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Phytoconstituents, Nutritional Value, UV and IR Spectra of Extracts and Dyes from *Bixa orellana* Seeds, *Sorghum bicolor* Stalks, and *Parkia biglobosa* Peels

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Abstract

The increasing consciousness about the usefulness of renewable and biodegradable source of materials, plants-based precursors for products development are preferred against synthetic sources mostly because of fear of adverse effect and source extinction. In this study, the dietetic and biological characteristics of raw materials from *Bixa orellan*a (Achiote), *Sorghum bicolor* (Sorghum) and *Parkia biglobosa* (Dorowa) were investigated. The results showed phytochemical compounds such as alkaloids, flavonoids, tannins, coumarins, sterols, triterpenoids, saponins, anthraquinones and anthocyanin with functional groups such as carbonyl, hydroxyl and nitrogenous groups confirmed by the FTIR results while UV spectroscopy showed absorption within visible light. Sorghum stalks presented the highest amount of crude fiber content (31.138% ±1.15) whereas the peels of Dorowa were the richest sample in carbohydrate content (82.209%) and the seeds of Achiote contained the highest amount of protein (14.805% ±0.12) and lipids (2.339%). Isolating necessary chemical components could lead to drug, food and paint development.

Keywords: Dietetic value, Soxhlet extraction time, traditional medicine, energy content

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1 Introduction

Plant parts that do not interfere with the plant's primary metabolism have gained researchers' interest since they have additional advantage of being an abundant renewable and cleaner source of chemical components or precursors for synthesis, with less risk and toxicity, and are biodegradable. The extracts of those plant parts, such as fruits pericarps, stalks, flowers, barks not directly involved in the plants' growth mechanism, have been used in crude extracts stated by our fore fathers in traditional medicine for disease treatment [1]. Some of the extracts were used to dye cloths [2], make paint or makeup [2]. Others are uses for food coloring or flavoring [3]. In recent research, extracts in dyes or pigments were used in a dye sensitized solar cells for electricity generation [3], [4].

Many applications exist, and extracting the components optimally and cost-effectively becomes fundamental. Soxhlet extraction method uses heat at the solvent's boiling point with a reflux part to efficiently extract chemical components while optimizing solvents use[5]. The study on *Parkia biglobosa* and *Parkia bicolor* leaves on phytoconstituents revealed the potential to improve cardiac conditions. In many reviews, many dyes extracts such as dyes from *Hybiscus sabdarifa* were used to produce dye-sensitized solar cell as the new generation of photovoltaic [6]. Dye extracts from African marigold flower (*Tagetes ereecta* L) were used for the coloration of textile [7]. Another use of plants parts was as cooling materials for ecological greenhouse coolers technology whereby fibres from *hyphaene thebaica* happened to have the capability of replacing commercial cooling pads [8], [9].

Therefore, investigation of the components present in those plants parts raw extract and dyes that draw various applications will provide a wide library to understanding the core functionality of the materials, opening opportunities for various applications. This work identifies some components of Achiote *(Bixa orellana*), Sorghum (Sorghum bicolor) and Dorowa (Parkia biglobosa) for possible use in medicine, energy and food industries.

2 Experimental section

2.1 Chemicals

All chemicals are of analytical grade and chemically pure.

2.1.1 For the extraction process

Ethanol (96%) was purchased from Central House Drug Ltd.

2.1.2 For Phytochemical screening test

Hydrochloric acid, picric acid, potassium mercury iodide, sodium hydroxide, hydrogen peroxide, ammonium hydroxide, acetic acid, benzene, bromine water, chloroform, acetic anhydride, sulphuric acid (concentrated), ferric acid (2.5%), acetic acid, ammonia were all obtained from VWR ProLabo Chemicals.

2.2 Materials

The materials used for the phytochemical screening and the extraction methods were comprised of a filter paper, a water bath, some glass and plastic containers, a thermometer/pyrometer, an electric blender, 50, 100 and 1000 mL beakers, a spatula, 500 mL measuring cylinders, a petri dish, a funnel, a wash bottle, a glass rod, some test tubes, 1 mm plastic mesh, an oven, a soxhlet apparatus set-up, a stopwatch and a UV light.

2.3 Instrumental analysis tools

For the infrared, an Ultra Attenuated Total Reflectance Fourier Transform Infrared (UATR-FTIR) spectrometer PerkinElmer Spectrum

Version 10.03.09 (USA) was used and for the ultraviolet analysis a Shimadzu UV mini-1240 spectrometer (USA) was used.

2.4 Sample preparation

The samples collected were dried in an oven at 50°C on daily basis until a constant weight was observed. Then, the dried samples were milled and sieved using a 1 mm mesh. The samples were, finally, stored in plastic containers in a dried environment away from sunlight.

2.5 Extraction of dyes and pigments by Soxhlet method

Soxhlet setup was used, and the extraction was done at an average temperature of 78°C (boiling point of the solvent). This method used 20 g of dried material with ethanol as the solvent. The extraction was done until a colourless column solvent was observed. Then, the crude extracts and the original material were taken out, stored in glass containers and left to dry in an oven at 50°C after each extraction. All the final dried crude extracts were stored in a refrigerator at 4°C before further usage.

2.6 Phytochemical screening tests

0.05g of dried dye powder was weighed with an analytical balance and used in each of the phytochemical screening test for all the dyes.

2.6.1 Alkaloids

Hager's Test: The individual dyes were dissolved in 5 mL dilute hydrochloric acid (10% HCl) and filtered. The filtrates were treated with Hager's reagent (solution of saturated picric acid, $C_6H_3N_3O_7$). The formation of a yellow-coloured precipitate confirms the presence of alkaloids.

Wagner's Test: The individual dyes were dissolved in 5mL dilute sulphuric acid (10% H_2SO_4) and filtered. The filtrates were treated with Wagner's reagent (solution of iodine in potassium iodide, I_2 + KI). The presence of alkaloids is confirmed by the appearance of a brown/reddish precipitate.

Mayer's Test: The individual dyes were dissolved in 5mL dilute sulphuric acid (1-10% H_2SO_4) and filtered. The filtrates were treated with Mayer's reagent (solution of iodine in potassium mercury iodide, I_2 + HgI_4K_2). The formation of a yellow precipitate confirms the presence of alkaloids.

Only Hager's test gave a positive result.

2.6.2 Coumarins

Each dye was dissolved in 10 mL ethanol in a test tube. The solution was covered with filter paper moistened with dilute sodium hydroxide (10% NaOH), then heated in a water bath for 1 minute at the solvent's boiling point. The test tubes were vigorously shaken to stain the filter paper, which is later examined under an ultraviolet lamp. A yellow fluorescence indicates the presence of coumarins.

2.6.3 Glycosides

Bromine water test: The individual dye samples were dissolved in bromine water (Br_2+H_2O). The formation of a yellow precipitate indicates the presence of glycosides.

2.6.4 Saponins

Froth Test: Dye extracts were diluted with distilled water to 10 ml and this was shaken vigorously in a test tube for 1-2 minutes. The formation of 1 cm layer of foam / froth indicates the presence of saponins.

2.6.5 Sterols

Liebermann – Burchard Test: The dye extracts were mixed with 3 mL chloroform ($CHCl_3$). To this 1-2 ml acetic anhydride ($C_4H_6O_3$) and two drops of concentrated sulphuric acid (H_2SO_4) was added from the side of the test tube. First red, then blue and finally green colour appears, indicating the presence of sterols.

2.6.6 Tannins

Ferric Chloride Test: To test for the presence of tannins, the extract was dissolved in 10 mL of distilled water, warmed in a water bath (i.e. at 70°C for 2 min) and filtered. 2 mL of the filtrate reacted with 0.5 mL of 2.5% ferric chloride ($FeCl_3$) solution. Tannins are present if a dark green or deep blue colour is obtained.

2.6.7 Triterpenoids

Salkowski's Test: About 10 ml of chloroform was added to the extract in a test tube and the solution was vigorously shaken. Concentrated (85 %) sulphuric acid was added to the filtrate. A golden yellow colour (reddish brown colour) at the interface showed the presence of triterpenoids

2.6.8 Flavonoids

Alkaline Reagent Test: The various dyes were treated with a few drops (2-5m L) of sodium hydroxide solution. The presence of flavonoids is noticed by of an intense yellow color that turns colourless upon the addition of a dilute acid (i.e. acetic acid).

Anthocyanin: 2 mL of 10% HCl were added to the plant extract followed by a few amount (3-5 mL) of ammonia (NH_3) with the appearance of a pink-red colour at first which later turned purple blue after the ammonia addition. This indicated the presence of anthocyanin.

Carotenoids: Plant materials were mixed with 1 mL diethyl ether ($(C_2H_5)_2O$). About four drops of concentrated sulphuric acid were added carefully to this mixture to form a layer under the ethereal solution. The presence of an intense dark-blue, blue-violet or greenish-blue colour in the acid layer shows the presence or absence of carotenoids.

Anthraquinones: A small amount of the sample was mixed with 3 mL of 0.5 M sodium hydroxide (NaOH) and 1 mL of hydrogen peroxide (H_2O_2). The mixture was heated to boiling in a water bath for 30 seconds and then cooled. Few drops (3-4 drops) of acetic acid (CH_3COOH) were added to acidify the mixture, as well as 2 mL of benzene (C_6H_6). After shaking the mixture and filtering it, a small amount (2 – 4 mL) of ammonium hydroxide (NH_4OH) was added. A red coloration indicated the presence of anthraquinones, whereas a colourless alkaline later indicated the absence.

2.7 Nutritional value study

2.7.1 Determination of Dry matter and moisture content

Beakers were put into an oven to dry up for 15 minutes at 105°C before being transferred into a desiccator for 15 minutes again to cool down. Beakers were removed and weighed immediately removed from the desiccator. Beakers filled with samples were put into an oven for 24 hours at 105°C. The whole was weighed as soon as brought out of the oven.

$$\%DM = \frac{\text{mass}_{\text{final}} - \text{mass}_{\text{emplty}}}{\text{mass}_{\text{sample}}} \times 100\%$$

(Equation 1)

$$\%\text{Moisture} = 100 - \%DM$$

(Equation 2)

2.7.2 Determination of total ash

Empty crucibles were incinerated in an oven at T = 600°C in order to remove any humidity trace for 15 minutes. Then, the oven was left to cool for another 15 minutes. Samples was placed into crucibles and weighed before bringing the whole back to the oven for calcination for 2 hours. Cooling for 30 minutes or to room temperature was allowed.

$$\%\text{Ash} = \frac{\text{mass}_{\text{final}} - \text{mass}_{\text{emplty}}}{\text{mass}_{\text{sample}}} \times 100\%$$

(Equation 3)

2.7.3 Determination of Protein and nitrogen content

Kjeldahl method was used to find protein content. This method contained three main steps: mineralization, distillation and titration.

Samples were weighed and put into tubes with a witness standard solution as an additional parallel tube. KJELDHAL standard tablets were added into each of the tubes with 10 mL concentrated H_2SO_4. All were put into the mineralizer (oven) set at 420°C for 30 minutes and left to cool to room temperature overnight. After mineralization, each sample was distilled, followed by titration.

$$\%\text{Nitrogen} = \frac{(\text{mass}_{\text{sample}} - \text{mass}_{\text{emplty}}) \times N \times [H_2SO_4]}{\text{mass}_{\text{sample}} \times 1000} \times 100\%$$

(Equation 4)

%Protein = % Nitrogen × 6.25 (constant used mostly for beverages and foods)

(Equation 5)

2.7.4 Determination of Crude fiber test

Crude fiber content was determined using Weende's method.

Pots containing samples were weighed first. On the one hand, dilute sulphuric acid (H_2SO_4) 14.03 mL was prepared, adding 2 L distilled water (H_2O). On the other hand, 25g of sodium hydroxide (NaOH) was put into 2 L. The H_2SO_4 solution was heated to boiling and then added to the sample. The whole is poured into the column of the crude fibre apparatus till columns' marked line. The temperature was set to 60°C for 30 minutes. Meanwhile, The NaOH solution was also being heated to boiling point. After the 30 mn of H_2SO_4 running, the tubes were emptied and rinsed by running distilled H_2O 2 – 3 times. Next, the boiled NaOH solution was run in, and the same procedure was repeated as in the case of H_2SO_4. 30 minutes later, the tubes were put into a desiccator and then transferred into an oven for drying for 24 h. Dried samples were weighed and put into an oven for calcination for 2 h, then, weighed again [10].

$$\%\mathrm{CF} = \frac{\mathrm{mass}_{\mathrm{after\ drying}} - \mathrm{mass}_{\mathrm{after\ calcination}}}{\mathrm{mass}_{\mathrm{sample}}} \times 100\%$$

(Equation 6)

2.7.5 Determination of lipid or Fat content

The soxhlet extraction method was used with Hexane as a solvent for this test.

Round bottom flasks are washed and oven dried for 30 minutes before letting to dry in a desiccator for 15 minutes. Soxhlet extraction of the oil was done with 5.003 g sample and 150 mL hexane for 4 hours before allowing it to cool down to room temperature. The result was, then, weighed [10].

$$\%\mathrm{Lipids} = \frac{\mathrm{mass}_{\mathrm{f}} - \mathrm{mass}_{\mathrm{emplty}}}{\mathrm{mass}_{\mathrm{sample}}} \times 100\%$$

(Equation 7)

2.7.6 Determination of carbohydrate content

The carbohydrate determination was carried out according to the differential method which considers the dry matter as being the sum of carbohydrates, lipids, proteins and ashes [10].

Dry matter = Proteins + Lipids + Carbohydrates + Ashes.
Carbohydrates = Dry matter – (Proteins + Ashes + Lipids).

(Equation 8)

2.7.7 Determination of energy content

Energy intake in kcal was also calculated by the following differential method.

Energy in Kcal = (%proteins ×4) + (%carbohydrates ×4) + (%lipids ×9)

(Equation 9)

3 Results and Discussion

3.1 Dyes extraction

The active materials in these plant extracts were extracted by soxhlet extraction method. This exhaustive extraction method of the dyes (Figure 1A) took 130380 seconds (36 hours 12 minutes 36 seconds), 30120 seconds (8 hours 22 minutes) and 67320 (18 hours 42 minutes) seconds for Sorghum, Dorowa and Achiote, respectively to observe a colourless column liquid synonym of complete extraction. This method helped extract, dry and store up to 54.1%, 79.85% and 57.1 % by weight Sorghum, Dorowa and Achiote respectively (Figure 1B). It was observed that the sorghum dye extraction required more than one batch of extraction due to the saturation of the solvent because of the high content of dye components in the plant material.

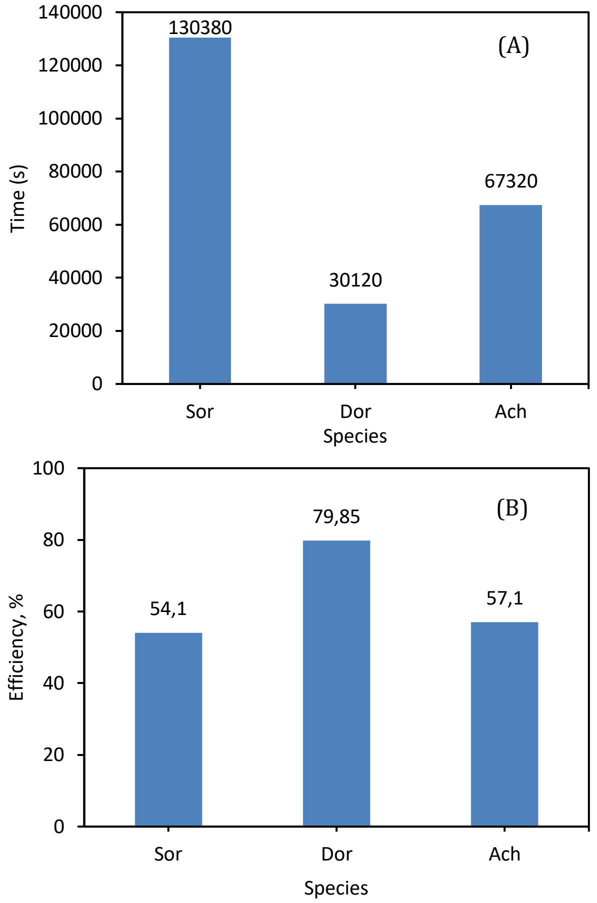
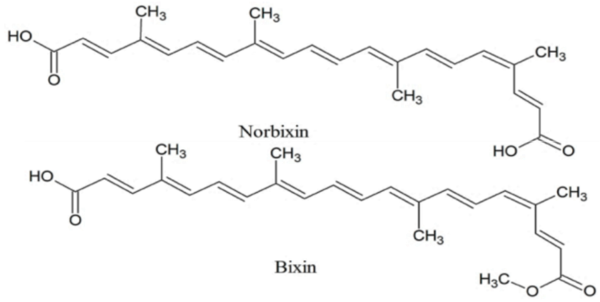


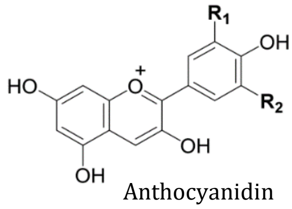
Figure 1.(A) Time laps for the exhaustive extraction of some plant dyes and (B) Dye recovery efficiency of the extraction method

3.2 Phytoconstituents and main functional groups

The phytochemical screening of the plant materials gave an idea about chemical compounds naturally occurring, also known as secondary metabolites responsible for the organoleptic and other properties of the materials, such as medicinal properties. The main functional groups were ascertained through FTIR spectroscopy graphs, and UV spectra gave the absorption range of those families of compounds. All this information opens up for a large use potential for *Sorghum bicolor*, *Parkia biglobosa* and *Bixa orellana*.



R_1	R_2	Anthocyanidin
H	H	Pelargonidin
OH	H	Cyanidin
OH	OH	Delphinidin
OH	OCH_3	Petunidin
OCH_3	H	Peonidin
OCH_3	OCH_3	Malvidin



Anthocyanidin

Figure 2. Bixin, Norbixin, and Anthocyanidin molecular structure

Table 1 shows the results obtained from the phytochemical screening test of the various plant materials in which some of the phytoconstituents appeared to be present while other were absent or not detectable in the plant samples. Among the chemical constituents tested, it was found that all three plant dyes had some traces of alkaloids, saponins, tannins and triterpenoids. In contrast, none of them presented traces of glycosides.

The crude extracts or dyes obtained were analysed under a UV spectrometer in order to get their absorption capabilities. The results, presented in Figure 5 shows an absorption from the ultra violet region (200 – 400 nm) to the visible light region (400 – 700 nm) and even near infrared region with visible peaks at 505 and 365 nm for Sorghum, 475 and 305 nm for Achiote and an absorption between 700 and 300 nm for Dorowa. This absorption is consequence of the colour the dyes display as being visible to the naked eye and intensively coloured (see dyes pictures in table 1).

Table 1. Results obtained from the phytochemical screening test of various plant materials

Chemical Constituents	Dyes Extracts				Samples
	Sorghum	Dorowa	Achiote	Sorghum	
Alkaloids	+	+	+		
Coumarins	+	-	-		
Glycosides	-	-	-		
Saponins	+	+	+	Dorowa	
Sterols	-	-	-		
Tannins	+	+	+		
Triterpenoids	+	+	+		
Flavonoids	-	-	-	Achiote	
Anthocyanins	+	-	-		
Carotenoids	+	-	+		
Anthraquinones	+	-	+		

Note: + indicates present, - indicates absent

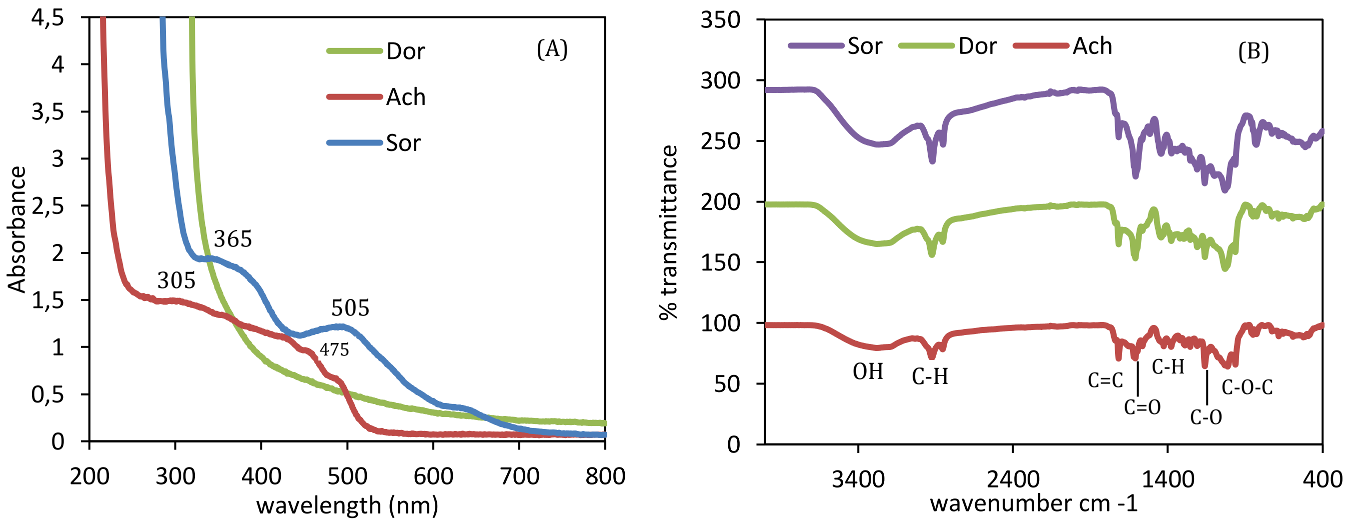


Figure 3. (A) UV and (B) FTIR spectra of *Sorghum bicolor* (Sor), *Parkia biglobosa* (Dor) *and Bixa orelana* (Ach) dye extracts

The dyes were further subjected to Fourier transform infrared spectroscopy (FTIR) to confirm the presence of the functional groups characteristic of the phytoconstituents found in them previously. Figure 6 presents the FTIR test results. The three dye extracts presented similar wave numbers with a variation in % transmittance due to the amount of molecules in them. Based on their similarities, the following assignments were made: the broad peak signal from 3600 to 2900 cm^{-1} is characteristic of the O–H stretching vibration. The two sharp peaks between 2900 and 2800 cm^{-1} show a C–H stretch due to methyl and methylene groups. These groups could be CH_3 or CH_2 asymmetry stretching from lipids at around 2945.30 and 2931.80 cm^{-1}. At around 1700 cm^{-1} the carboxylic C=O group is seen. The sharp peaks between 1700 and 1500 cm-1 are due to the alkene C=C stretch conjugated with C=O. At around 1743.65 cm^{-1}C=O of esters, fatty acid is observed. Between 1400 and 1300 $cm^{-1,}$ the C–H bending of the methyl groups is observed. Between 1350 and 1200 cm^{-1}, the C–O acyl and phenyl vibrations and between 1200 and 1000 $cm^{-1,}$ symmetric and asymmetric vibrations of the C–O–C ester group are also observed. These FTIR results complete the phytochemicals detected by the previous methods in the dye extracts.

3.3 Biological activity and potential use in traditional medicine

Sorghum bicolor was found to contain a high amount of anthocyanidins (see figure 4), such as 3-deoxy anthocyanidins apigenidin and luteolinidin, with 3-deoxyanthocyanidins amounting to over 4% of the total dry weight of *Sorghum bicolor* [11]. Besides, the extracts have a total oxygen radical scavenging capacity of 37 622 µmol/ Trolox equivalent /gram [11]. The complexity of compounds found in Sorghum goes beyond anti-inflammatory and antioxidants since ethanol and water-based extracts were found to contain immune-modulating compounds with selectively different biological effects [11].

The medical use of *Bixa orellana* might be associated with bioactive metabolites as detected through phytochemical screening (table 1). Despite the previous reports of the anti-inflammatory property of its components, such as salicylic acid, lutein, polyphenols, and tannins, many uncertainties are preventing large-scale application and medication of *Bixa orellana* extracts derivatives. Similarly, the plant's essential oils have shown antibacterial activity [12]**.** However, Bixin, a carotenoid (see figure 3), is predominant in the dyes giving them a deep orange colour [12]. Dyes from bixin derived from different parts of Achiote have been used in medicine [13] for their antioxidant activity. Most of the antioxidants are found in lipids extracts, which are in high quantity. Experiments done in vitro showed that seeds of achiote extracts have a high capacity for scavenging oxygen species depending on bixin concentration in the extract [13]. For instance, cisplatin (cis diamminedichloroplatinum II) was administered to cells and animals as a treatment against tumor, though side effects were registered [14].

Dorowa (*Parkia biglobosa*) is even highly used by our African traditional medicine in treating Leprosy and hypertension [5]. Other studies on the leaves of Dorowa revealed similar phytochemical results, with the difference that the leaves presented some traces of cardiac glycosides. In contrast, the peels we studied rather showed more triterpenoids. This difference gives the peel dye extract the brown colour contrary to the leaf extract. Besides, fruit pulp and seeds were rich in protein and amino acids with a high amount of glutamic acid [1]. Extracts of oils from the seeds of Dorowa showed a high amount of fatty acid, with arachidic acid being predominant [5].

3.4 Nutritional value and dietetic contribution analysis

Table 2. Protein, crude fiber, lipids carbohydrate content of various plants extracts

Sample	Dry Matter content (%)	Moisture content (%)	Ash content (%)	Protein content, (%)	Nitrogen content, (%)	Crude fiber content (%)	Lipids content (%)	Carbohydrate (%)	Energy kCal
Sorghum	89.022	10.978	8.982 ±0.34	4.669 ±0.02	0.747	31.138 ±1.15	0.320	75.051	321.760
Dorowa	93.513	6.487	3.293 ±0.11	6.712 ±0.03	1.074	28.443 ±0.00	1.299	82.209	367.375
Achiote	93.413	6.587	4.990 ±0.00	14.805±0.12	2.370	12.774 ±0.00	2.339	71.279	365.387

Mostly, the edible parts of plants such as leaves are analyzed. However, stalks, peels and seeds, being less edible, could also contain the same properties since being part of the same plant (table 3). *Sorghum bicolor* stalks happened to contain the highest amount of moisture (10.978%), total ash (8.982% ±0.34) and crude fiber content (31.138% ±1.15), whereas the peels of *Parkia biglobosa* was the richest among the samples in terms of carbohydrate content (82.209%) and energy content (367.375 kCal). However, the seeds of *Bixa orelana* had the highest amount of protein (14.805% ±0.12), nitrogen (2.370%) and lipids (2.339%).

In fact, in the African diet, sorghum stalk is used to colour and add nutrients to food such as beans or cowpea that are heavy to digest. This ancestral practice could be due to the high amount of crude fiber (31.138% ±1.15), carbohydrates (75.051%) and overall energy content (321.760 kCal) in sorghum extracts. Dietary fiber aids digestion and helps reduce serum cholesterol levels, the risk of coronary heart disease, and colon cancer, and the risk of high blood pressure [15]. Fibers help fight diarrhea in infants. The recommended intake for fiber is between 18 g and 35 g for an adult [16]. In this case, we will need between 0.58 g and 1.12 g of sorghum stalk powder to cover daily fibre needs for an adult.

The seeds of Achiote, usually used in a powder form to regulate digestion, were found to be rich in protein (14.805% ±0.12), lipids (2.339%), carbohydrates (71.279%) and overall energy content (365.387 kCal). Lipids are involved in the hormonal synthesis, the absorption of vitamins A, D, E, K, and cell membranes' constitution. Lipids, which are unsaturated fatty acids, are beneficial for covering the daily needs of consumers [16]. The recommended daily intake allowance for protein in children, adults and pregnant women are 28, 63 and 50 -60 g, respectively [16]. Scaling it to our case, a powder of achiote seeds of 189.12 g, 425.53 g and 337.72 – 405.264 g is needed to cover the daily protein needs of a child, an adult and a pregnant woman, respectively.

To the best of our knowledge, the peels of Dorowa are generally thrown away after consuming the inside part of the fruit even though this study shows a high content of carbohydrate (82.209%), protein (6.712 ±0.03), crude fibre (28.443 ±0.00) and overall energy content (367.375 kCal). However, to cover daily fiber needs for an adult, we will need between 0.63 g and 1.23 g of Dorowa peels powder, whereas 417.16 g, 938.62 g, and 744.93 – 893.916 g of such a powder could cover the daily protein need for a child, an adult and a pregnant woman respectively. To the best of our knowledge, such studies have not been done before.

3.5 Potential use in energy generation

Sorghum dye contains other phytochemicals such as anthocyanin and carotenoids that are natural pigments recently proven to be useful for energy generation in the concept of natural dye-sensitized solar cells due to their high electron density and the conjugation in their structure allowing easy flow of electrons [4], [17], [18]. The conjugation is assured by alternating double bonds whose presence has been shown in the IR spectrum in figure 6. The UV graphs in Figure 5 showed absorption within the visible light regions at 478 and 538 nm, proof of the capability of light harnessing [4]. In another research, dyes from Sorghum were used to obtain a DSSC of 0.18% efficiency [4], [18]. The deep red colour of the Sorghum bicolor (Sorghum) dye could be due to its high content of anthocyanin, especially cyaniding-3-O-glucoside, which is a conjugated compound with hydroxyl groups [6].

The orange colour of the *Bixa orellana* (Achiote) extract could be due to the Carotenoids being in high quantities as many research on Achiote revealed similarities and claimed that a type of Carotenoids called bixin is the main pigment responsible for the dye's colour [19]. Achiote seed dyes have been intensively used for energy generation, whereby a DSSC using achiote dye could reach an efficiency of 0.16% [4]. This potential for energy is seen in figure 5 by the ability of the dye to absorb visible light (peak at 432 nm) and its carbonyl and carboxyl group, as shown by the IR graph (figure 6). Besides, Bixin, a high component in achiote dye, is a conjugated compound with a hydroxyl group at the end. The possible mechanism for this electron transfer ability is due to alternating double bonds found in bixin structure or hydrogen displacement from carotenoid molecule functioning the chain-breaking antioxidant [12], [13].

Extracts from *Parkia biglobosa* (Dorowa) were investigated as a potential dye for energy generation in dye sensitized solar cells. The potential of this plant extract is a good candidate due to its absorption of visible light with a pick at 450 nm, though slightly observable, and the presence of conjugated chemical compounds as shown by IR spectra. In fact, an extract of Dorowa used in DSSC got an efficiency of 0.12% [4]. *Parkia biglobosa* contains a lot of tannins and alkaloids with almost no anthocyanin or carotenoids for efficiently anchoring and transferring electron. That could explain a relatively lower efficiency than Achiote and sorghum [4], [5].

4 Conclusions

In this work, the phytochemical screening, Ultra violet and Fourier Transform Infrared spectroscopy and nutritional value of *Sorghum bicolor* (sorghum), *Parkia biglobosa* (Dorowa) and *Bixa Orellana* (Achiote) were successfully investigated. Indeed, this study helped identify roughly the components of those plant materials, their dyes and extracts, the presence of antibacterial components, and sources of vitamins and immune system reinforcement components. *Sorghum bicolor*, *Parkia biglobosa* and *Bixa orellana* demonstrated their potential application in the food, medicine and energy sector industry. Besides being a sustainable source, these plants are adapted to our environment, sub-Saharan climate zone, easy and cheap to extract, non-toxic and environmentally friendly.

5 Declarations

5.1 Acknowledgments

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5.2 Author Contributions

- Alio Sanda M. Djibrilla: Paper writing and revision, data acquisition and analysis, field work, technical work, laboratory work (including manipulations, chemicals and analysis tools);
- Badu Mercy: Paper revision, Work supervision, technical support and laboratory work support (including materials, chemical and accessibility);
- Boadi O Nathaniel: Paper revision, Work supervision, technical support and laboratory work support (including materials and chemical);
- M. Djika Hachimou: Work supervision, technical support, design and development
- Awudza A.M. Johannes: Work supervision, technical support and field and laboratory availability.

5.3 Conflicts of Interest

Authors have no competing interests to declare that are relevant to the content of this article.

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