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Research Article

An Ethnobotanical Survey, Pharmacognostic Profile and Phytochemical Analysis Investigation of *Chrysobalanus icaco* L.

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Abstract: The spice known as *Chrysobalanus icaco* L. (Chrysobalanaceae) was found near the coast of the Niger Delta in Nigeria. A survey on the ethnobotany of *C. icaco* seeds was conducted in Warri, Abraka, Delta State, Ezetu village, and Onitsha. Standard techniques were used to determine the pharmacognostic profile, phytochemical screening, physiochemical parameters, and elemental analysis. The findings showed that the Ezetu village people utilized the seeds traditionally for stomachache, anti-diarrhea, and post-child delivery. Histochemical analysis revealed the presence of tannins and proteins in the seed. The seed powder's physicochemical parameters are as follows: pH (1 g/100 ml distilled water) (6.00±0.00) and pH (10 g/100 ml), water-soluble ash (1.5±0.00%), alcohol soluble ash (1.0±0.00%), acid insoluble acid (0.25±0.00%), acid soluble ash (1.0±0.00%), and sulfated ash (2.0±0.00%). The seed oil's physicochemical properties were: density (0.936±0.0%), refractive index (1.491±0.00%), iodine value (15.9±0.01%), peroxide value (25.31±0.01%), acid value (29.44±0.00%), and ester value (34.75±0.21%). The elements discovered in the seed included lead, copper, nickel, chromium, cadmium, potassium, sodium, calcium, phosphorus, magnesium, iron, and zinc. Phytochemicals found in the extract include reducing sugars, proteins, amino acids, fats, oils, alkaloids, tannins, phenolic compounds, flavonoids, cholesterol, steroids, terpenoids, triterpenoids, phytosterols, saponins, and cardiac glycosides. Quantitative phytochemical results include total phenolics (11.63±0.03), total flavonoids (2.35±0.06), total alkaloids (5.50±0.03), and total tannins (12.48±0.01). Consequently, it is possible to verify the authenticity of the seeds using these pharmacognostic features.

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1. Introduction

Ethnobotanical study together with phytochemical screening, pharmacognostic properties, and bioactive activities of plants is a convincing procedure for the identification of chemical constituents from medicinal plants. New medications from medicinal plants can be identified rationally by combining phytochemical screening, pharmacognostic properties, and ethnobotanical documentation (Hammad et al., 2017; Ohemu et al., 2024). The survival of folk medicine relies majorly on the variety of medicinal plants and the related ethnobotanical documentation mode of preparation and use (Joseph et al., 2019)

Pharmacognostic profiles provide plant identification and authenticity, guard against adulteration, and guarantee repeatable quality, all of which improve the effectiveness and safety of herbal medicines (Sumitra, 2014).

Chrysobalanus icaco is a plant that belongs to the Chrysobalanaceae family. It is commonly called paradise plum. In Brazil, this species is called the Abajurú (De Aguiara et al., 2017). According to Silva et al. (2017), *Chrysobalanus icaco* is popular in the Caribbean, South Florida, Central America, Northwestern South America, and tropical West Africa. According to Erhenhi et al. (2016), the Ijaws in Bayelsa State, Nigeria, refer to it as "Ebulo," while Iteskiri in Delta State calls it "Omilo." *C. icaco* in Yoruba is locally known as Amukan, Awọ́nrinwán, Ikat, and Elewu (Janick et al., 2008; Ogunka-Nnoka, 2008; Onilude et al., 2020; CABI, 2023).

Chrysobalanus icaco is used in folk medicine to treat diabetes, malaria, chronic diarrhea, bleeding, infections, inflammation, dyslipidemia, and leucorrhoea. It is also used as a diuretic agent as well as possesses antioxidant activity and antiangiogenic effects (Vargas Simon et al., 1997; De Paulo et al., 2000; Presta et al., 2007; Silva et al., 2008; Ferreira-Machado et al., 2014; De Aguiara et al., 2017; Venancio et al., 2018).

Chrysobalanus icaco plant possesses a high level of phytochemicals such as polyphenols which include steroids, triterpenoids, alkaloids, saponins, tannins, phenolic acids such as flavones, and flavonoids**;** as reported by de Oliveira Barbosa et al. (2013), Silva et al., 2017, Onilude et al. (2020).

Literature search revealed that limited ethnobotanical studies have been conducted on the *C. icaco* plant. Also, comprehensive preliminary phytochemical screening and pharmacognostic profile have not been carried out on the seed *C. icaco*. Therefore, this study aimed to conduct an ethnobotanical survey on *C. icaco* seed and carry out phytochemical screening and pharmacognostic profile on the seed of *C. icaco*.

2. Material and Methods

2.1. Ethnobotanical survey on *C. icaco* seeds

A systematic questionnaire was used to perform an ethnobotanical survey on the traditional applications of *C. icaco* seeds among the local people in Ezetu village, Warri, Onitsha, and Abraka in the Southern region of Nigeria. The questionnaire gathered primary data on the seed, including its toxicity, preparation method, route of administration, and traditional medicinal uses. Pidgin English, Ijaw, Urhobo, and Itsekiri were the common languages used to interview respondents. All pertinent data was then translated into English language and recorded.

2.2. Ethical consideration

The World Medical Association's Declaration of Helsinki (Percie et al., 2020) was followed when conducting the study. Ethical permission was requested (using reference number REC/FBMS/DELSU/22/146) to the College of Health Sciences Ethical Approval Review Committee at Delta State University in Abraka, Nigeria. Enrollment in the research was entirely voluntary.

2.3. Collection and preparation of the seeds

The dry seeds of *C. icaco* were purchased from Relief Market, Onitsha, Anambra State, Main Market, Abraka, Delta State, Ogbe-Ijaw Market, Warri, Nigeria. The seed was authenticated in the Department of Botany, Delta State University, Abraka, with a voucher number (DELSUH-209), and a voucher specimen was deposited in the herbarium. The seeds were allowed to air dry for several days. The seeds were dehulled and crushed with a mortar and pestle to a coarse consistency. Finally, the coarse powder was ground into fine powder form using an electric blender that had been dried and sterilized. Using a 2.0 mm sieve, the dried powdered seeds were sieved and then kept in an airtight sterile container.

2.4. Organoleptic/macroscopic evaluation of *C. icaco* seeds

According to the African Pharmacopoeia (1986), the World Health Organization (1998), and Wallis (2005), the seeds were macroscopically evaluated for color, shape, size, surface characteristics, odor, appearance, and taste.

2.5. Histological study of *C. icaco* seeds

The histology of the seeds with hard seed coats was done according to the guidelines provided by Ribeiro (2014) and Yusuf (2015).

2.6. Histochemical analysis *C. icaco* powder

After boiling the seed powder for ten minutes with chloral hydrate, the mixture was stained with phloroglucinol, hydrochloric acid, safranin, glycerin, Million's reagent, Sudan IV, and iodine solution, respectively. The mixture was examined under a microscope to check for starch grains, calcium oxalate crystals, lignified cells, etc. (Kokate, 2003; Mali, 2017).

2.7. Physicochemical parameters of *C. icaco* seeds

As stated by (Vilash et al., 2016; Magbool et al., 2018), physicochemical parameters such as pH, moisture content, total ash, acid-insoluble ash, water-soluble ash, alcohol soluble ash, extractive value, crude lipid content, crude protein, crude carbohydrate, heavy metals, and minerals were carried out on the powdered sample. Peroxide value, acid value, saponification value, iodine value, and refractive index were among the physicochemical characteristics that were measured for the seed oil, as stated by (Warra et al., 2011; Aremu, 2014; Zahir et al., 2014).

2.8. Extraction of seed material

Five hundred (500 g) dried seed powder was extracted with ethanol (70%) using a Soxhlet extractor. The extract filtrate was concentrated using a rotary evaporator.

2.9. Phytochemical screening of *C. icaco* seeds

Qualitative and quantitative phytochemical screening of *C. icaco* seed powder was used to identify and quantify the presence of classes of phytochemicals in the seed using the methods described by Silva et al. (2017) and Singh (2017).

2.10. DPPH (α, α-diphenyl-β-picryl-hydrazyl) radical scavenging assay

α, α-diphenyl-β-picryl-hydrazyl was done as McCune (2002) and Chandha (2009) described.

2.11. Statistical analysis

Statistical analysis of the data was carried out using one-way analysis of variance (ANOVA) to assess the significance level in the mean concentrations of parameters. All statistical analyses were done using SPSS version 16.0 (IBM Corp., USA) software for Windows. P-value of < 0.05 (95% confidence interval) was statistically significant.

3. Results

3.1. Ethnobotanical survey

The study included fifty-one (51) respondents between the ages of 20 and 65, all female (100%). Figure 1 shows locations of the respondents; seventeen (33.33%) were from Ezetu village, Ekeremor LGA of Bayelsa State; twelve (12) (23.53%) were from Ogbe-Ijaw Market, Warri South LGA of Delta State; eight (8) (15.69%) were from Relief Market, Onitsha, Anambra South LGA of Anambra State; and fourteen (14) (27.45%) were from Abraka Main Market, Abraka town, Ethiope East LGA of Delta State. In Figure 2, the occupations of the respondents were presented. Twenty-one 21 (41.8%) worked as fishermen, and 30 (58.82%) were traders who sold spices. The survey also recorded the traditional medicinal uses of the seed, as seen in Figure 3, which include stomachache: 32 (67.75%), anti-diarrhea: 9 (17.65%), and post-child delivery: 10 (19.60%). When consumed in excess, the fruit of the seeds can cause harmful side effects such as constipation and hard stool. Nonetheless, it has been noted that particular creatures, such as birds, eat the plant or the seed fruits. According to the survey shown in Figure 4, the following modes of usage were observed to include concoction ingredients (11 (21.57%), powdery (15 (29.41%), and entire seed (25(49.02%)). According to the survey, the seed was often used with other spices to prepare pepper soup, which Iteskiris, Ijawas, and Urhobos primarily consume. In April 2023, a trip to Ezetu village was undertaken to gather the *C. icaco* plant. Ezetu village is a village in Ekeremor LGA, Bayelsa State, Nigeria.

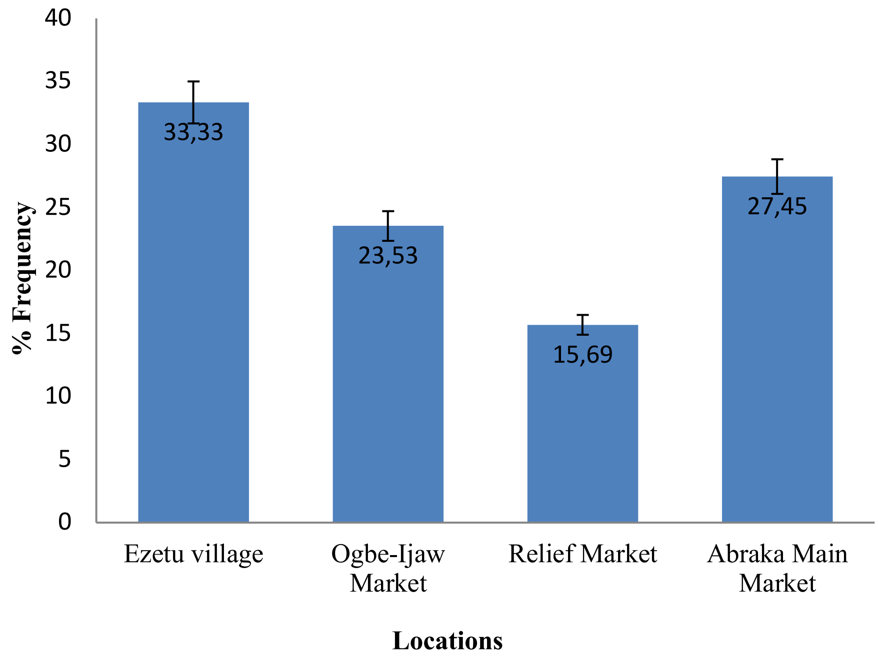

Figure 1. Showing places where the survey was carried out.

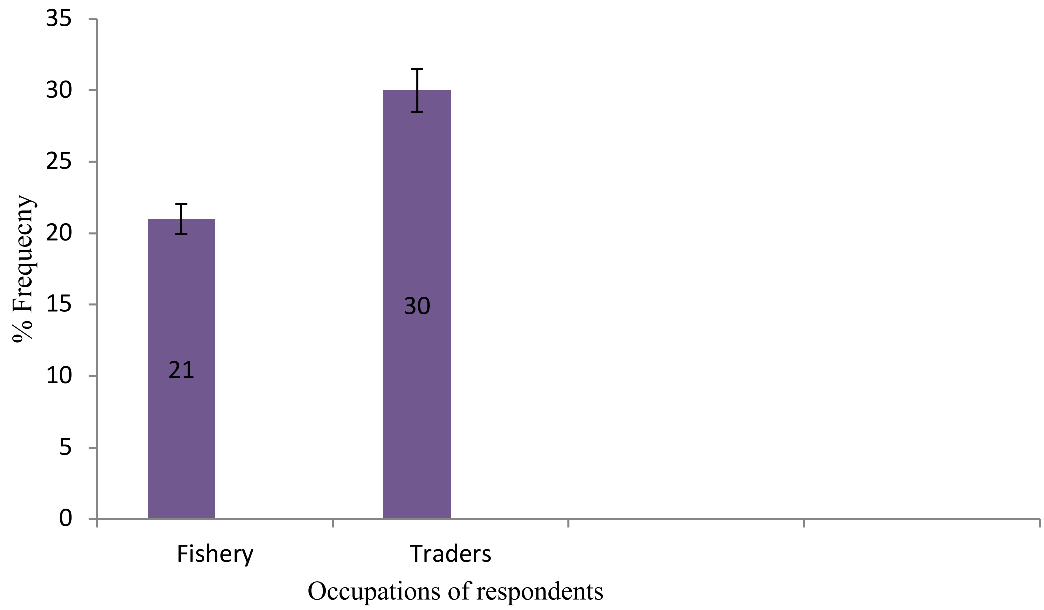

Figure 2. Showing occupations of the respondents.

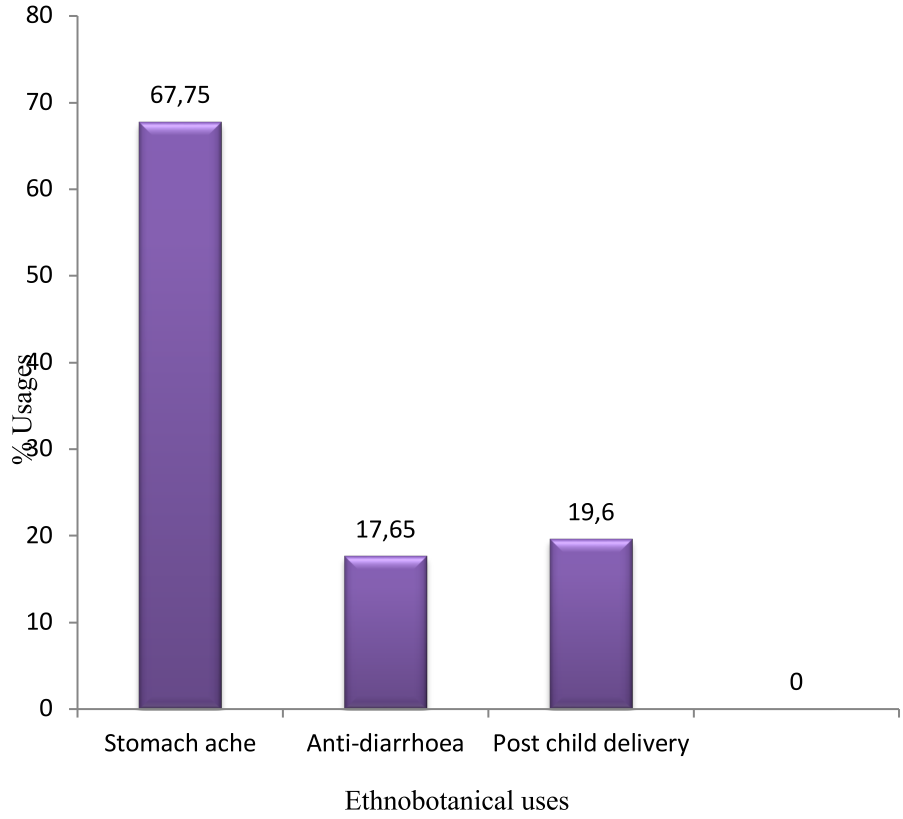

Figure 3. Showing ethnobotanical uses of *C. icaco*.

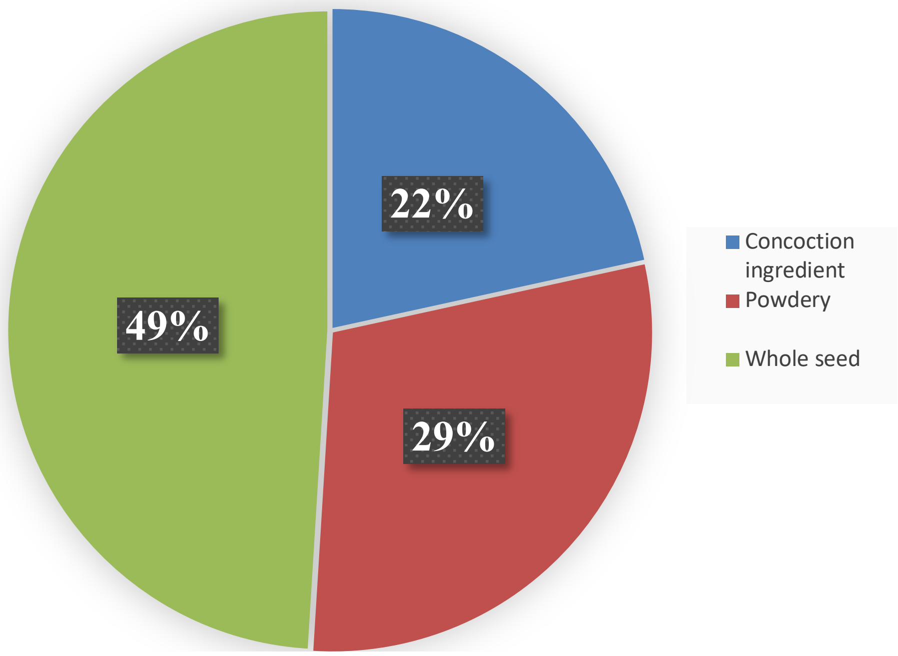

Figure 4. Showing the mode of use of *C. icaco* seeds in traditional medicine.

3.2. Macroscopic evaluation of *C. icaco* seeds

The macroscopic and organoleptic characteristics of *C. icaco* seeds and powder are shown in Table 1. The macroscopic and organoleptic characters revealed that the seed size was 7–10 mm, the shape was oblong or oval, and the fruit was pinkish when fresh, berry blue and brown when dried. The seeds appeared brown and slightly hard when the seed coat was removed. The seed coat was rough and cracked like a shell when dried. The number of seeds per fruit was one. The seed had a weakly aromatic odor and possessed a characteristic taste. The powder was greyish brown and had an aromatic odor and characteristic taste. The part of the *C. icaco* fruit is shown in Figure 4.2. The various parts of *the C. icaco* fruit include the exocarp, mesocarp, endocarp, seed coat, and seed.

Table 1. The macroscopic character of *C. icaco* seeds

Character	Observation
Seed test	
Size	7-10 mm
Shape	Oblong or oval
Color	Fruit is pinkish or blackish when fresh and black or brown when dry. The seeds appear brown when the seed coat is removed.
Odor	Weakly aromatic
Surface characteristics	The seed coat is complex, and the seed is slightly stiff when the seed coat is removed
Texture	The seed coat is rough and cracks like a shell when dry
Taste:	Characteristic
Number of seeds per fruit:	1
Powder study test	
Color	Grayish brow
Odor	Aromatic
Taste	characteristics
Filter paper test	+++

3.3. Histochemistry of *C. icaco* dry seed

After mounting the finely cut slides of the seed on the microscope, the slides were observed, and pictures of the observed features were taken and presented in Plates 1, 2, and 3 and Plate 4. Plate 1 shows the transverse section of *C. icaco* seed, showing the epidermis, endodermis, and epicarp stained with hematoxylin and eosin x 400. Ep-epidermis, en-endodermis, and ei-epicarp. Plate 2 shows a transverse section of *C. icaco* seed showing stomata seeds stained with hematoxylin and eosin x 400; plate 3 shows a transverse section of *C. icaco* seed showing schizogenous cavities; and plate four shows cork cells of a transverse section of *C. icaco* seed.

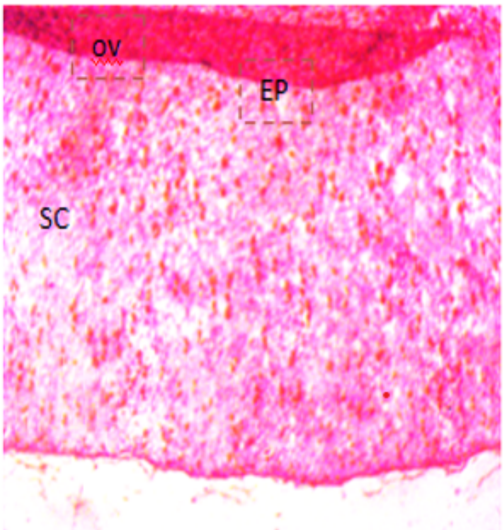

Plate 1: T. S of *c. icaco* seed showing the ovule stalk, secretory cavity, epidermis, and epicarp stained with H&E x 400. OV-Ovule stalk, SC-secretory cavity, EP-epicarp

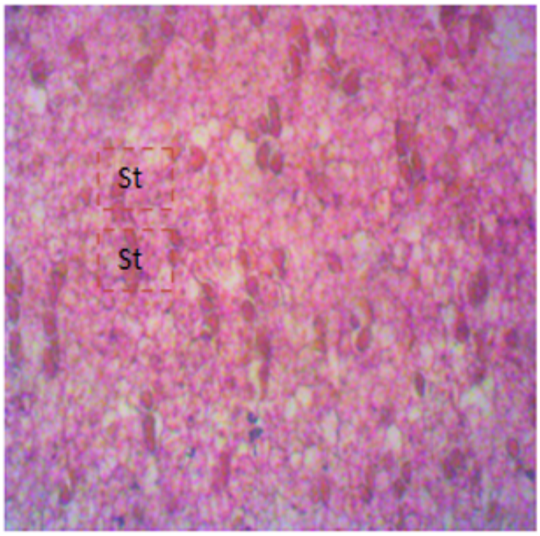

Plate 2: Transverse section of *C. icaco* seed showing stomata seeds

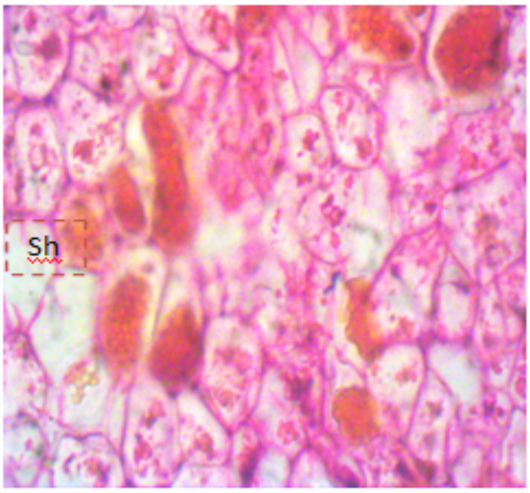

Plate 3:T.S of *C. icaco* seed showing schizogenous cavities stained with H & E x 400. Sh- Schizogenous cavities

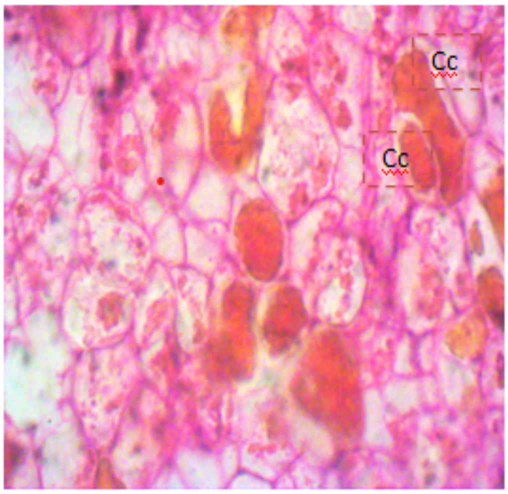

Plate 4: T.S of *C. icaco* seed showing cork cells, stained with H&E, Cc- Cork cells

Figure 5. After mounting the finely cut slides of the seed on the microscope.

3.4. Histochemical Characters of Dry Powder C. icaco Seed

The histochemical characteristics of dry powder *C. icaco* seeds are presented in Table 2. The yellow color was observed when a million reagents were added to the powder, confirming the protein's presence. A greenish color showed the presence of tannin when ferric chloride was added to the powder. No starch, blue, or black was observed when iodine and 66% H_2SO_4 were combined with iodine, which confirmed the absence of starch and cellulose, respectively. The absence of lignin was confirmed with no color change when phloroglucinol and conc. HCl was added to the seed powder.

Table 2. Histochemical characters of dry powder *C. icaco* seed

Reagent	Observation	Inference
Cell wall materials		
Sudan IV	Pinkish coloration	Oils present
66 % H_2SO_4 + iodine	No blue-black	Cellulose absent
Phloroglucinol + conc.HCl	No red color	Lignin absent
Cell constituents		
80 % H_2SO_4	No crystals	Calcium oxalate absent
Glycerol + 5 % acetic acid	No evolution of gas	$CaCO_3$ absent
Million's reagent	Yellow colour	Protein present
Picric acid	Yellow colour	Protein present
Ferric chloride	Greenish color	Tannin present
N/50 iodine	No blue-black	Starch absent
Safranin	Black present	Nuclei present
Fast green	No purple or red stain	

3.5. Fluorescence analysis of dry powder of C. icaco seeds.

Table 3 presents the results of the fluorescence analysis observed in daylight and UV light. The fluorescence results for the *C. icaco* powder treated with different chemicals for daylight (UV-365 and UV-254 nm) are summarised as follows: HCl (green), (black), and (brown); HNO3 (green), (black), (brown); Acetic acid (yellow), (black), (yellow); Aqueous (prick red), (dark brown), (dark brown); NaOH (orange), (black), (black); Ammonia (brown), (dark brown), (yellow); FeCl3 (yellow), (dark brown), (green); Iodine (green), (black indigo), (brown); N-hexane (brown), (dark brown), (violet); Ethyl acetate (orange), (indigo), (brown); Butanol (orange), (indigo), (brown); Ethanol (orange), (indigo), (brown); Methanol (orange), (indigo), (brown); and Chloroform (colorless), (brown), (brown).

Table 3. Fluorescence analysis of dry powder of *C. icaco* seeds

Extract	Ordinary	UV-345 nm	UV-254 nm
HCl	Green	Black	Brown
HNO_3	Green	Black	Brown
Acetic acid	Yellow	Black	Yellow
Water	Prick red	Dark brown	Dark brown
NaOH	Orange	Black	Black
Ammonia	Brown	Dark brown	Yellow
$FeCl_3$	Yellow	Dark brown	Green
Iodine	Green	Black indigo	Brown
N-hexane	Brown	Dark brown	Violet
Ethyl acetate	Orange	Indigo	Brown
Butanol	Orange	Indigo	Brown
Ethanol	Orange	Indigo	Brown
Methanol	Orange	Indigo	Brown
Chloroform	Colourless	Brown	Brown

3.6. Physiochemical and proximate parameters of C. icaco seeds dried powder

Physiochemical and proximate parameters of *C. icaco* seeds dried powder in percentage are shown in Table 4. The results were moisture content (3.18±0.0%), crude protein (5.29±0.01), crude fat (9.53±0.01), crude fibers (2.54±0.01), crude carbohydrates (54.26±0.01), pH (1 g/100 ml distilled water) (6.00±0.00) and pH (10 g/100 ml distilled water) (5.57±0.007), ethyl acetate (10.0±5.29 %), *n*-hexane (10.0±2.00%), dichloromethane (14.67±1.16%), butanol (8.0±2.00%), water (4.0±0.00%), methanol (5.33±1.15%), ethanol (7.3±1.16%), water-soluble ash (1.5±0.00%), alcohol soluble ash (1.0±0.00%), acid insoluble acid (0.25±0.00%), acid soluble ash (1.0±0.00%) and sulfated ash (2.0±0.00%).

Table 4. Physiochemical and proximate parameters of *C. icaco* seeds dried powder

Physiochemical parameters	**Composition (%)**
Moisture content	3.18±0.00
Crude carbohydrates	54.26±0.01
Crude fat	9.53±0.01
Crude protein	5.29±0.01
Crude fiber	2.54±0.01
pH (1 g/100 mL distilled water)	6.00±0.00
pH (10 g/100 mL distilled water)	5.57±0.007
Extractive value	
Ethyl acetate	10.0±5.29
n-hexane	10.0±2.00
Dichloromethane	14.67±1.16
Butanol	8.0±2.00
Water	4.0±0.00
Methanol	5.33±1.15
Ethanol	7.3±1.16
Total ash	
Water soluble ash	1.5±0.00
Alcohol soluble ash	1.0±0.00
Acid insoluble acid	0.25±0.00
Acid soluble ash	1.0±0.00
Sulfated ash	2.0±0.00

*Mean value of three determinations. ($P < 0.05$).

3.7. Physiochemical analysis of ethanol of *C. icaco* seeds oil

The physicochemical parameters of the ethanol extract of *C. icaco* seed oil were determined using standard guidelines. The results were preset in Table 5 below as follows: refractive index (1.491±0.00%), density (0.936±0.0%), peroxide value (25.31±0.01%), iodine value (15.9±0.01%), acid value (29.44±0.00%), and ester value (34.75±0.21%).

Table 5. Physicochemical analysis of oils obtained from *C. icaco*

Physiochemical parameter	**Composition (%)**
Refractive index	1.491±0.00
Density	0.936±0.0
Peroxide value	25.31± 0.01
Iodine value	15.9±0.01
Acid value	29.44±0.00
Ester value	335.75±0.21
Saponification value	349.1±0.28

*Mean value of three determinations. ($P < 0.05$).

3.8. Elemental content composition of C. icaco seeds dried powder

The elemental analysis of the dry powder of *C. icaco* seeds showed the presence of potassium (1.0692 ppm), sodium (2.1095 ppm), calcium (1.5240 ppm), phosphorus (0.2018 ppm), magnesium (2.996 ppm), manganese (0.3163 ppm), iron (0.3159), and heavy metals such as zinc (1.1098 ppm), lead (0.0138 ppm), copper (1.4509 ppm), nickel (1.1040 ppm), chromium (1.2023 ppm), and cadmium (0.1788 ppm), as summarised in Table 6.

Table 6. Elemental content composition of *C. icaco* seeds dried powder

Metal	**Conc. in sample (ppm)**	**FAO/WHO (1984) limit (ppm)**

Potassium	1.0692	NA
Sodium	2.1095	NA
Calcium	1.5240	NA
Phosphorus	0.2018	NA
Magnesium	2.996	NA
Manganese	0.3163	NA
Iron	0.3159	NA
Zinc	1.1098	NA
Copper	1.4509	NA
Nickel	1.1040	NA
Chromium	1.2023	NA
Lead	0.0138	10.0
Cadmium	0.1788	0.30

For edible plants, ppm: Parts per million. NA: Not applicable (Obiajunwa et al., 2002; Abdulkadir et al., 2023; Karahan, 2023).

3.9. Qualitative phytochemical screening of ethanol extracts of *C. icaco* seeds

The qualitative phytochemical analysis of the ethanol extract of *Chrysobalanus icaco* seeds showed it contains alkaloid, tannin, phenolic compounds, flavonoid, cholesterol, steroid, terpenoid, triterpenoids, phytosterol, saponin, cardiac glycoside, carbohydrate, reducing sugars, proteins, amino acids, fats, and oil, as summarised in Table 7.

Table 7. Qualitative phytochemical screening of ethanol extracts of *C. icaco* seeds

Phytochemicals	**Extract**
Alkaloids	+++
Phlobatannins	++
Tannins	++
Phenolic compounds	++
Flavonoids	++
Cholesterol	+
Terpenoids	+
Triterpenoids	+
Phytosterols	++
Saponins	+++
Cardiac glycosides	++
Carbohydrates	++
Reducing sugars	+++
Proteins and amino acids	+
Detection of fats and oils	+++
Coumarins	++

Key: += low, ++ = moderate, +++ = high.

3.10. Quantitative phytochemicals screening of ethanol extract of C. icaco seeds

The results for the quantitative phytochemicals present in *C. icaco* were total phenolics (11.63±0.03), total flavonoids (2.35±0.06), total alkaloids (5.50±0.03), and total tannins (12.48±0.01), which are presented in Table 8.

Table 8. Quantitative phytochemicals screening of ethanol extract of *C. icaco* seeds

Bioactive compounds	**Standard (mg Gallic Acid Equivalents /g dry matter)**

Total phenolics	11.63±0.03
Total tannins	12.48±0.01
Bioactive compounds	**Standard (mg Quercetin Equivalents /g dry matter)**
Total flavonoids	2.35±0.06
Bioactive compounds	**Standard (AE/g dry matter)**
Total alkaloids	5.50±0.03

*Mean value of two determinations. ($P < 0.05$).

4. Discussion

Ethnobotany survey, phytochemical screening, and pharmacognostic profile of medicinal plants have been conducted by various researchers and the uses and potential of plants have been recorded (Mahajan et al., 2017, Fonseca-Kruel et al., 2020; Rakib-Uz-Zaman et al., 2020; Elhewehy et al., 2024). In this study, the seed of *C. icaco* used in traditional medicine was studied ethnobotanically, phytochemically, and phramacognostically to assess its folkloric uses, phytochemical constituents, and pharmacognostic properties

The ethnobotanical survey was conducted among communities' people who are into fishery along the coastal area in the southern region, such as Ezetu in Bayelsa State, Ogbe-ijoh in Delta State as well as local traders who deal in spices in Onitsha, Anambra State, Abraka, and Warri in Delta State. The ethnobotanical uses of the seed in the Southern region of Nigeria have revealed that the *C. icaco* plant was used for the treatment of stomachache, diarrhea, and post-child delivery. A similar ethnobotany study reported by Fonseca-Kruel et al. (2020) showed that *C. icaco* has the potential to treat diabetes. The study revealed that the seed of *C. icaco* was used in the form of whole seeds, concoction ingredients, and powdery by the local communities. The pharmacognostic properties of this plant highlighted in this review are crucial for accurate identification of the plant

The pharmacognostic profiles of this seed highlighted in this study are very vital for the proper identification of seeds. The results of the macroscopical characteristics of the seed showed that the fruits were pinkish and berry blue when fresh and brown when dried. The seed had an oval or oblong shape and measured 7–10 mm. The seeds appeared brown once the seed coat was removed. When the harsh seed coat was dried, it cracked like a shell. There is just one seed in the fruit, which is somewhat firm on the inside and has a hard seed coat. Hematoxylin staining of the *C*. icaco seed revealed stomata, cork cells, schizogenous cavities, epidermis, and epicarp in the transverse slice. The seed powder of *Chrysobalanus icaco* showed various colors after chemical treatment when exposed to UV-345 nm, UV-254 nm, and daylight.

Assessing the pH of a crude extract was a crucial first step in determining whether the powder seed could irritate the gastrointestinal tract when taken orally. The seed powder's pH values were 6.00±0.00 at 1 g/100 ml distilled water and 5.57±0.007 at 10 g/100 ml distilled water, respectively. The powder's comparatively low acidity lends credence to Franco's (1996) recommendation that it be classified as a low-acid food.

Several solvents were used to ascertain the extractive value of the powdered form of *C. icaco* seed. The highest extractive value was 14.67±1.16 for dichloromethane, followed by 10.2±5.29% for ethyl acetate, 10.0±2.00% for n-hexane, 8.0±2.00% for butanol, 7.3±1.16% for ethanol, 5.33±1.15% for methanol, and 4.0±0.00% for water.

The physiochemical analysis revealed that the powder of *C. icaco* seeds had a relatively low ash value. This implied that the *C. icaco* seeds used in the investigation were unadulterated and free of extraneous elements. The research conducted by Rajan et al. (2011), Sree et al. (2018), and Baidoo et al. (2019) are consistent with this study. *Chrysobalanus icaco* seed powder had a moisture value of 3.18 ± 0.0%. A low moisture content is evident from this. This is far less than the eight to fourteen percent (8 to 14%) maximum water content restriction for vegetable treatments (African Pharmacopoeia, 1985; Fatokun et al., 2017). Crude drugs with lower moisture content have a longer shelf life and are safe from bacterial and fungal contaminants (Anokwah et al., 2021; Pandiyan, 2022; Obia et al., 2022).

According to the outcome of the proximate analysis, the primary nutrients included in the powdered seed of *C. icaco* were crude protein (5.29±0.01), crude fiber (2.54±0.01), crude fat (9.53±0.01), and carbs (54.26±0.01).

The atomic absorption spectroscopy analysis showed that the powdered seed of *C. icaco* had thirteen (13) elemental components. Iron (0.3159 mg kg^{-1}), calcium (1.5240 mg kg^{-1}), phosphorus (0.2018 mg kg^{-1}), magnesium (2.996 mg kg^{-1}), manganese (0.3163 mg kg^{-1}), potassium (1.0692 mg kg^{-1}), and sodium (2.1095 mg kg^{-1}) were the macrominerals found. The following trace elements were discovered: arsenic (0.1020 mg kg^{-1}), chromium (1.2023 mg kg^{-1}), zinc (1.1098 mg kg^{-1}), copper (1.4509 mg kg^{-1}), nickel (1.1040 mg kg^{-1}), lead (0.0138 mg kg^{-1}), and mercury (0.1001 mg kg^{-1}). The elements were below the hazardous metals' minimal allowable limits (African Pharmacopoeia, 1986. The ethanol oil of *C. icaco* seeds was subjected to physiochemical analyses. The results obtained were refractive index (1.491±0.00), density (0.936±0.0%), iodine value (15.9±0.01), peroxide value (25.31±0.01), acid value (29.44±0.00), ester value (335.75±0.21), and saponification value (349.1±0.28) These findings were just slightly higher than the vegetable oil range of refractive indices given in the Codex Alimentarius Standard (Zhang et al., 2015). This research is similar to the findings reported by Owaba et al. (2017) and De Aguiara et al. (2017).

The oil extracted from *C. icaco* had an astonishingly high acid value of 29.44±0.00 mg KOH g^{-1} (Adegbe et al., 2016). Owaba et al.(2022) observations of lower acid levels in the dichloromethane and hexane fractions of *C. icaco* seeds contradict these findings. As per Bahl et al. (2005) report, there might be a significant hydrolysis of the glycerides indicated by the elevated acid levels. Therefore, due to the elevated acid value, direct consumption of C. icaco *oil* is not advisable. The oil exhibited a high degree of saponification (349.1±0.28 mg KOH). Its low impurity concentration might be the reason for this. According to Ezeuko et al. (2017), vegetables with high saponification are suitable for manufacturing paints, shampoos, soaps, and detergents. The peroxide value obtained from the physiochemical analysis of *C. icaco* seed oil was 25.31± 0.01 meq kg^{-1}. This is far higher than the permissible peroxide limits (10–15 meq/kg oil) (Olaniy et al., 1991). Olaniy et al. (1991) stated that vegetable oil with high peroxide value suggests a solid vulnerability to oxidative rancidity. The iodine value discovered in *C. icaco* seed oil was 15.9±0.01 g 100 g^{-1}. Compared to the FAO/WHO norm for edible oil (80 and 106 g 100 g^{-1}) (Orhevba et al., 2017), the iodine value of *C. icaco* seed oil is relatively low. Higher iodine values correspond to higher unsaturation and, hence, higher fluidity(Orhevba et al., 2017). The ester value was relatively high at 335.75±0.21. Belsare (2017) asserts that a high ester content indicates a high low molecular weight fatty acid content in the oil. This implies that *C. icaco* seed oil contains many low molecular weight fatty acids.

Numerous phytoconstituents were identified based on the preliminary qualitative phytochemical results. These included amino acids, proteins, carbohydrates, reducing sugar, alkaloids, saponins, tannins, terpenoids, steroids, phenolic compounds, phytosterol, cholesterol, triterpenoids, flavonoids, etc. Quantitative phytochemical research found that the *C. icaco* seed ethanol extracts had significant tannin and phenol levels but low alkaloids and flavonoids.

Conclusion

The study's findings showed that Chrysobalanus icaco has a variety of secondary metabolites, inorganic compounds, acids, crude fibers, proteins, carbohydrates, and mineral components. These pharmacognostic characteristics may be used to confirm the seed's authenticity, which is essential for foiling any adulteration attempts.

Ethical Statement

Ethical approval for this study was obtained from the College of Health Sciences Ethical Approval Review Committee at Delta State University in Abraka, Nigeria (REC/FBMS/DELSU/22/146).

Conflict of Interest

The authors declare that there are no conflicts of interest.

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Author Contributions

Jacinta E. Apitikori-Owumi: Conducted experiments, analyzed data, and wrote the manuscript.
Mubo A. Sonibare: Supervised the experiment and reviewed and edited the manuscript.
Marwa A. A. Fayed: Edited the manuscript.
Sayed M. Firdous: Edited the manuscript.

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