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In-vitro Antioxidant potentials of some selected Plants used in managing Sickle Cell Disease (SCD) in Ekiti Central senatorial District, Ekiti- State.

[1]Mary Kehinde Olanipekun [2]Olusola Michael Obembe
[1,2]*Department of Plant Science and Biotechnology, Faculty of Science, Ekiti State University, P.M.B 5363, Ado Ekiti, Nigeria*

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ABSTRACT

This study evaluated the antioxidant potential and phytochemical composition of six medicinal plants *Amaranthus hybridus*, *Boerhavia diffusa*, *Ocimum basilicum*, *Ocimum gratissimum*, *Pergularia daemia*, and *Solanum macrocarpon* for their possible role in managing oxidative stress associated with sickle cell disease (SCD). Fresh leaves were collected from Ekiti State University, air-dried, powdered, and extracted with water. In vitro antioxidant activities were assessed using DPPH radical scavenging, hydrogen peroxide neutralization, ferric reducing antioxidant power (FRAP), and quantification of total phenolics, flavonoids, and vitamin C. Phytochemical analysis confirmed the presence of alkaloids, tannins, saponins, terpenoids, flavonoids, and phenolic compounds in all plants. The extracts showed significant DPPH scavenging (42.9 to 57.01%), FRAP activity (50 to 83.3%), and hydrogen peroxide neutralization, notably in *Ocimum basilicum*, *Ocimum gratissimum*, and *Pergularia daemia*. Total flavonoid contents ranged from 8.6 to 96 mg CEQ/g and total phenolics from 3 to 17 mg GAE/g, reflecting strong antioxidant potential. These bioactive compounds act as free radical scavengers, reducing oxidative stress that contributes to heamolysis, vaso-occlusive crises, and membrane damage in SCD. The aqueous extraction preserved active metabolites effectively, supporting traditional medicinal practices. The results indicate that these plants may serve as natural antioxidants with potential therapeutic relevance for SCD management. Further in vivo studies are recommended to evaluate bioavailability, safety, and clinical efficacy. This research underscores the promise of local medicinal plants as complementary interventions for oxidative stress mitigation in SCD patients.

KEYWORDS: Antioxidants, Phytochemicals, Sickle cell disease, Oxidative stress, Free radical scavenging, Flavonoids, Phenolics, Medicinal plants

I. INTRODUCTION

Sickle cell disease (SCD) is a severe inherited blood disorder characterized by the production of abnormally shaped red blood cells. These sickle-shaped cells impair blood flow and lead to a range of complications. The condition predominantly affects populations in Africa, South America, and Asia, and is also found among Mediterranean and Middle Eastern groups [1, 2, 3, 4]. SCD represents a major global health burden [5-8]. It is clinically marked by recurrent painful crises, chronic anemia, increased susceptibility to infections, and progressive organ damage. Each year, approximately 300,000 infants are born with SCD worldwide, with nearly 80% of these births occurring in Africa. In the United States, an estimated 100,000 individuals primarily Afrid can Americans are living with the disease [3; 9-11]. SCD significantly contributes to childhood mortality, accounting for an estimated 50% of under-five year's old deaths in some high-burden regions, and up to 16% in countries such as Nigeria. In many affected areas, only about half of children born with SCD survive beyond their fifth birthday [12]. The highest prevalence of the disease is observed in tropical regions, particularly in Sub-Saharan Africa, India, and the Middle East [12]. In Nigeria, traditional medicine, with the use of medicinal plants, has been a cornerstone in managing SCD's painful crises [13, 6]. Scientific studies have begun to validate the anti-sickling properties of various plant extracts traditionally used in various communities [14]. However, despite the success of advanced treatments like bone marrow transplantation and gene therapy, the high costs and logistical challenges make them inaccessible in many rural areas in the developing countries [15, 3]. Consequently, many current pharmaceutical interventions for SCD are either neglected or SCD patients taking incomplete dosage. [14]. Medicinal plants are a diverse group of plants that have been used as medicine and as an antioxidant from history to prevent a wide range of ailments [9]. They are found to be available, effective and cheaper than synthetic drugs. The use of herbal medicine in managing SCD is well-documented across Africa, with several plant species demonstrating anti-sickling and therapeutic properties. In Nigeria, Yoruba traditional medicine incorporates medicinal plants such as *Entandrophragma utile, Chenopodium ambrosioides and Petiveria alliacea,* which have exhibited anti-sickling effects in vitro [16]. Similarly, in Western Cameroon, the Euphorbiaceae family is widely utilized in SCD treatment, with plant parts such as bark (39.3%) and seeds (35.7%) being administered via maceration, decoction, and direct chewing. Studies on pigeon peas (*Cajanus cajan*) have indicated anti-sickling activity, with clinical evaluations suggesting a reduction in vaso-occlusive crises and potential hepato-protective effects. Also, herbal medicines such as Zanthoxylum species, including *Zanthoxylum chalybeum* in Uganda, have been implicated in fetal hemoglobin (HbF) induction, offering potential therapeutic benefits. However, it was observed by many researchers who opined that Medicinal plants possess both healing power and high antioxidant capacity due to rich phytochemicals like polyphenols, flavonoids, and tannins, which neutralize free radicals to reduce oxidative stress [17]. They are highly relevant for preventing chronic and non-chronic diseases including cancer, cardiovascular disease, diabetes and SCD by scavenging radicals and modulating biological defense [18-24]. Free radicals are widely believed to play a significant role in human health by contributing to the development of various chronic conditions, including cancer, diabetes, aging, atherosclerosis, hypertension, heart attacks, sickle cell disease and other degenerative diseases. Consuming plants with antioxidants potentials from external sources can help neutralize free radicals and reduce their harmful effects. Earlier studies have indicated that compounds such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) can accumulate in the body, potentially leading to liver damage and even carcinogenic effects. Incidentally, it has been obviously noticed in recent years, there has been growing interest in natural antioxidants over synthetic ones, particularly those capable of protecting the human body from the damaging impact of free radicals and preventing the oxidation of fats and other components [21-23]. However, there is a dearth of studies on the investigation on the antioxidant properties of these selected plants, thus needs to investigate on their antioxidant potentials.

Amaranthus hybridus L. (popularly called Amaranth or spinach) is an erect annual herbaceous flowering plant belonging to the *Amaranthaceae* family. Widely cultivated as a vegetable for its nutritional benefits and is currently naturalized in many locations with warm climates [25, 26]. The plant is well accepted and consumed across various ethnic groups in Nigeria as a vegetable soup, together with other condiments, due to its richness in nutrients and mineral elements that supplement the daily body requirement [27]. *Amaranthus* are leafy vegetable that are rich in squalene, making them a valuable alternative to marine sources.

Boerhavia diffusa L. belongs to the family *Nyctaginaceae* and is commonly known as Punarnava, red spiderling, and spreading hogweed [28]. It is a perennial, creeping or prostrate herb that spreads extensively along the ground, often forming a diffuse mat and can grow up to 60–90 cm in length [28]. The plant possesses a stout, cylindrical taproot that is thickened and tuberous; the fleshy root is considered the main medicinally valuable part of the plant [28]. Stems are prostrate or ascending, swollen at the nodes, and may be slightly hairy or smooth [28]. Leaves are simple, opposite with entire or slightly wavy margins [28]. The inflorescence is a terminal or axillary cymose cluster of small flowers [28]. Flowers are bisexual; the perianth is petaloid and fused, with a superior ovary [28]. The fruit is a small, one-seeded anthocarp covered with sticky glandular hairs that facilitate dispersal by animals or human clothing [28]. *B. diffusa* is widely distributed in tropical and subtropical regions across Asia, Africa, and the Americas, commonly growing in wastelands, roadsides, cultivated fields, and open dry areas [28]. The plant is highly valued in traditional medicine systems such as Ayurveda and is known for its diuretic, hepatoprotective, anti-inflammatory, antioxidant, and nephroprotective properties [28].

Ocimum basilicum L. (Lamiaceae), commonly referred to as sweet basil, has been reported to exhibit diverse pharmacological activities [29]. The essential oil of *O. basilicum* contains a complex mixture of terpenoids and phenylpropanoids, such as eugenol, methyl eugenol, citral, and methyl chavicol, among other bioactive constituents [29]. Traditionally, the leaves have been used as antispasmodic, carminative, digestive, stomachic, and tonic agents [29]. The traditional uses of *O. basilicum* are partially supported by phytochemical and pharmacological investigations, which have identified a variety of bioactive compounds in its extracts and essential oils with potential therapeutic effects including antimicrobial, antioxidant, anti-inflammatory, and wound-healing activities [29, 30].

Ocimum gratissimum L. is an herbaceous plant in the Lamiaceae family, commonly known as clove basil, African basil, or scent leaf [31]. It is a perennial aromatic shrub typically growing 1–3 m tall and is strongly scented due to rich essential oil content, particularly eugenol [31]. The plant has a well-developed root system, an erect stem that is woody at the base and herbaceous above, and simple opposite petiolate leaves [31]. The inflorescence takes the form of terminal or axillary verticillasters composed of small bisexual flowers; the fruit is a schizocarp that splits into four nutlets upon maturity [31]. *O. gratissimum* is native to tropical Africa and is widely cultivated or naturalized in tropical and subtropical regions worldwide, thriving in warm climates, well-drained soils, and full sunlight [31]. It is widely used in traditional medicine for its antimicrobial, antioxidant, anti-inflammatory, and antidiabetic properties [31].

Pergularia daemia (Forssk.) Chiov. belongs to the family *Apocynaceae* (formerly *Asclepiadaceae*) and is commonly known as trellis vine or veliparuthi [32]. *P. daemia* is a perennial, twining or trailing herbaceous climber with milky latex, commonly growing over shrubs, fences, and hedges, forming dense mats in open fields and wastelands [32]. The plant has a well-developed root system; stems are slender, cylindrical, and branched, covered with fine pubescence and exuding milky latex when cut [32]). Leaves are simple, opposite, and broadly ovate to cordate with entire margins [32]. The inflorescence is axillary, typically arranged in umbellate cymes bearing several small flowers [32]. Flowers are bisexual, actinomorphic, and greenish-yellow to pale white [32]. The fruit consists of paired follicles that split open to release flat seeds with silky hairs (coma) aiding in wind dispersal [32]. *P. daemia* is widely distributed in tropical and subtropical regions of Africa and Asia and is used in traditional medicine for its anti-inflammatory, anthelmintic, antidiabetic, and analgesic properties, with various parts employed in herbal preparations [32].

Solanum macrocarpon L. belongs to the family *Solanaceae* and is commonly known as African eggplant, gboma eggplant, or garden egg [33, 34]. It is an erect annual or short-lived perennial herb typically growing 0.5–1.5 m tall [33, 34]. The plant is robust and widely cultivated as a vegetable crop in tropical regions [33]. It has a well-developed root system with lateral roots supporting nutrient and water uptake [33]. The stem is stout, branched, and cylindrical, varying in color from green to purplish [33]. Leaves are simple, alternate, large (about 10–30 cm long), ovate to oblong with wavy or lobed margins, and often consumed as leafy vegetables [33, 34]. The inflorescence is extra-axillary arranged in cymes bearing several flowers; flowers are bisexual and actinomorphic with a superior ovary [33]. The fruit is a large, globose to slightly flattened berry varying in color among cultivars [33, 34]. The fruit contains small flattened seeds within fleshy pulp [33]. *S. macrocarpon* is native to tropical Africa and widely cultivated throughout West and Central Africa, thriving in warm climates and well-drained fertile soils [33, 34]. It is cultivated for its leaves and fruits, which are important sources of vitamins, minerals, and dietary fiber, and is reported to possess medicinal properties including antioxidant and anti-inflammatory activities [33, 34].

This study aimed to evaluate the phytochemical and antioxidant potentials of the selected medicinal plants. The results are expected to contribute to a better understanding of the plants' medicinal value and their potential as natural sources of antioxidants for managing sickle cell disease.

II. MATERIALS AND METHODS

Plant collection

The fresh leaves of *Amaranthus hybridus, Boerhavia diffusa, Ocimum basilicum, Ocimum gratissimum, Pergularia daemia, and Solanum macrocarpon* plant samples were collected in June 2025 from several locations at the research farm land in the Faculty of Agricultural Science, Ekiti State University. The taxonomic identification of the plants was verified by the curator at the Herbarium unit of the Department of Plant Science and Biotechnology. The plant materials were thoroughly washed with tap water to remove every dirt after collection and identification. The samples were air-dried in the shade for fifteen days to avoid volatilization of the active ingredients. The dried materials were then ground into a fine powder using an electric blender and stored in clean, properly labeled airtight containers for further analysis.

Preparation of the Plant Extract

One hundred grams of powdered material from each plant part were extracted by maceration in 400 mL of distilled water and shaken overnight with regular agitation for effective extraction. The

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resulting mixture was first filtered through clean muslin cloth and then re-filtered twice using Whatman No. 1 filter paper. The resulting filtrate was concentrated under reduced pressure at 50 °C using a rotary evaporator. The concentrated extract was transferred into glass Petri dishes and dried in an oven at 60 °C until complete dryness was achieved. The filtrate of each of the plants sample were taken and used for in-vitro antioxidant analyses.

Antioxidant and phytochemical screening

The antiradical activity of the plants extract were examined based on the scavenging effects of the stable DPPH and hydroxyl free radical activity as well as the determination of power reducing and antioxidant capacity activities

Diphenyl-1, 2 picrylhydrazyl (DPPH) assay

The free radical scavenging activity of the six plants samples were measured by using DPPH assay. Five millilitres of 0.004% DPPH radical solution was added to the plant extract solutions ranging from 0.031 to 2 mg/mL. The mixtures were vortex-mixed and kept at room temperature under dark conditions for 30 min. The optical density (OD) was measured at 517 nm (Shimadzu UV-Mini1240, UV/Vis spectrophotometers). Methanol was used as a blank, the methanol and DPPH solution as a baseline control (A_0) and BHT as positive control. The DPPH radical concentration was calculated using the following equation: Scavenging effect (%): (A_0 - A_1) 100%/A_0, where Ao is the absorbance of the control reaction and A_1 is the absorbance in the presence of the sample of the tested extracts. The IC_{50} (concentration providing 50% inhibition) was calculated graphically using a calibration curve in the linear range by plotting the extract concentration vs the corresponding scavenging effect. DPPH radical is a free radical that accepts an electron or hydrogen radical to become a stable molecule. The reduction capability of DPPH radicals could be determined by the decrease in its absorbance at 517 nm induced by antioxidants. DPPH was reduced to a pale yellow color due to the abstraction of hydrogen atom from antioxidant compound. The higher the quantity of value of antioxidants occurred in the extract, the more the reduction of DPPH. High reduction of DPPH is related to the high scavenging activity performed by the particular sample. Also, IC_{50} was calculated as amount of antioxidant present in the sample necessary to decrease the initial DPPH concentration by 50%. Therefore, the lower the IC_{50} value, the higher the antioxidant activity [(4)].

Determination of Hydrogen peroxide (H_2O_2)

This is commonly tested using Potassium Iodide (KI), which turns yellow/brown due to iodine oxidation, or with specific test strips that change color from white to yellow/magenta (e.g., Titanium(IV) or DPD methods). A simple, rapid, qualitative test is adding a small piece of fresh liver or raw potato; if it is active, the catalase enzyme causes immediate bubbling, as it decomposes into oxygen and water

Determination of Ferric Reducing Antioxidant Power

This method is based on the reduction of (Fe^{3+}) ferricyanide in stoichiometric excess relative to the antioxidants. Different concentrations of the methanolic extract of the sample and its various fractions (10-50µg/mL) was added to 1.0 mL of 200mM of sodium phosphate buffer pH 6.6 and 1.0 mL of 1% potassium ferricyanide [$K_3Fe(CN)6$]. The mixture was incubated at 50oC for 20min, thereafter 1.0 mL of freshly prepared 10% TCA was quickly added and centrifuged at 2000 rpm for 10 min, 1.0 mL of the supernatant was mixed with 1.0 mL of distilled water and 0.25 mL of 0.1% of $FeCl_3$ solution was added. Distilled water was used for blank without the test sample while control solution contained all other reagents except the 0.1% potassium ferricyanide. Absorbances of these mixtures were measured at 700 nm using a spectrophotometer. Decreased absorbance indicates ferric reducing power capability of sample.

Determination of total phenolics content

The total phenolic content of the plants extracts were also determined by the Folin-Ciocalteu reagent according to Singleton and Rossi procedure. The plants extract (three replicates of 1.0 mg/mL) were introduced into test tubes; 500 mL of 10% Folin-Ciocalteu's reagent, 500 mL of distilled water and 800 mL of 7.5% saturated aqueous sodium carbonate (Na_2CO_3) were added. The tubes were mixed thoroughly and allowed to stand in dark condition at ambient temperature for 30 min. Absorption was measured at 765 nm using spectrophotometer (Hitachi U-1900, Tokyo, Japan). Distilled water was used as a blank and garlic acid (0-250 mg/L) was used to produce standard calibration curve. The total phenolic content was expressed as garlic acid equivalent per gram of dry weight (mg GAE/g) of extracts. Total content of phenolic compounds in the plant extract was calculated using this formula: Total phenolic content = GAE V/m. Where GAE is the garlic acid equivalence (mg/mL) or concentration of garlic acid established from the calibration curve (Y=0.0073X+ 0.1003; r^2= 0.987); V is the volume of extract (mL) and m is the weight (g) of the pure plant extract.

Determination of total flavonoids content

The total flavonoid content of the whole plants water extracts was determined by using aluminum chloride colorimetric method. Briefly, 250 mL of each extract (1 mg/mL) was mixed with 1 mL of distilled water and subsequently with 75 µL of sodium nitrite solution [5% (w/w) $NaNO_2$]. After 6 min of incubation, 75 mL of Aluminum trichloride solution (10% $AlCl_3$) was added and then allowed to stand for 6 min, followed by addition of 1 mL sodium hydroxide solution (4% NaOH) to the mixture. Immediately, water was added to bring the final volume to 2.5 mL, and then the mixture was thoroughly mixed and allowed to stand for another 15 min at room temperature. Absorbance of the pinkish color mixture was measured at 510 nm versus reagent blank containing water instead of the sample. Catechol was used as a standard compound for the quantificationn of total flavonoid.

Results were expressed as milligrams of catechol equivalent per gram of dry weight of extracts (mg CE/g). Total content of flavonoid compounds in the plant extract was calculated using thisformula:

Total flavonoid content = CE V/m. Where CE is the catechol equivalence (mg/mL) or concentration of catechin solution established from the calibration curve; V is the volume of extract (mL) and m is the weight (g) of the pure plant extract. Data was recorded as mean SD for three replications.

Estimation of Vitamin C

To the 0.5 and 1.0 mL of the filtered sample solution in separate standard volumetric flasks, few drops of bromine water were added until the solution became coloured (to confirm the completion of the oxidation of ascorbic acid to dehydro-ascorbic acid). Then few drops of 10% thiourea solution were added to it to remove the excess bromine and thus the clear solution was obtained. Then 0.5 mL of 2, 4-dinitrophenyl hydrazine (DNPH) reagent (2% in 9N H_2SO_4) was added and mixed thoroughly with the oxidized ascorbic acid and solution made up to 2 mL mark with the 10% acetic acid solution. Volumes of standard ascorbic acid (2mg/mL) solution ranging between 0.2-1.0ml were treated similarly as the samples. The absorbance was read at 520 nm in a spectrophotometer. The concentration of ascorbic acid in the sample was calculated from the standard calibration curve in linear regression mode and expressed in terms of mg/g of sample.

III. RESULTS AND DISCUSSION

Phytochemical screening

The qualitative phytochemical screening of the plants revealed the presence of alkaloids, tannins, saponins, flavonlids and phenolic compounds. Thus the plants could serve as potentials source of herbal medicine drugs. The reports of [19] support the claimed that many medicinal plants have bioactive compounds that make them very active against communicable and non-communicable diseases.

Table 1: Qualitative phytochemical composition of the selected plants

S/N	Parameters (%)	*A. hybridus*	*B. diffusa*	*O. bacilicum*	*O. gratisimum*	*P. daemia*	*S. macrocarpon*
1	Alkaloids	+	+	+	+	+	+
2	Tannins	+	+	+	+	+	+
3	Saponins	+	+	+	+	+	+
4	Terpenoids	+	+	+	+	+	+
5	Flavonoids	+	+	+	+	+	+
6	Phenols	+	+	+	+	+	+

Table 2: Anti-Oxidant Potentials of Aqueous Extraction of the selected plants used in managing SCD

S/N	Parameters (%)	*A. hybridus*	*B. diffusa*	*O. bacilicum*	*O. gratisimum*	*P. daemia*	*S. macrocarpon*
1	DPPH (%)	57.01 ± 0.03	43.00 ± 0.02	42.9 ± 0.002	42.9 ± 0.002	57.00 ±0.03	57.01 ± 0.003
2	H_2O_2	9.05 ±0.02	0.00 ± 0.02	52.30 ± 0.004	52.30 ± 0.02	33.0 ± 0.04	6.08 ± 0.002
3	NO	42.05 ± 0.03	32.5 ± 0.04	50.00 ± 0.03	70.00 ± 0.04	25.00 ±0.02	67.05 ± 0.04
4	FRAP	50.00±0.04	67.00 ± 0.03	83.30 ± 0.05	83.30 ± 0.04	67.00 ±0.04	50.00 ± 0.03
5	Flavonoids (mg	43.00 ± 0.02	8.6 ± 0.02	43.00 ± 0.02	43.00 ± 0.02	8.6 ± 0.01	96.00 ± 0.02

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	CEQ/g),						
6	Phenols (mg GAE/g)	17.00 ± 0.02	14.00 ± 0.03	17.00 ± 0.03	7.00 ± 0.02	3.00 ± 0.02	7.00 ± 0.03
7	VIT.C	1.96 ± 0.03	1.74 ± 0.01	17.00 ± 0.03	7.00 ± 0.02	1.74 ± 0.01	1.78 ± 0.03

The aqueous extract of *A. hybridus, B. diffusa, O. basilicum, O. gratissimum, P. daemia, and S. macrocarpon* leaves exhibited a maximum antioxidant potential, scavenging free radicals and neutralizing their harmful effects on the various symptoms associated with SCD as revealed in table 2. Renewed interest in medicinal plants acting as antioxidants has emerged in the recent years, probably due to the appearance of undesirable side effects of certain commercial and synthetic antioxidant drugs. In the medicinal plants world, there are huge number of different types of bioactive compounds with antioxidant activities that play a significant role in terminating generation of free radical chain reactions [35,36]. Therefore, *A. hybridus, B. diffusa, O. basilicum, O. gratissimum, P. daemia, and S. macrocarpon* evaluated in this study revelaed their potentials as antioxidant agents using different in vitro antioxidant tests. The aqueous leave extract of the plants show the in-vitro antioxidant potential against DPPH radical. The plants samples exhibited a high significant antioxidant scavenging potential of phenolic, flavonoids content by DPPH and ferric reducing power assays respectively [37, ,38]. Also, some of the plants like *O. bascilicum, O. gratissimum and P. daemia* had high hydrogen peroxide of 52.30±0.004; 52.30± 0.02 and 33.00.04 respectively. This expresses the level of antioxidant defence of proteins and enzymes. It also acting as an inflammatory initiator to fight infections against stresses like heat, cold, and various stresses in SCD patience. Plant which demonstrated antioxidant properties can be good as medicine and having potentials for external sources that can help neutralizing free radicals and reduce their harmful effects [39, 40]. Thus it is believed that the higher the antioxidant potential in a plant, the higher its effect in alleviating diseases, as this enables it reduce oxidative stress that contributes to the sickle cell crises and increase the membrane protection of the cells.

Phenolic and flavonoids are polyphenolic compounds with secondary metabolites. They are natural antioxidant known as the scavenger of free radicals believing to be major components of the anti-sickling properties are relatively distributed in plants, thus capable of alleviating diseases. They act as free radical scavengers which prevent oxidative cell damage through their water soluble property, and also possess antioxidant, antimicrobial, anti-allergic, antithrombotic, antimutagenic, and anticarcinogenic activities [41, 42, 43]. Similarly, the plants shown a significant antioxidant potentials using Ferric Reducing Antioxidant capacity (FRAP) assay which is the ability of compound to reduce ferric iron (Fe^{3+}) to ferrous iron (Fe^{2+}), thus alleviating chronic anaemia in SCD, [44] Activity may also come from the presence of other antioxidant secondary metabolites such as vitamins, volatile oils and caretenoids which in this case contribute to about 1.1% as asserted by [45] who also found a strong relationship between the antioxidant capacity and the phenolic content. Previous studies also reported that the consumption of food high in phenolic content can reduce the risk of heart disease by slowing the progression of Atherosclerosis, since they act as antioxidants. The high contents of flavonoids and other phenolic compounds found in *Amaranthus sp, Ocimum sp., and Solanum macrocarpon* could probably be as a result of the efficiency with polar solvents extraction. Thus, this likely contributed to the strong antioxidant activity exhibited by the plants. In folk medicine, extraction is carried out with water or liquor (polar solvent), which is highly efficient in the extraction of the active ingredients as observed in this study [46] The results of this study revealed the potentials of the plants as a source of natural antioxidant source and as an alternative to synthetic antioxidants [46] for drug discovery in alleviating some of the pains associated with SCD. However, bioavailability, safety, adverse reactions and investigation to determine the antioxidant activity by in-vivo methods remain unresolved, necessitating further scientific scrutiny in Ekiti State, Nigeria.

Declaration of Competing interest the author declared there is no conflict of interest

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