leaf and fruit (fleshy part) *T. daniellii*. The leaf contained per 100 g: 0.10±0.02 g calcium, 0.08±0.01 g magnesium, 0.01±0.00 g iron and 0.37±0.03 g phosphorus. The mineral content of the fleshy fruit part was 0.34±0.02, 0.30±0.02, 0.01±0.00 and 0.21±0.03 g per 100 g, respectively for calcium, magnesium, iron and phosphorus.

The result of the phytochemical screening of the leaf and fruit of *T. daniellii* is presented on Table 3. Tannin, terpenoids, flavonoids, alkaloids and cardiac glycosides were significantly present in the leaf whereas phlobatanin, saponin, steroids, anthraquinones and ascorbic acid were

Table 1: Proximate composition of the leaf, fruit and seed of *Thaumatococcus daniellii*

Parameters	Composition (g per 100 g)		
	leaf	Fruit	Seed
Moisture Content	10.67±0.03	10.04±0.03	15.15±0.04
Ash	8.95±0.05	21.08±0.12	11.30±0.07
Fat	17.21±0.03	0.93±0.02	0.21±0.00
Protein	21.06±0.12	11.53±0.11	10.36±0.04
Crude Fiber	24.61±0.42	18.43±0.18	20.52±0.98
Carbohydrate (NFE)	17.50±0.06	37.27±1.14	42.46±1.15

Table 2: Mineral content of the leaf and fruit of *Thaumatococcus daniellii*

Mineral	Composition (g per 100 g)	
	Leaf	Fruit
Calcium	0.10±0.02	0.34±0.02
Magnesium	0.08±0.01	0.30±0.02
Iron	0.01±0.00	0.01±0.00
Phosphorus	0.37±0.03	0.21±0.03



Fig. 1 (a-d): *Thaumatococcus daniellii* (Benn.) Benth: (a) Leaf, (b) Fruits, (c) Seeds and (d) Arils

Table 3: Phytochemical Screening of the leaf and fruit *Thaumatococcus daniellii*

Parameters	Leaf	Fruit
Tanins	+	-
Phlobatanins	-	-
Saponins	-	-
Steroids	-	-
Terperoids	+	+
Flavonoids	+	+
Anthraquinones	-	-
Alkaloids	+	+
Ascorbic acid	-	-
Cardiac Glycosides	+	+

+: Present, -: Absent

absent. Terpenoids, flavonoids, alkaloids and cardiac glycosoides were significantly present in the fruit while there was no trace of phlobatanin, saponin, steroids, anthraquinones and ascorbic acid.

DISCUSSION

Thaumatococcus daniellii fruit is made up of the fleshy part, seeds and arils. The arils which contain the thaumatin, constitute 4.8% of the fruit while the fleshy part and the seed account for 72.4 and 22.8%, respectively. This implies that over 95.2% of the fruit will end up as wastes in the processing plant. This underscores the need to explore other beneficial uses of the fruit parts which can turn the waste into a resource. Studies indicate that the wastes could serve as a source of useful chemicals and enzymes (Elemo *et al.*, 1999; Raimi *et al.*, 2011).

The proximate compositions of the leaf, fruit and seed of *T. daniellii* show that they have obvious nutritional and medicinal benefits. All the plant parts contained high

levels of ash (minerals). The ash content of the fleshy part of the fruit (21.08 ± 0.12 g/100 g) was about 2 times higher than that of the leaf (8.95 ± 0.05 g/100 g) and seed (11.30 ± 0.07 g/100 g). The fruit is a good source of minerals, particularly, calcium (0.34 g/100 g), magnesium (0.30 ± 0.02 g/100 g) and phosphorus (0.21 ± 0.03 g/100 g) whereas the leaf has a high content of phosphorus (0.37 g/100 g). Both the leaf and fruit contained low amount of iron. The leaf of *T. daniellii* has high level of protein (21.06 ± 0.12 g/100 g) compared to the fruit (11.53 ± 0.11 g/100 g) and seed (10.36 ± 0.04 g/100 g). The fat content of the leaf (17.21 ± 0.03 g/100 g) was much higher than that of the fruit (0.93 ± 0.02 g/100 g) and the seed (0.21 g/100 g). This makes the leaf a good source of protein and fat. All the plant parts have high crude fiber contents: leaf (24.61 ± 0.42 g/100 g), fruit (18.43 ± 0.18 g/100 g) and seed (20.52 ± 0.98 g/100 g). The high crude fiber and low fat content of the fruit and seed indicate that they can be helpful in improving intestinal motility and prevention of intestinal disorders such as constipation, colon and rectum carcinoma (Showemimo and Olarewaju, 2004).

Phytochemical screening show that the leaf and fruit of *T. daniellii* contain terpenoids, flavonoids, alkaloids and cardiac glycosides; tannin was present only in the leaf. There was no significant presence of phlobatamin, saponin, steroids, anthraquinones or ascorbic acid in both the leaf and fruit. Flavonoids were copiously present in the leaf and fruit of *T. daniellii*. The quantitative analysis of the flavonoids showed 9.9 and 3.5% respectively for the leaf and fruit (unpublished data). *In vitro* studies have shown that flavonoids have anti-allergic, anti-inflammatory (De Sousa *et al.*, 2007), anti-microbial (Cushnie and Lamb, 2005), anti-cancer (Yamamoto and Gaynor, 2001) and hypolipidemic effects (Sudheesh *et al.*, 1997). Flavonoids have also been reported to be potent antioxidant and free radical scavengers capable of protecting cell membranes from damage (Noda *et al.*, 2000). Thus, the leaf and fruit of *T. daniellii* have potential medicinal properties.

CONCLUSION

In conclusion, the leaf, fruit and seed of *T. daniellii* have high nutritional value and potential medicinal uses. *T. daniellii* leaves could serve as nutritious vegetables in addition to the traditional use for wrapping processed foods. The leaves can also be incorporated into animal feed, especially taking into cognizance the high protein and fat content. The fruits and seed can be exploited for the mineral content. The prospect for medicinal use of the plant parts should also be explored.

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