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Estimation of the Biochemical Compositions and Nanoparticle Properties of *Brachystegia eurycoma* and *Colocasia esculenta* (L.) Schott Soup Thickeners

Veronica Anab-Atulomah*, Nnenna Ejije Okoronkwo and Ijeoma Joy Agbai

Department of Pure and Industrial Chemistry, Abia State University, Uturu Nigeria

***Corresponding Author:** Veronica Anab-Atulomah, Department of Pure and Industrial Chemistry, Faculty of Physical Sciences, Abia State University Uturu Nigeria, PMB 2000, E-mail: veronica.anab@abiastateuniversity.edu.ng

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Abstract

The biochemical compositions and nanoparticle properties of *Brachystegia eurycoma* (achi) and *Colocasia esculenta* (ede) were studied in this research by analyzing their proximate, phytochemical, vitamin and mineral (elemental) compositions. The samples were also subjected to GCMS and SEM-EDX analyses. Results of proximate analysis revealed that *Colocasia esculenta* is a richer source of carbohydrate with carbohydrate content of 80.24±0.2% while *Brachystegia eurycoma* is a richer source of protein with a protein content of 13.42±0.5%. The soup thickeners were predominantly carbohydrates. *Brachystegia eurycoma* contained 3.67±0.50% crude fibre while *Colocasia esculenta* contained 1.93±0.5%. From the phytochemical screening conducted, flavonoid concentration was higher in *Brachystegia eurycoma* (79.34mg/100g) while alkaloid concentration was higher in *Colocasia esculenta* (158.25mg/100g). Vitamin analysis showed that *Colocasia esculenta* had a riboflavin concentration of 13.66±0.45mg/100g while *Brachystegia eurycoma* had a concentration of 16.68±0.68mg/100g. Results of mineral analysis showed that both soup thickeners are rich sources of carbon and nitrogen and contained other essential elements like calcium, sodium and magnesium. GC-MS analysis showed the presence of six bioactive compounds in the chromatogram of *Brachystegia eurycoma*, a molecular ion peak of 48.18% at a retention time of 35.85 minutes while the chromatogram of *Colocasia esculenta* showed five bioactive compounds, a molecular ion peak of 51.64% and a retention time of 19.09 minutes. SEM analysis showed the surface morphology and sizes of the synthesized nanoparticles to be spherical/distorted and 81.83nm/70.38nm for *Colocasia esculenta* and *Brachystegia eurycoma* respectively. The exceptional biochemical compositions of these soup thickeners make them an excellent choice in nutrition, drug binding/pharmaceuticals, and a great alternative to the use of glucose in nanosynthesis.

Keywords: Nanoparticles; *Colocasia esculenta; Brachystegia eurycoma*; Soup Thickeners; GCMS; Hydrocolloids

Introduction

Soups are mainly liquid foods mostly served warm or hot and sometimes cold. They are made by incorporating ingredients of vegetables or meat with water, milk or stock. Hot soups are made by boiling solid ingredients in liquids until the flavors are extracted to form a broth Soup is a nutritious and tasteful liquid broth having a key ingredient usually eaten with a hard meal mostly gotten from starch sometimes called swallow. Soups can be thick or light. Thick soups are most often homogenized with soup thickeners to get a consistency of interest [1].

Thickeners or thickening agents are hydrocolloids that increase the viscosity of a solution or mixture without significantly affecting its properties such as taste [2]. Hydrocolloids are a heterogeneous group of long chain polymers that when sprinkled in water, gives a thickening or viscous or gelling effect [3]. Soup thickeners are therefore, edible hydrocolloids used to thicken soups.

Biochemical refers to chemical processes that occur in living systems. Biochemical composition in its simplest term is the particular quantity and combination of different biological components in an organism or substance. It is capable of impacting the possible applications, functionality and biological activity of an organism.

Brachystegia eurycoma, of the kingdom plantae, belongs to the genus *Brachystegia*, of the order Fabales, and family Fabaceae. It is a fairly large type of tree found in southern Nigeria and western Cameroun with a spreading flattened crown. *Brachystegia eurycoma* fruits are usually in pods which break violently from internal pressure when ripe, throwing out the seeds. The seeds are hard, flat and round in shape and have a shiny brown colour [4]. *Brachystegia eurycoma* is an important African seed for soup thickening. It is also used for herbal products and for medicinal purposes. It is called "achi" by the Igbos and "akpa" by the Akwa-Ibom people, both of Nigeria. It is an emulsifier and thickener for traditional soups. When ground, it gives a white brownish powder. It is a leguminous plant that is popular amongst the people of the Southern part of Nigeria for its ethnomedicinal and nutritional values. However, this legume has been grossly underutilized albeit the promise it holds for food and drug development. Achi is an all-important vegetable, fundamental for soup thickening in Nigeria. To use achi as thickener in soups, the seeds are crushed, ground into fine powder and dispersed in soups as desired [5].

Plate 1: Brachystegia eurycoma (achi) seeds

Colocasia esculenta (L.) Schott belong to the genus *Colocasia* Schott, of the kingdom plantae and family Araceae. *Colocasia esculenta* is most of the time called cocoyam, elephant's-ear, dasheen and taro. It is commonly known as "ede" by the Igbo people of Nigeria. Two commonly grown species of cocoyam are taro and tannia. Tannia (*Xanthosoma sagittifolium*) originated from America while taro (*Colocasia esculenta*) is said to have originated from Asia but were both introduced and grown in West Africa. These two species of cocoyam are the most widely

known and cultivated in Nigeria and other parts of the tropics and subtropics of Africa [6]. *Colocasia esculenta* (L.) Schott is a staple food grown primarily as a root vegetable for its edible starchy corm. The corm lies just below the surface of the soil from which roots grow downward and leaves grow upwards [7]. The corms grow laterally and comprises three parts; the skin, the cortex and the core. The skin may be smooth and fibrous and mostly brownish yellow in colour. Taro leaves and corms are poisonous if eaten raw; the acrid calcium oxalate they contain must first be destroyed by heating or soaking in water. After yam and cassava, *Colocasia esculenta* is the next most significant source of staple carbohydrate [8]. Taro is said to be one of the major sources of dietary fibre, a good source of easily digestible carbohydrate, and rich in vitamins [9].

Plate 2: *Colocasia esculenta* (L.) Schott corms and flour

A nanoparticle also called ultrafine particle is a particle of matter that is between 1 and 100 nanometers (nm) in diameter. The term is sometimes used for larger particles up to 500nm, or fibers and tubes that are less than 100nm in only two directions. Nanoparticles refer to very small objects having a size range of 1 to 100nm capable of behaving as a whole unit with respect to its transport and properties. They exhibit different properties compared to the bulk of same materials making them very attractive for commercial and industrial development. Nanotechnology finds applications in various fields. In the food industry it is used to improve food texture, food appearance, food packaging, food taste, and nutritional value of food, food shelf life and a host of others [10]. Nanomaterials used for food packaging provide many advantages including improved mechanical barriers, detection of microbial contamination and enhanced bioavailability of nutrients. This is probably the most common application of nanotechnology in food and food-related industries [11].

The aim of this study was to evaluate the biochemical compositions and nanoparticle properties of *Brachystegia eurycoma* and *Colocasia esculenta* and their possible/further applications in food, drug and nanosynthesis.

Materials and Methods

Sample Collection

Fresh *Colocasia esculenta* corms and dried seeds of *Brachystegia* eurycoma were purchased from Onu-Imo, a market in the boundary axis of Imo and Abia States in the South Eastern part of Nigeria. The samples were identified by a professor of Organic Chemistry in the Department of Pure and Industrial Chemistry, Abia State University, Uturu, Nigeria.

Sample Preparation and Processing

The cocoyam (*Colocasia esculenta*) corms were sorted, washed thoroughly and cooked on medium heat for about 1 hour. They were peeled, allowed to cool and cut into small pieces. The cut pieces were spread on a tray and sundried in a dust free chamber for six days. The dried corms were ground into flour and stored in an airtight plastic container. *Brachystegia* eurycoma seeds were already roasted before purchase. The seeds were dehulled. To ease dehulling, the seeds were soaked in water at room temperature for about 30 minutes. This was followed by thorough washing, drying, grinding and storage. Both processed sam-

ples were stored in air tight plastic containers for further analysis.

Proximate Analysis

Proximate analysis was done using standard methods. Determination of Crude Protein; this was done using the Kjeldahl method as described by [12], determination of crude fibre; [13], determination of fat content; [15], determination of moisture content; [12,13], determination of total ash content; [15], determination of carbohydrate; [13].

Phytochemical Screening

Chemical test were carried out on the samples to identify the secondary metabolites using standard procedures. 10g of each flour sample was extracted using 100ml of methanol at 25◦C for 24hours after which the mixture was filtered using a filter paper. The residue was extracted with additional 100ml of methanol by following the initial extraction procedures. The extracts from the 1st and 2nd extraction attempts were combined. 10ml of the mixture was evaporated at 50◦C by oven drying and the resulting extract stored away from light for use [16].

Test for Reducing Sugar (Fehling's Test)

0.5g of each of the flour sample extract was dissolved in distilled water and filtered after which the filtrate was subjected to heating with 5ml of equal volumes of Fehling's solution A and B. Appearance of red precipitate of cuprous oxide showed that reducing sugars were present [17].

Test for Tannins

0.5g of each flour sample extract was suspended and stirred in 10ml of distilled water and filtered. Few drops of 1% ferric chloride solution were introduced to 2ml of the filtrate. Formation of blue-black, green or blue green precipitate showed the presence of tannins [18].

Test for Saponins

1g of each flour sample extract was boiled with 5ml of distilled water and filtered. 3ml of distilled water was added to the filtrate and shaken vigorously for 5mins. Frothing, which persist on warming indicates the presence of saponins [18].

Test for Protein (Xanthoproteic Test)

To each of the flour sample extract, few drops of nitric acid were added. Formation of yellow colour proves the presence of protein [18].

Test for Alkaloids (Mayer's Test)

50mg of each flour sample extract devoid of solvent was stirred in 2ml hydrochloric acid (HCl) and filtered. Few drops of Mayer's reagent were added by the side of the test tube to the filtrate. Formation of white or creamy precipitate indicates the presence of alkaloids [19].

Test for Flavonoids (Shinoda's Test)

0.5g of each flour sample extract was allowed to dissolve in ethanol, warmed and filtered. 3 pieces of magnesium chips was added into the filtrate. This was followed by addition of few drops of conc. HCl. Appearance of pink, orange, or red to purple colour showed the presence of flavonoids [18].

Test for Terpenoids (Salkowski Test)

2ml of chloroform was introduced into a test tube containing 0.5g of each sample extract. 3ml of H_2SO_4 was added to form a layer. The appearance of a reddish brown colour at the interface showed the presence of terpenoids [19].

Test for Phenols (Ferric Chloride Test)

Few drops of neutral 5% ferric chloride solution was introduced into a test tube containing 50mg each of the flour sample extract dissolved in 5ml of distilled water. A dark green colour suggests the presence of phenolic compounds [20].

Test for Steroids

5ml of distilled water was added into a test tube containing 0.5g of each flour sample extract and the mixture shaken vigorously and observed for a stable persistent froth. The resulting froth was mixed with 3 drops of olive oil and shaken vigorously. Formation of emulsion showed that steroids were present [18].

Test for Cardiac Glycosides (Keller Killiani's Test)

100mg of each of the flour sample extract was dissolved in 1ml of glacial acetic acid containing one drop of ferric chloride solution. This was then under layered with 1ml of conc. H_2SO_4 acid. A brown ring obtained at the interface showed the presence of cardiac glycosides [18].

Test for free Anthraquinones

2mg each of the sample extract were introduced into a dry test tube after which 5ml of chloroform was added and shaken for at least 5mins. The mixture was filtered and the filtrate was added into an equal volume of 10% ammonia solution and shaken again. The presence of bright pink colouration in the aqueous upper layer is a pointer that free anthraquinones were present [18].

Determination of Vitamins

Vitamins were analysed using standard methods. Determination of ascorbic acid (Vitamin C) content: [14], determination of niacin content: [21], determination of riboflavin content: [14], determination of thiamine content: [14].

Bioactive Compound Composition Using Gas Chromatography Mass spectrometer

Each flour sample was centrifuged at 10,000rpm for 15–20 min., and then the supernatant was transfer to a fresh micro centrifuge tube. 2 ml of each of the supernatant was mixed with 2 ml of methanol. Thorough mixing was done and kept for some time at room temperature for separation. The samples were extracted with methanol and that extract was analysed using GC-MS for different bioactive components. GC analysis was carried out on a GC102AF system comprising Injector Port and Fid Detector auto sampler and GC instrument employing the following conditions: Column Elite - 1 fused silica capillary column (30 × 0.25 mm ID 1 × EM df, composed of 100% dimethylpolysiloxane), operating in electron impact mode at 70 eV; helium (99.999%) will be used as carrier gas at a constant flow of 1 ml/min and an injection volume of 0.5 EI will be employed (split ratio of 10:1 injector temperature 250 ° C; ion source temperature 280° C. The oven temperature was programmed from 110°C (isothermal for 2 min) with an increase of 10°C/min, to 200°C then 5 EI/min to 280°C, ending with a 9min isothermal at 280°C. Mass spectra will be taken at 70 eV; a scan interval of 0.5 s and fragments from 40 Da to 550 D [22].

Identification of Components

Interpretation on mass spectrum GC was conducted using the database of National Institute of Standards and Technology (NIST) having > 62,000 patterns. The spectrum of the unknown component was compared with the spectrum of the known components stored in the NIST library.

Synthesis of Nanoparticles

Preparation of Sample Extracts

10g of each flour sample was boiled for 40 minutes at 60◦C in 100ml distilled water to prepare the sample extracts. They were left standing for 3hours to cool. The boiled liquid was filtered through a buckner funnel using a filter paper and a vaccum pump to separate the extracts from the aqueous samples. The obtained extracts were stored in flasks for FeNP synthesis [23].

Synthesis of Iron Nanoparticles (FeNPs)

1mM solution of $Fe_2SO_4.7H_2O$ was prepared according to the requirement for generating FeNPs. (Briefly, since mass of 1 mole of $Fe_2SO_4.7H_2O$ = 334g, mass of 1 millimole (mM) of $Fe_2SO_4.7H_2O$ = 334g/1000; this gives 0.334g. To prepare 1L of 1mM $Fe_2SO_4.7H_2O$, weigh out 0.334g of $Fe_2SO_4.7H_2O$ into a standard flask and add the required amount of water, that is, 1000ml). Each prepared sample extract was added for the reduction and capping of Fe ions. 50ml of the prepared solution of $Fe_2SO_4.7H_2O$ was added to 2ml of each sample extract. The mixture was boiled for 30minutes at 65◦C. This was followed by incubation for 24hours at room temperature. There was a colour change to dark brown which confirmed the formation of FeNPs. The obtained solutions were periodically rinsed with distilled water after centrifugation at 3000 rpm for 10minutes [23].

Characterization of Iron Nanoparticles

The synthesized Iron nanoparticles were further characterized using Scanning Electron Microscopy Energy

Dispersive X-ray (SEM-EDX) analysis.

Statistical Analysis

Data generated from all analysis were subjected to analysis of variance and means where significant ($p \leq 0.05$) were separated with Fisher's least significant difference using Statistical Package for Social Sciences (SPSS) version 13.0

Results and Discussion

Proximate Analysis

Proximate analysis results of *Colocasia esculenta* and *Brachystegia eurycoma* are as presented in table 1 below.

Table 1: Result of Proximate Analysis of the samples

Parameter (%)	*Colocasia esculenta*	*Brachystegia eurycoma*
Crude Protein	$5.08^{b} \pm 0.02$	$13.42^{a} \pm 0.5$
Crude Fibre	$1.93^{b} \pm 0.5$	$3.67^{a} \pm 0.50$
Moisture Content	$7.63^{b} \pm 0.04$	$9.16^{a} \pm 0.30$
Fat Content	$2.31^{b} \pm 0.50$	$8.23^{a} \pm 1.93$
Ash	$2.81^{b} \pm 0.03$	$3.48^{a} \pm 0.02$
Carbohydrate	$80.24^{a} \pm 0.2$	$62.04^{b} \pm 0.65$

Values show means of triplicate analysis ± standard deviation. Figures with different superscript across the rows are significantly different at ($p \leq 0.05$).

Results of proximate analysis showed that the soup thickeners were predominantly carbohydrates with the carbohydrate contents of *Colocasia esculenta* (ede) and *Brachystegia eurycoma* (achi) being 80.24±0.2% and 62.04±0.65%, respectively. *Colocasia esculenta* contained more carbohydrate. This is evident in the fact that root tubers are mostly starchy foods with large carbohydrate contents. The high carbohydrate contents of the soup thickeners showed their essence in nutrition. The variations in carbohydrate levels of the samples result from differences in other proximate composition parameters. The results obtained from carbohydrate are in concordance with that of [24]. Carbohydrates along with protein and fat are the macronutrients in the human diet. Carbohydrates act as a major energy source by providing the body with glucose. Glucose is converted to energy which the body needs for day to day activities and bodily processes. They help to metabolise insulin and cholesterol and also in fermentation [25].

The soup thickeners showed an appreciable amount of protein. *Brachystegia eurycoma* was the more proteineous thickener with percent protein content of 13.42±0.5% while the protein content of *Colocasia esculenta* was 5.08±0.02%. Protein is necessary to build the body and replace worn out tissues. This result is similar to those of [26]. Like carbohydrates, proteins are macronutrients in the human diet. Proteins are life's building blocks. They build the body and replace worn out tissues. They are crucial in the growth and development of children, teens and even pregnant women [27].

Colocasia esculenta contained 7.63±0.04% moisture while *Brachystegia eurycoma* contained 9.16±0.30%. The low moisture content of the soup thickeners can be attributed to the fact that *Brachystegia eurycoma* is a dry and hard seed although *Colocasia esculenta* (ede) is a root tuber. Low moisture retards deterioration and inhibit microbial attack thereby slowing spoilage. Moisture is essential in food as it is responsible for the chemical changes that take place in food and therefore, a determining factor on food quality and nutritional value [28].

The ash content of the samples ranged from 2.81±0.03% in *Colocasia esculenta* to 3.48±0.02% in *Brachystegia eurycoma* with *Brachystegia eurycoma* having the higher value. Ash content of food eases weight loss, fights against water retention, and promotes the passage of faecal bulk. It also provides substantial information on how processed a food is. The higher the ash content, the more processed the food.

Crude fibre analysis showed the percentage composition to be 1.93±0.5% for *Colocasia esculenta* and 3.67±0.50% for *Brachystegia eurycoma*. Fibre plays a vital role in diet. Crude fibre helps to regulate bowel activities and guard against rectal and colon cancer. Some physiological responses have been linked with crude fibre consumption lowering the plasma cholesterol and lowering the faecal bulk.

Fat contents were valued at 2.31±0.50% and 8.23±1.93%, for *Colocasia esculenta* and *Brachystegia eurycoma* respectively. Fat is a source of essential fatty acids which the body cannot make itself. For a healthy balanced diet, a small amount of fat is necessary. Dietary fats are essential to give the body energy in the form of calories, support cell growth, guard organs, monitor body temperature, keep blood pressure and cholesterol level under control, produce and control hormones, and helps the body to absorb fat soluble vitamins (vitamins A, D, E and K) [29]. The values obtained from proximate analysis of the samples are very close to those obtained by [30].

Phytochemical Screening

The qualitative and quantitative phytochemical tests results of the samples are as presented in tables 2 and 3.

Table 2: Qualitative Phytochemical Screening Results

Parameters	*Colocasia esculenta*	*Brachystegia eurycoma*
Flavonoids	+	++
Alkaloids	+++	–
Saponins	–	+
Tannins	+	–
Protein	++	++
Terpenoids	+++	++
Phenol	+	+
Steroids	+++	+++
Cardiac glycoside	–	++
Reducing sugar	+	+
Anthraquinones	–	+

KEY: +++ Significantly present, ++ moderately present, + weakly present, – absent

Table 2 gives the results of qualitative phytochemical screening carried out on each sample extract to identify the secondary metabolites. Alkaloids, terpenoids and steroids were significantly present in *Colocasia esculenta*, protein; moderately present, phenols, tannins, flavonoids; weakly present and saponins and cardiac glycosides absent. While steroids were significantly present in *Brachystegia eurycoma*, flavonoids, protein, terpenoids and cardiac glycosides were moderately present and saponins, reducing sugar and anthraquinones were weakly present. These pytochemicals present in the soup thickeners exhibit strong antimicrobial, antiviral, antidiarrhea, antiallergic, anthelmintic, and antispasmodic activities and posses strong antioxidant activities. Saponins lower plasma cholesterol levels in humans. Tannins are used in the treatment of haermorrhoids, varicose ulcer, gum inflammation and minor burns [31,32].

Table 3: Quantitative Phytochemical Screening Results in mg/100g

Parameters	*Colocasia esculenta*	*Brachystegia eurycoma*
Flavonoids	$10.91^{b} \pm 2.89$	$79.34^{a} \pm 2.02$
Alkaloids	$158.25^{a} \pm 4.9$	$0.85^{b} \pm 0.10$
Saponins	$0.54^{b} \pm 0.02$	$1.68^{a} \pm 0.05$
Tannins	$53.88^{a} \pm 1.83$	$15.98^{b} \pm 3.01$
Protein	$60.09^{b} \pm 3.15$	$69.84^{a} \pm 3.61$
Terpenoids	$240.08^{a} \pm 6.4$	$202.38^{b} \pm 6$
Phenol	$71.22^{a} \pm 2.32$	$68.89^{b} \pm 3.00$
Steroids	$75.90^{b} \pm 5.60$	$77.06^{a} \pm 3.41$
Cardiac glycoside	$0.87^{b} \pm 0.01$	$3.68^{a} \pm 0.25$
Reducing sugar	$19.07^{b} \pm 2.03$	$20.88^{a} \pm 1.9$
Anthraquinones	$0.38^{b} \pm 0.08$	$3.48^{a} \pm 1.10$

Values show means of triplicate analysis ± standard deviation. Figures with different superscript across the rows are significantly different at ($p \leq 0.05$).

The concentrations of flavonoid in the samples were 10.91±2.89mg/100g for *Colocasia esculenta* and 79.34±2.02mg/100g for *Brachystegia eurycoma*. Flavonoids have been proven to have antioxidative activity, prevent coronary heart disease, anticancer activity and free radical scavaging ability [33].

The concentrations of alkaloid in the samples were 158.25±4.9mg/100g for *Colocasia esculenta*, and 0.85±0.10mg/100g for *Brachystegia eurycoma*. It can be noted that *Colocasia esculenta* was significantly high in alkaloids. Alkaloids are known to have therapeutic properties. They are well known as anaesthetics, cardioprotective, and anti-inflammatory agents [34].

Saponin levels in the soup thickeners were generally low. *Brachystegia eurycoma* had the higher saponin concentration of 1.68±0.05mg/100g when compared to *Colocasia esculenta* with a value of 0.54±0.02mg/100g. Saponins lower cancer risks, lower blood glucose response, and reduce blood lipids. A diet high in saponin is used in dentistry for the inhibition of dental caries and platelet aggregation, and as an antidote against acute lead poisoning [35].

The concentration of tannin in *Colocasia esculenta* was 53.88±1.83mg/100g and 15.98±3.01mg/100g for *Brachystegia eurycoma*. Tannins have been reported to have antimicrobial properties. They also exhibit physiological effects such as acceleration of blood clothing, reduction of blood pressure, and control immunoresponses [36].

Both samples contained protein in good amounts. *Colocasia esculenta* had a protein concentration of 60.09±3.15mg/100g, and *Brachystegia eurycoma*, 69.84±3.61mg/100g. Protein is essential in body building and replacement of worn-out tissues.

The concentrations of phenolic compound were 71.22±2.32mg/100g for *Colocasia esculenta*, and 68.89±3.00mg/100g for *Brachystegia eurycoma*. Phenolic acids wards off the destruction of cells which results from free-radical oxidation reactions. They easily absorb through intestinal tract walls and are advantageous to human health due to potential oxidants [37].

Terpenoid levels are markedly noted in both samples. The concentration ranged from 240.08±6.4mg/100g in

Colocasia esculenta, to 202.38±6.0mg/100g in *Brachystegia eurycoma*. Terpenoids have a wide range of biological activities including anti-inflammatory, antioxidant, antimicrobial, anticancer and antiallergic properties [38].

Steroids were present in both soup thickener samples. *Colocasia esculenta* had a concentration of 75.90±5.60mg/100g, and *Brachystegia eurycoma,* 77.06±3.41mg/100g. Steroids are beneficial in a number of ways; they improve bone mineral density, increase muscle endurance, increase production of red blood cell, reduce body fat percentage, increase muscle tissue due to enhanced protein synthesis.

The levels of cardiac glycosides in mg/100g in *Colocasia esculenta*, and *Brachystegia eurycoma* were 0.87±0.01 and 3.68±0.25 respectively. Their concentrations were generally low. Cardiac glycoside has its most important use to be in the treatment of heart failure and certain irregular heartbeats. It is used to enhance cardiac output in people who have heart failure [39].

Reducing sugar concentration in *Colocasia esculenta* was 19.07±2.03mg/100g and 20.88±1.9mg/100g in *Brachystegia eurycoma*,. Reducing sugar lowers blood pressure and decreases the risk of cardiovascular disease. It also prevents tooth decay and reduces the chances of dementia. It has the advantage of decreasing the risk of overweight and obesity as well as diabetes [40].

The concentrations of anthraquinones were 0.38±0.08mg/100g for *Colocasia esculenta*, and 3.48±1.10mg/100g for *Brachystegia eurycoma*. Asides being used as colourants, anthraquinone derivatives find application in medicine. It is used as laxative and antimicrobial and anti-inflammatory agents. Currently, it is used for treatment of constipation, arthritis, multiple sclerosis and cancer [41].

Vitamin Analysis

The results of vitamin analysis of both samples are as shown in table 4 below

Table 4: Vitamin Contents of Soup Thickeners in mg/100g

Parameter	*Colocasia esculenta*	*Brachystegia eurycoma*
Ascorbic acid (Vitamin C)	25.21^{b} ±0.02	216.11^{a} ±4.38
Niacin (Vitamin B3)	4.55^{b} ±0.69	8.59^{a} ±0.74
Riboflavin (Vitamin B2)	13.66^{b} ±0.45	16.68^{a} ±0.68
Thiamine (Vitamin B1)	6.38^{b} ±0.98	18.24^{a} ±3.77

Values show means of triplicate analysis ± standard deviation. Figures with different superscript across the rows are significantly different at ($p \leq 0.05$).

Vitamin C levels in *Colocasia esculenta and Brachystegia eurycoma* were 25.21±0.02mg/100g and 216.11±4.38mg/100g respectively. *Brachystegia eurycoma* is richer in vitamin C. Vitamin C is needed by the body for the biosynthesis of certain neurotransmitters, for the formation of blood vessels, muscle, cartilage and collagen in bones. It is also important in protein metabolism [42].

The concentrations of niacin in mg/100g of *Colocasia esculenta* and *Brachystegia eurycoma* were 4.55±0.69 and 8.59±0.74, respectively. The soup thickeners were observed to have low niacin contents compared to other vitamins present. Niacin in diet is said to improve skin, promote heart health, boost brain function, prevent erectile dysfunction, reduce arthritis and prevent diabetes [43].

Riboflavin concentration was higher in *Brachystegia eurycoma*at 16.68±0.68mg/100g and *Colocasia esculenta* 13.66±0.45mg/100g. Riboflavin is necessary for growth and red blood cell production, assists the body to change folate and vitamin B6 into usable forms. Riboflavin also serves as an antioxidant and can fight free radicals and may reduce or help prevent some of the harm caused by them [44].

Brachystegia eurycoma had the higher thiamine content of 18.24±3.77mg/100g, and *Colocasia esculenta*; 6.38±0.98mg/100g. Thiamine helps the body cells convert carbohydrates into energy and to keep the nervous system healthy [27].

The results obtained show only a small difference from those of [24].

Results on Mineral Compositions (Energy dispersive X-ray analysis)

The results of Energy dispersive x-ray (EDX) analysis for mineral (elemental) compositions of the samples are as presented in table 5.

Table 5: EDX elemental composition of the phyto-synthesized nanoparticles

Colocasia esculenta			*Brachystegiaeurycoma*	
Element	**Atomic Conc.**	**WeightConc.**	**AtomicConc.**	**Weight Conc.**
C	72.97	66.16	79.60	73.47
N	23.72	25.08	17.22	18.54
Si	0.14	0.30	0.15	0.33
Fe	0.25	1.04	-.	-
Ca	0.18	0.54	1.02	3.14
Ti	0.12	0.44	0.13	0.46
Al	0.34	0.70	0.34	0.71
K	1.05	3.10	-	-
P	0.31	0.72	0.35	0.83
Na	0.32	0.56	0.32	0.56
S	0.19	0.47	0.36	0.89
Mg	0.24	0.43	0.40	0.76
Cl	0.17	0.46	0.12	0.32

Energy dispersive X-ray (EDX) analysis of the iron-synthesized materials was performed to estimate the composition of various elements present in the nanomaterials. Table 5 shows the EDX data of the nanomaterials from the extracts of *Brachystegia eurycoma,* and *Colocasia esculenta*. Noteworthy, was the abundance of carbon and nitrogen in both samples. Both samples contained sodium (Na), phosphorus (P), sulfur(S), magnesium (Mg), chlorine (Cl), iron (Fe), aluminium(Al), silicon(Si). titanium (Ti), and calcium (Ca). Carbon is an essential element for every form of life, whether in the form of taking in carbon to help manufacture food or giving out carbon as part of respiration. It is the main building block needed to form proteins, carbohydrates and fats. It also regulates the body's physiology [45]. Nitrogen is a major body component required for both tissue protein synthesis and production of various nitrogenous compounds involved in a number of functions including immune mediators, neurotransmitters. Genes are made up of DNA and RNA which nitrogen is a major part of. Nitrogen plays a very important role in the development of the human fetus and is necessary for healthy food digestion and growth. The body needs phosphorus for repair of tissues and cells, growth and development, for the balance of other vitamins and minerals (like vitamin D and magnesium), and for the production of the genetic building block DNA and RNA. Sodium is an essential nutrient needed by the body in small amounts to maintain body fluid (water and mineral) balance and keep nerves and muscles running smoothly. Like sodium, calcium is an essential mineral that helps our muscles, heart and nerves to function properly and to help move nutrient and wastes around body cells. Calcium helps to regulate normal heart rhythms and nerve

functions, helps muscles to contract and helps in blood clothing. Magnesium is also an essential mineral for healthy muscles, bones, nerves and blood sugar level. Deficiency may lead to stroke, heart attack and diabetes. Potassium is another essential mineral necessary for all body functions. It ensures proper functioning of the muscles and nerves; it regulates heartbeat, helps in metabolizing carbohydrate and synthesizing protein [46]. Aluminium is a non-essential metal in food. Aluminium containing food ingredients are used mainly as colouring, leavening agent, preservatives, anti-caking agents [47]. In food, titanium is known as E171 and helps define colours clearly and can prevent degradation of materials from exposure to sunlight. Silicon is said to be necessary for the synthesis of collagen and elastin. Chloride is the naturally found mineral in food but our main dietary source is sodium chloride. It helps to maintain pH levels and stimulate stomach acid needed for digestion, helps to regulate the amount of fluid and types of nutrients going in and out of the cell. It also helps the flow of oxygen and carbondioxide within cells [46]. Sulfur contributes to the health of the skin, tendons and ligaments. It protects the cell from damage that can lead to serious disease like cancer, and helps to build and fix DNA. It is the third most abundant mineral in the body. Thus, the elemental analysis confirmed the presence of several minerals in the materials under investigation with *Colocasia esculenta* having two elements more than *Brachystegia eurycoma* [48,49].

It can be further observed that the carbon and nitrogen weight percentage is high in both materials. This is a strong indication that the nanomaterials are more organic than inorganic. The carbon-to-nitrogen ratios of the samples; *Brachystegia eurycoma* and *Colocasia esculenta* were 4:1 and 3:1 respectively. Consequently, the EDX analysis proved the presence of all the elements presented in Table 5 in the iron-synthesized nanomaterials [50].

GCMS Analysis Results

The results of GCMS analysis are as presented in Tables 6 and 7 below.

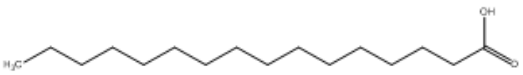
Table 6: GC-MS Results of *Brachystegia eurycoma*

RT (min)	Compound	Molecular Formula	MW $gmol^{-1}$	Peak Area %
25.57	Eicosene, (E)-	$C_{20}H_{40}$	280	2.12
29.68	n-hexadecanoic acid	$C_{16}H_{32}O_2$	256	17.58
33.14	9,17-Octadecadienal, (Z)-	$C_{18}H_{32}O$	264	16.67
34.73	Oleic acid	$C_{18}H_{34}O_2$	282	10.25
35.85	Octadecanal	$C_{18}H_{36}O$	268	48.18
38.85	17-pentatriacontene	$C_{35}H_{70}$	490	5.20

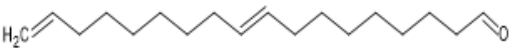
Table 7: GC-MS Results of *Colocasia esculenta*

RT (min)	Compound	Molecular Formula	MW $gmol^{-1}$	Peak Area %
10.85	Benzoic acid	$C_7H_6O_2$	122	15.89
19.09	Butylated hydroxytoluene	$C_{15}H_{24}O$	220	51.64
23.47	Heptadecane	$C_{17}H_{36}$	240	6.45
25.62	9-eicosene, (E)-	$C_{20}H_{40}$	280	5.86
36.45	1-hexacosene	$C_{26}H_{52}$	364	20.16

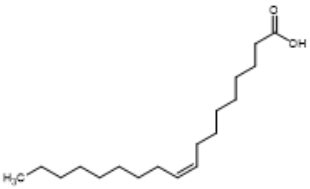
Structure 1: Eicosene, (E)-



Structure 2: n-hexadecanoic acid



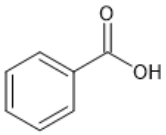
Structure 3: 9, 17-octadecadienal, (Z)-



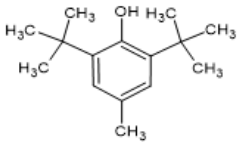
Structure 4: Oleic acid

Structure 5: Octadecanal

Structure 6: 17-pentatriacontene

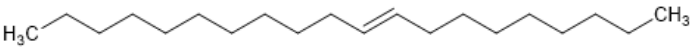


Structure7: Benzoic acid

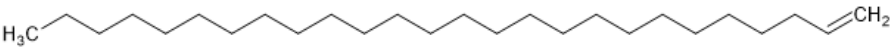


Structure 8: Butylatedhydroxytoluene
(2, 6- di-tert-butyl-4-methylphenol)

Structure9: Heptadecane



Structure 10: 9-eicosene, (E),
(E)-icos-9-ene



Structure11: 1-hexacosene

Structures

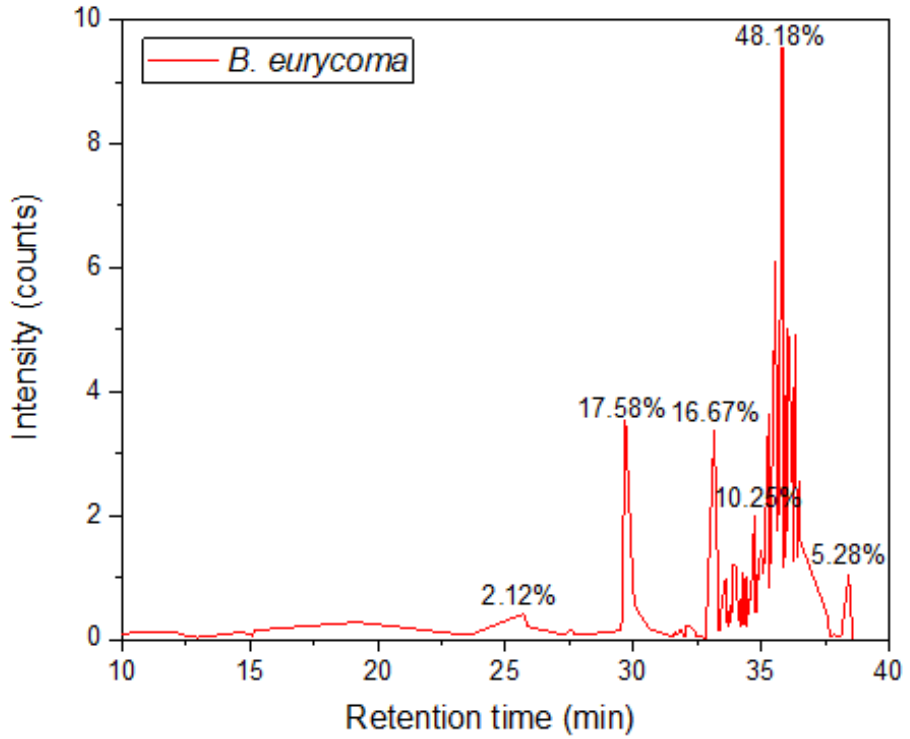


Figure 1: GC-MS Chromatogram of *B. eurycoma* extracts

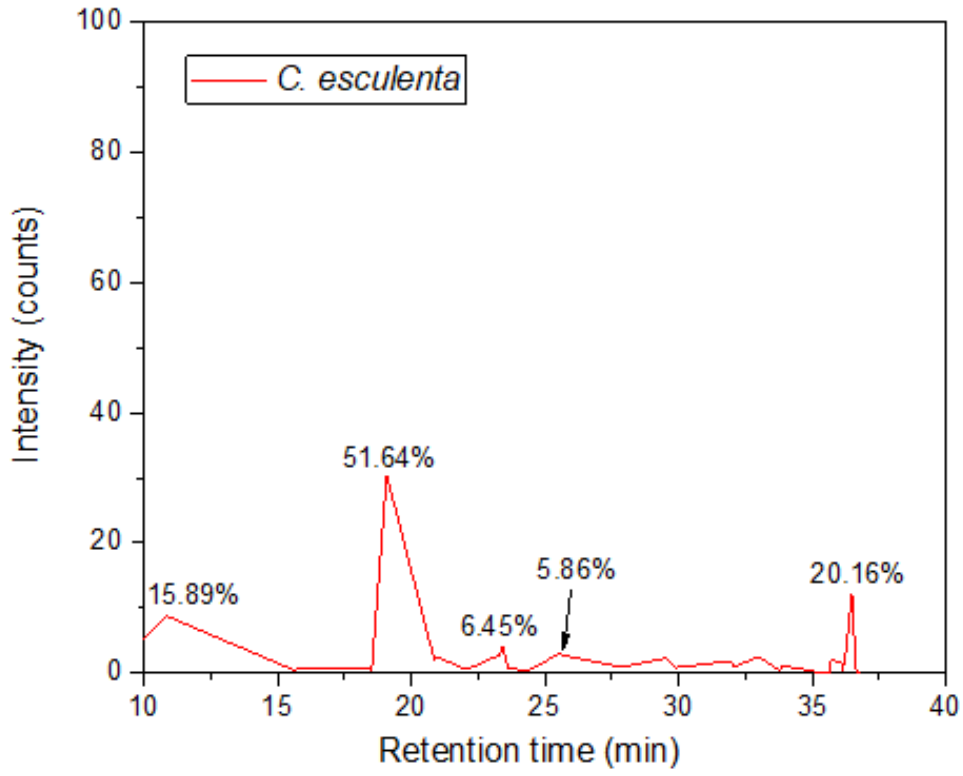


Figure 2: GC-MS Chromatogram of *C. esculenta* extract

The chemical compositions of the extracts of *Brachystegia eurycoma* and *Colocasia esculenta* was studied using a Gas Chromatography-Mass Spectrometer (GC/MS) system. Comparisons of MS fragmentation patterns were used to preliminarily identify the samples by matching them with an NIST library (51, 52). The GC-MS analysis of the samples indicated distinct profiles as shown in the tables 6, 7 and figures 1, 2. In the chromatogram of *Brachystegia eurycoma* extract (Table 6 and Figure 1), six (6) compounds were identified which include eicosene, (E)-, n-hexadecanoic acid, 9, 17-octadecadienal, (Z)-, oleic acid, octadecanal, and 17-pentatriacontene. The major constituent present in the extract was octadecanal with a peak area of 48.18 % at 35.85 min retention time. In comparison, eicosene, a hydrocarbon was observed to be the least constituent of the *Brachystegia eurycoma* extract with a 2.12 % peak area at a retention time of 25.57 min. [53].

The chromatogram of *Colocasia esculenta* extract showed five (5) peaks which were identified as five (5) compounds (Table 7 and Figure 2) with the most prominent peak (area 51.64 %) associated with butylated hydroxytoluene appearing at 19.09 min retention time. Similarly, 9-eicosene, (E)- was observed to be the least constituent of *Colocasia esculenta* extract with a 5.86% peak area at a retention time of 25.62 min. Interestingly, eicosene appeared to be a constituent of both *Brachystegia eurycoma* and *Colocasia esculenta* extracts at a similar retention time- an indication of some similarity in the chemical composition profiles of the extracts [53].

Results on Characterization of Nanoparticles of the Samples

The results of Scanning Electron Microscopy of iron-synthesized nanoparticles from the extracts of both samples with their respective histograms are shown in figure 3 and table 8.

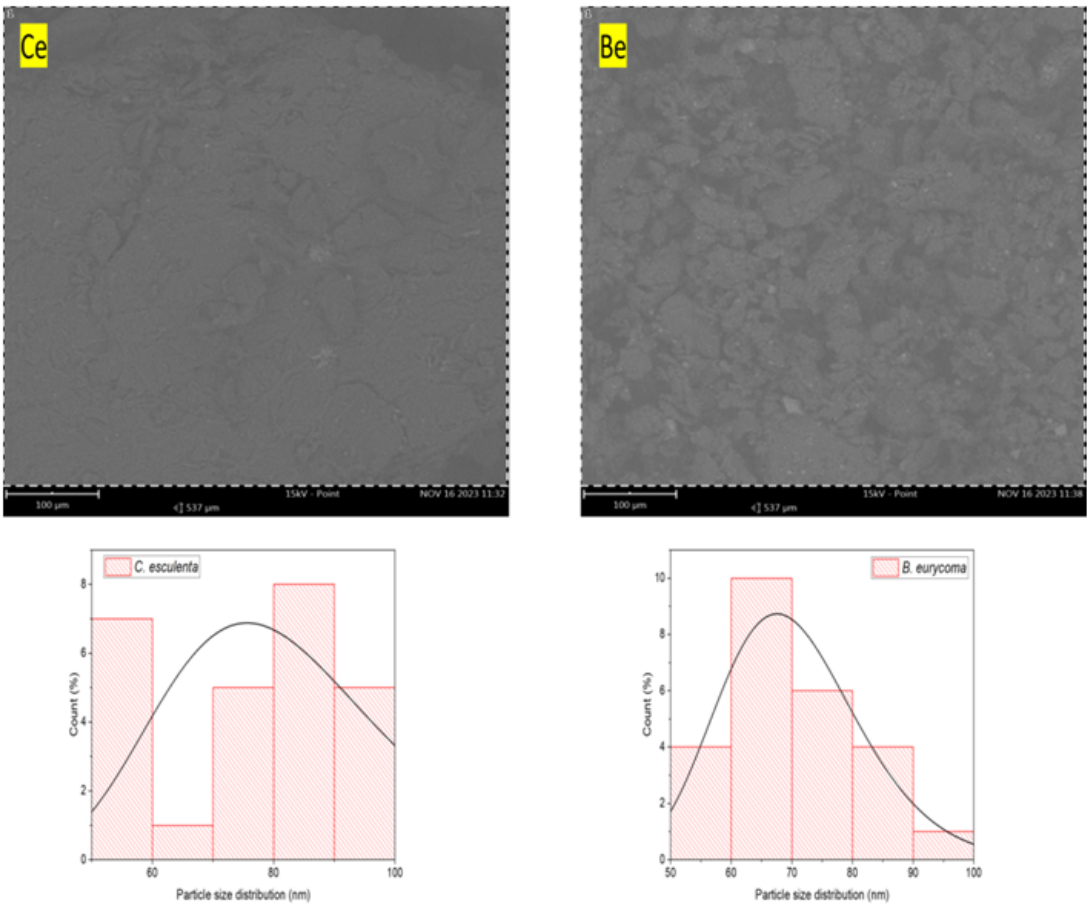


Figure 3: Scanning Electron Microscopy images of iron-synthesized nanoparticles using *Colocasia esculenta* (ede) and *Brachstegia eurycoma* (achi) extracts with their respective histograms showing particle size distribution

Table 8: Particle size and area of the phyto-synthesized nanoparticles of the samples

Sample	Average particle size (nm)	Average area (nm^2)
Colocasia esculenta	81.83	42.89
Brahystegia eurycoma	70.38	35.79

The soup thickeners were characterized by Scanning electron microscopy (SEM) with the micrographs presented in figure 3 for the different iron-synthesized nanoparticles with their respective histograms showing particle size distribution. Interestingly, the micrographs in both cases illustrated the surface morphology of the materials. When the micrographs from the two samples were compared, a difference in particle size and shape was observed. The differences in particle size and shape observed on the surface of the nanoparticles may be due to the reaction mode of the active phytochemicals present in the respective extracts [54,52]. Supporting evidence is the values of average particle sizes and average area of the respective samples. For example, the average particle sizes of *Colocasia esculenta* and *Brachystegia eurycoma* were observed to be 81.83 and 70.38nm respectively, while the average area was at $42.89nm^2$ and $35.79nm^2$ respectively. This is a strong indication that the microstructures of these nanomaterials are unique as revealed by the micrographs that the fabricated nanoparticles have a spherical structure and/or distorted spherical structures. Additionally, it is important to establish that the average particle sizes for the materials observed herein confirm their nanomaterials status. This observation agrees with those of other researchers for similar kinds of materials [55,56].

Conclusion

This investigation made evident, the promise this grossly insufficiently utilized soup thickeners hold. The different parameters analyzed have shown how rich a food source they are with great potentials to provide a wealth of nutrients as well as utilize the biochemicals inherent in them to inhibit a host of attacks. Their therapeutic properties make them a good choice in drug delivery systems. As far as we know, this research is the first to analyse the nanoparticle properties of the soup thickeners; *Brachystegia eurycoma* and *Colocasia esculenta.* From this standpoint, we will use them as binders in drugs to enhance the protein and value content of drug delivery systems and in green synthesis of nanomaterials, for antimicrobial, anticancer, and antibacterial activities against test organisms, even as a great alternative to the use of glucose as a reducing agent.

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