Assessment of the nutritional potentials of *Theobroma cacao* L. and *Coffee liberica* W. Bull.

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Abstract

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Introduction. Consumption of cocoa and coffee had been on increase due to a number of beneficial health properties attributed to the cash crops. The study of the phytochemical constituents and nutritional potentials of these valuable crops would further reveal their nutritional and phytomedicinal importance in human diet.

Materials and methods. Cocoa and coffee beans were harvested from a farm in Ado-Ekiti, Ekiti State, Nigeria and were studied for their proximate, mineral and phytochemical constituents using standard analytical procedures. The harvested cocoa and coffee were sundried for a week and later air dried, de-shelled, and ground into powder and then sent to the laboratory for phytochemical and proximate analysis.

Results and discussion. The results obtained showed that both plant samples contained alkaloids, tannins, saponins, flavonoids, phenol and cardiac glycosides. However, steroids, phlobatannin and terpenoids were present in *C. liberica* but absent in *T. cacao*. The proximate analysis revealed moisture content (12.16 and 10.84%), carbohydrate (57.19 and 62.51%), crude protein (4.08 and 3.75%), crude fiber (18.95 and 16.72%) and ash (6.82 and 5.58%) in the *C. liberica* and *T. cacao* respectively. The vital minerals (mg/100g) present in the coffee and cocoa were found to be Na (1050.14 and 1133.11), K (305.12 and 719.36), Ca (407.86 and 65.33), Mg (41.83 and 35.28), P (43.69 and 37.37), Mn (12.62 and 5.86), Fe (28.86 and 32.40) and Zn (2.41 and 3.61). Nickel contents were within the permissive level. No Pb and Cd were detected in the plant samples.

Conclusion. Cocoa and Coffee beans investigated could be considered as rich in bioactive secondary metabolites which justify their widely acclaimed health benefits.

Introduction

Since time immemorial, the importance of plants is well known irrespective of the era and area throughout the world. The beneficial roles of plants which include nutritional, aesthetic, cultural, religious and human health have been documented by several authors over the years. Almost all parts of plants have played significant roles in maintaining the health and promoting the well being of human life. Plant products which can be derived from roots, barks, gum, leaves, fruits, flowers, seeds and seed oil have been parts of phytomedicine. Cocoa and Coffee were the major export crops in the early 60's through 1970's and they provided highest foreign exchange in Nigeria [1]. However, evidence has shown that there is downward trend in the production and exportation of these cash crops due to oil boom that now account for the larger percentage of Nigeria foreign exchange [2].

Cocoa (*T. cacao*) discovery could be dated back to 1502 by Columbus on his fourth voyage to America [3] and introduced cocoa into Nigeria in 1874 by the Portuguese trade through Equatorial Guinea [4]. The seed of cocoa tree when further processed yields chocolate amidst other products. The plant is grown in different parts of the world like Brazil, Ghana, Ivory Coast, Malaysia, Nigeria, Venezuela and Indonesia [5]. *T. cacao* (Cocoa tree) is an evergreen tree of the family Sterculiaceae. It grows between 4–8m and preferred the shade of other layered trees. The leaves are dark green, shining, leathery, elliptical in shape, alternate and unlobed. The leaf surfaces are hairless. The flowers are small, yellowish, white to pale pink, non-scented and clustered. The fruits (Cocoa pods) ovoid, 15–30cm long and 8–10cm wide, cauliflower, when ripe, yellow to orange pods.

Cocoa is mainly consumed as chocolate and used beverages, cosmetics and pharmaceuticals [6]. Numerous researchers have documented various health beneficial effects associated with the consumption of cocoa products [7]. Consumption of cocoa and chocolate has been reported to combating diseases like cancer and cardiovascular diseases [8], diabetes mellitus [9] and in immune system boosting. Cocoa pod husk are used traditionally as medicine to treat the pains of pregnancy, fever and coughs [10].

Coffe (*C. liberica* W. Bull ex) is an evergreen shrub or tree up to 20 m tall, branchlets and glabrous. *C. liberica* is native to tropical West and Central Africa. Nowadays, it is fairly widely cultivated in Liberia, Malaysia and lesser extent in Sierra Leone, Nigeria, Sri Lanka and Taiwan. Leaves are opposite, stipules interpetiolar, triangular ovate to almost truncate, 2–4.5mm long, obtuse, petiole 0.8–2cm long. Flowers are in axillary clusters, 4–30 per axil. Fruits are oblong-ellipsoid drupe, red or yellow, mesocarp fleshy and endocarp fibrous. Seeds (commonly referred to as 'beans'), 0.7–1.15cm long, grey brown-green with a groove on the inner surface. Coffee has been used traditionally in the treatment of several diseases and ailments such as ashma, fever, headache jaundice, malaria, sores and vertigo [11].

Coffee is known to possess a number of beneficial health properties among them are diuretic, antimicrobial and antioxidant activities. Coffee served as the most consumed beverages in the world. It can be drink naturally, as a stimulant and painkiller. Coffee contains some biochemical compounds like chlorogenic acid and its derivatives that help in preventing different chronic degenerative disease [12]. Also caffeine is commonly found in coffee and its values vary widely with differences in species as well as within species [13]. Consuming high concentration of caffeine has adverse physiological [14] and psychological effects on man. As a result of this there is an increase demand for de-caffeination of coffee.

Considering the health potentials and economic importance of these crops, there is needs to renew research work which will provide information on the health promoting constituents of *Theobroma cacao* and *Coffee liberica* in Nigeria. More importantly and

pathetically, *C. liberica* have been abandoned for crops that are readily marketable locally. This important cash crop may go into extinction in Nigeria if adequate measures are not taken. Hence, this work was carried out to provide information on the nutritional potentials of *T. cacao* and *C. liberica* in Ekiti State, Nigeria.

Materials and methods

Collection of materials

The cocoa beans and coffee fruits were collected from a cocoa farmer in Ado Ekiti, Ekiti State. They were authenticated in the Department of Plant Science and Biotechnology, Ekiti State University, Ado Ekiti. The harvested coffee fruits were sorted out and cleaned by floatation in a washing basin using distilled water. The materials were put in a large tray and spread in the sun for a week and were later air dried for 5 days. The cocoa beans and coffee beans were de-shelled, then separated from the chaffs, ground into powder using electric blender (Binatone BLG-450). The powdered samples were tightly packed into separate plastic containers and taken to the Department of Biochemistry, University of Lagos, Lagos State for phytochemical, proximate and mineral analyses.

Preparation of plant extract

A portion (200g) of each of the powdered sample was extracted separately using distilled water for 48hours. The extract was filtered using Whatman filter paper and kept for further use.

Phytochemical analyses

Qualitative screening. Qualitative phytochemical screenings were carried out using standard procedures of [15, 16].

Test for alkaloids. Alkaloid was detected by taking about 1g of each plant sample and stirred with 5 ml of 1% HCl on a steam bath and filtered. 1ml of the filtrate was treated with a few drops of Dragendorff's reagent (Bismult nitrate + conc HCl). A change in the colour of the sample to black indicates alkaloid's presence.

Test for tannins. A portion (1g) of the plant sample each was taken and boiled in 10ml of distilled water in a test tube and filtered. A few drops of 5% ferric chloride were added. Black or blue-green colouration or precipitate shows the presence of tannins [17].

Test for saponins. One gram of each plant powdered sample was heated in 5 ml of distilled water in a test tube. The mixture was shaken vigorously by hand for about 15minutes and heated to boil. Persistent frothing shows the presence of saponins [18].

Test for phenols. A portion (1g) of the sample each was soaked in 25 ml of 2% HCl for 1hour and then filtered. 5 ml of each plant extract was then mixed with 1ml of 0.30% Ammonium thiocyanate solution and few drops of ferric chloride solution. A brownish yellow colour indicates the presence of phenol.

Test for flavonoids. A few drops of diluted NaOH solution were added to 0.5 ml of an aqueous extract of each plant sample. Intense yellow coloration which became colourless upon the addition of few drops of diluted H₂SO₄ acid shows the presence of flavonoids [19].

Test for steroids. Two milliliters of acetic anhydride was added to 0.5 g of the plant sample each with 2 ml of conc. H_2SO_4 acid. Presence of steroids is noted by the changing of colour from violet to blue [20, 21].

Test for terpenoids. One gram of each plant sample was mixed with 2 ml of chloroform and 3 ml of conc. H_2SO_4 were carefully added to form layer. A reddish brown colouration of the interface indicates the presence of terpenoids.

Test for cardiac glycosides (Keller-Killiani test). One gram of plant sample each shaken with 5 ml of distilled water in a tube and 2 ml of glacial acetic acid containing a few drops of ferric chloride was added slowly along the side of the test tube. Formation of brown ring at the interface gives positive indication for cardiac glycoside. A violet ring may also appear below the brown ring [22].

Test for anthraquinance (Bontrager's test). One gram of the plant sample was weighed and 1ml of 5% H_2SO_4 was added, boiled in a water bath and filtered. The filtrate was shaken with the equal volume of chloroform was then taken and shaken with half of its volume with dilute ammonia. Formation of rose pink to red colour of the ammonical layer shows the presence of anthraquinone [23].

Test for phlobatanins. A portion (2g) of the powdered sample each was boiled with 1% aqueous HCl. Presence of phlobatanins is noted by the formation of red precipitate [15, 19].

Quantitative phytochemical estimation

The phytochemicals which are present in the *C. liberica* and *T. cacao* powdered samples were determined and quantified by standard procedures of [15, 24, 25].

Proximate analyses

Moisture content for each sample was determined by weighing 5grams of each of the sample into a crucible and heated at 105°C until a constant weight was attained [26]. Total ash was determined by taking 5g of each of the sample in a crucible and ignited in a muffle furnace at 550°C for 6hours, cooled and weighed at room + temperature [27].

Total nitrogen was analyzed using Kjeldal digestion method followed by distillation and titration. The percentage nitrogen was calculated and multiplied by 6.25 to obtain the value of the crude protein [27]. Crude lipid estimation was carried out using the Soxhlet extraction method. N-hexane was used to extract the lipid [27]. Caffeine was determined by boiling 5g of each sample, filtered, washed with chloroform, evaporated, dried in an oven and weighed as outlined by the Kjeldal method [26]. The carbohydrate content was determined by subtracting the summed up percentage compositions of moisture, protein, lipid, fiber and ash contents from 100 [28].

Determination of minerals

For mineral determination, wet digestion of the two samples was carried out according to the method of [29]. Zinc, Manganese, Calcium, Magnesium and Iron were determined by atomic absorption spectrophotometer while Sodium, Potassium and Calcium were measured through flame photometer.

Results and discussion

Results

The results of the phytochemical constituents of *C. liberica* and *T. cacao* revealed the presence of alkaloids, tannins, saponins, phenols, flavonoids and cardiac glycosides. Steroids, phlobatannins and terpenoids were found in coffee but absent in cocoa while anthraquinones were detected in cocoa but absent in coffee (Table 1). The quantitative estimation (mg/100g) of the phytochemicals showed that *C. liberica* and *T. cacao* contained flavonoids (55.74 and 80.78), phenols (42.98 and 51.70), tannins (24.47 and 18.09), saponins (19.45 and 26.11), alkaloids (19.16 and 22.31) and cardiac glycosides (16.67 and 18.14) respectively (Table 2).

Table 1
Phytochemicals present in the seeds of *C. liberica* and *T. cacao* in Ekiti State, Nigeria

Phytochemicals/ Samples	Alk.	Tan.	Sap.	Phen.	Flav.	Ster.	Phlob.	Terp.	Car. Glyc.	Anth.
<i>C. liberica</i>	+	+	+	+	+	+	+	+	+	-
<i>T. cacao</i>	+	+	+	+	+	-	-	-	+	+

Alk. – Alkanoids, Tan. – Tannins, Sap. – Saponins, Phen. – Phenols, Flav. – Flavonoids, Ster. – Steroids, Phlob. – Phlobatanins, Terp. – Terpenoids, Car. Glyc. – Cardiac Glycosides and Anth. – Anthraquinone.

+ indicates presence, – indicates absence

Table 2
Quantitative phytochemical estimation of the seeds of *C. liberica* and *T. cacao* in Ekiti State, Nigeria

Phytochemicals/ Samples	Flavonoids	Phenols	Tannins	Saponins	Alkanoids	Cardiac Glycosides
<i>C. liberica</i>	55.74±0.23	42.98±0.43	24.47±0.26	19.45±0.40	19.16±0.78	16.67±0.31
<i>T. cacao</i>	80.78±0.23	51.70±0.24	18.09±0.15	26.11±0.75	22.31±0.28	18.14±0.18

Values are the mean of triplicates ± S.D

The percentage proximate content of coffee and cocoa beans investigated (Table 3) contained carbohydrate (57.19 and 62.51), crude protein (4.08 and 3.75), crude fat (0.80 and 0.61), crude fiber (18.95 and 16.72), ash content (6.82 and 5.58), moisture content (12.16 and 10.84) and caffeine (0.04 and 0.03) respectively.

The results of the mineral compositions (mg/100g) revealed coffee and cocoa to contain Na (1051 and 1133), K (305.12 and 719.36), Ca (407.86 and 65.33), Mg (41.83 and 32.28), P (43.69 and 37.37), Mn (12.62 and 3.61), Cu (0.15 and 0.04), Zn (2.41 and 3.61), Fe (28.86 and 32.40) and Ni (0.03 and 0.07) respectively. Pb and Cd were not found in the two samples investigated (Table 4).

Table 3

Proximate composition of the seeds of *C. liberica* and *T. cacao* in Ekiti State, Nigeria

Parameters (%)	<i>C. liberica</i>	<i>T. cacao</i>
Carbohydrate	57.19±0.32	62.51±0.25
Crude Protein	4.08±0.04	3.75±0.09
Crude Fiber	18.95±0.28	16.72±0.18
Crude Fat	0.08±0.04	0.61±0.02
Ash Content	6.82±0.03	5.58±0.22
Caffeine	0.04±0.00	0.03±0.00
Moisture Content	12.16±0.34	10.84±0.09

Values are the mean of triplicates ± S.D

Table 4

Mineral compositions of the seeds of *C. liberica* and *T. cacao* in Ekiti State, Nigeria

Mineral Element (g/mg)	<i>C. liberica</i>	<i>T. cacao</i>
Sodium	1051.04±2.35	1133.11±1.27
Potassium	305.12±1.25	719.36±1.79
Calcium	407.86±0.43	65.33±0.66
Magnesium	41.83±0.62	35.28±0.83
Phosphorus	43.69±0.62	37.37±0.16
Manganese	12.62±0.09	5.86±0.35
Copper	0.15±0.00	0.04±0.01
Zinc	2.41±0.24	3.61±0.10
Iron	28.86±0.44	32.40±0.48
Nickel	0.03±0.00	0.07±0.01
Lead	ND	ND
Cadmium	ND	ND

Values are the mean of triplicates ± S.D and ND means not detected.

Discussion

The phytochemicals found in the coffee and cocoa seeds in this study play diverse roles in these plants as well as various biochemical and pharmacological actions when ingested by animals [30]. The presence of these bioactive secondary metabolites in the seeds investigated suggests their importance as health promoting cash crops. Several authors such as [31, 17, 32, 33] had previously reported the therapeutic properties of these phytochemicals in various plant parts.

The phytochemical profile obtained in this study for *T. cacao* was similar to the reports of [34]. The result of the phytochemical estimation revealed that *T. Cacao* had higher concentration of flavonoids, phenols, saponins, alkaloids and cardiac glycosides when compared to *C. liberica*. However, qualitatively, *C. liberica* contained more phytochemical constituents. Alkaloid in coffee and cocoa in this study are found in considerable quantity which makes them biologically active and equally suggests their potential for disease resistance and stress [35]. Alkaloids offer a wide range of health benefits which ranges from anti-inflammatory [36], antimalarial [37], antimicrobial and antispasmodic [38].

High quantity of flavonoids in both beans suggests that they perform some biological functions. Our finding is similar to the reports of [39] and [40] who reported higher concentrations of flavonoids in cocoa than coffee. Lee *et al.* [39] reported that cocoa have higher contents of phenolic and flavonoids than any other phytochemical-rich foods. Flavonoids are effective antioxidant and have strong anti cancer activities [41, 42]. The presences of flavonoids in the two seeds lead to their antioxidant effects which may influence insulin resistance hence reduce the risk for diabetes [43]. Tannins contents in *C. liberica* were higher than that of *T. cacao*. Tannins according to several researchers are known to have anti-inflammatory and antibacterial properties [44], wound healing properties [45], as well as in treatment of intestinal disorders. Plant extracts containing saponins have been reported to exhibit a wide spectrum of biological activity such as inhibitory effect on inflammation [46], antifungal and antibacterial agents, lowering of blood cholesterol and adding bitter taste [47]. In the previous work of Okwu and Okwu [48], it was reported that saponins and steroids have relationships with sex hormones like oxytocin which stimulates contractions during labour in pregnant women and followed by the release of milk. The palatability characteristics of these beverages revealed that they are bitter and this might be due to the high levels of saponins.

Several beneficial health effects that have been attributed to these cash crops may be largely explained by their rich bioactive phytoconstituents. Consumption of cocoa rich in phytochemicals may confer its effectiveness in maintaining skin health and phytoprotection. The presence of these constituents in coffee buttresses its uses traditionally in the treatment of fever, headache, malaria, sores and vertigo. The proximate composition results revealed that *C. liberica* contained higher crude protein, fiber and ash contents while carbohydrate obtained is higher in *T. cacao* than *C. liberica*. The crude protein content in the coffee is higher than 1.43 mean distribution of total nitrogen content reported by [49] for some brands of tea in Nigeria. The crude protein content of the cocoa beans is lower compared to the values range of 6.11% to 9.25% [50]. The crude protein in *C. liberica* and *T. cacao* may contribute to their health potential as it supports growth and development in infant and children as well as constant replacement and turnover of protein in adult [51].

Fiber content in our cocoa is comparatively higher than value of 1.80% reported by [52]. The fiber content of the coffee is in agreement with reports of [53]. Several researchers have documented the health benefits of fiber to include; lowering the risk of diabetes and heart disease, as well as preventing constipation [54]. Crude fat content in the two plants are relatively low and quite reasonable as excess fat consumption has health implications such as cardiovascular diseases [55]. Considerable amount of crude fiber and low crude fat in the cocoa and coffee studied suggest that the beverage may help to protect against the aetiology of certain coronary heart and cardiovascular diseases. The products could also be recommended as good drinks for people who suffer from high cholesterol level.

The percentage ash content value is an indication of its mineral contents. The two samples compare favorably with the value range of 5.32 to 6.31% and Carbohydrate values are low when compared with the value range of 67.24% to 73.00% reported by [50]) for cocoa beans The carbohydrate contents of *T. cacao* and *C. liberica* are high, an indication that this beverage could serve as a good source of energy for human being.

The caffeine content in *C. liberica* is comparatively higher than the value obtained for *T. cacao*. Interestingly, the values of our findings are comparatively low to 0.07% caffeine reported in Ethiopian coffee designated as naturally decaffeinated varieties [12]. The caffeine content in our study falls within the range of 0.036 to 0.041% reported by [56] for decaffeinated coffee. Caffeine is found in various kinds of foods and drinks that we

consume every day. Several researchers had reported various physiological and psychological effects of consuming high concentration of this compound [57, 58]. Caffeine concentration evaluation have been used as an additional tool for assessing beverage (such as cocoa and coffee) quality. Farah *et al.* [59, 60] reported that higher caffeine content is associated with less quality samples. Hence, the two beverage samples evaluated are good for human consumption.

The cocoa and coffee beans investigated in our study are very rich source of many macro and micro elements that are needed in normal human metabolism. These essential minerals include Sodium, Potassium, Calcium, Magnesium, Phosphorus, Manganese and Iron. Comparing with other results previously documented, our result for cocoa beans is similar to the reports of [61] and [43]. Our work disagrees with dominant magnesium in the reports of the former and low potassium in the reports of the latter.

Also the result of the mineral content for coffee in this study is in line with previous work of [56]. Determination of these minerals in cocoa and coffee is of great interest and will help immensely in improving their nutritional effects. Minerals play vital roles in physiological functions. Lead and Cadmium were not detected which suggest that the beverage under investigation cannot pose any health risk for consumers. Sodium in moderate quantity plays a role in nervous and muscular body function. Calcium is necessary for the development of bones and teeth. Magnesium is an anti arrhythmic and hypertensive agent [62]. Copper helps in glucose metabolism and brain development [63].

Conclusion

Several health promoting effects have been attributed to these cash crops. These may be largely explained by their rich bioactive phytoconstituents and nutritional compositions as revealed in this study. *C. liberica* and *T. cacao* investigated are rich in health promoting chemicals and their consumption should be encouraged. They also contain very low caffeine which makes them to be considered as good for human well being. Nigeria government needs to look at how to boost the production of these important cash crops more importantly *C. liberica* which is more nutritious and contain very little amount of caffeine. Its seeds do not need laborious and expensive chemical decaffeination.

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