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Phytochemical, Phenolic, and Proximate Contents of *Cucumis sativus* Extracts

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ABSTRACT
Background and Objective: *Cucumis sativus* (cucumber) is known to contain a variety of bioactive substances and phytochemicals. Some of these chemical compounds have been linked to the plant's pharmacological effects. This study aimed to evaluate the phytochemical, phenolic, and proximate contents of *Cucumis sativus* extracts. **Materials and Methods:** Cucumis sativus fruits were collected, authenticated, shade-dried, and extracted using aqueous and ethanol solvents. Proximate and phytochemical compositions were determined using standard methods. Total phenolic, flavonoid, flavonol, and proanthocyanidin contents were quantified spectrophotometrically. The study spanned six months at the University of Benin, Nigeria. **Results:** The results of phytochemical analyses revealed the presence of alkaloids, tannins, saponins, and other polyphenolics. Phenols and saponins were present in the highest concentration (11.79±0.73 and 8.50±0.37%, respectively), while glycosides and tannins (2.13±0.01 and 2.60±0.15%, respectively) were present in the least amounts. Proximate analysis indicated low moisture content (7.69±0.34%), crude fat (7.91±0.24%), ash (3.89±0.22%), fibre (3.00±0.24%), high protein (24.25±0.80%), and nitrogen-free substances (NFS) (53.59±1.04%). While the ethanol extract had significantly higher total phenol, total flavonoid, flavonol, and proanthocyanidin contents were significantly higher in the aqueous extract than in the ethanol extract ($p<0.05$). **Conclusion:** The results obtained in this study indicate that *C. sativus* is a reservoir of potentially useful chemical compounds that may serve as drugs and provide newer leads and clues for modern drug design.

KEYWORDS
Cucumis sativus, nitrogen-free substances, phytochemicals, phenolic compounds, proximate composition

INTRODUCTION
The use of plants in the maintenance of good health is well documented[1]. It has also been reported that the bases of many modern pharmaceuticals used today for the treatment of various ailments are plants and plant-based products. About 80% of the world population depends on plant-based medicine for their health care. Medicinal plants are plants that contain substances that could be used for therapeutic purposes or which are precursors for the synthesis of useful drugs[2]. A plant becomes a medicinal plant only when its biological activity has been ethno-botanically reported or scientifically established. Medicinal plants, since time immemorial, have been used virtually in all cultures as a source of medicine. Their use

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is increasing worldwide, because of the tremendous expansion of medicine and a growing interest in herbal treatments[3]. Plants are used in medicine to maintain and augment health physically, mentally, and spiritually, as well as to treat specific conditions and ailments. Medicinal plants are divine gifts to us from Mother Nature, who has kept those remedies in the plant kingdom for mankind to use to fight diseases and cure themselves from ailments[4].

Over 500 plants are known to be useful for medicinal purposes in Africa, but only a few have been described or studied[3]. Natural products from plants constitute another potent source for the discovery of excellent activities such as blood booster, antioxidant, anti-ulcer, anticancer, antimicrobial, among others. The World Health Organization (WHO) continues to emphasize the importance of scientific research into herbal medicine. Many developing countries of the world look upon native medicinal plants as a possible addition to WHO's list of "essential drugs" once their value has been clinically proven[6]. One of the emerging plants of interest is *Cucumis sativus*. It is a vegetable crop, belonging to the family *Cucurbitaceae*[5].

Cucumbers, although commonly treated as vegetables in culinary contexts, are botanically classified as berries. They come in various sizes, shapes, and colours. The plant's leaves, flowers, seeds, fruits, and bark are all traditionally utilized for their medicinal properties. These parts contain bioactive compounds that contribute to their pharmacological effects[6]. *Cucumis sativus* has been used in traditional medicine to address a variety of health conditions[7]. This study aimed to evaluate the phytochemical, phenolic, and proximate contents of *Cucumis sativus* extracts.

MATERIALS AND METHODS

Study area and duration: This study was carried out at the Department of Biochemistry, Faculty of Life Sciences, University of Benin, Benin City, Nigeria, and it lasted six months from the time of materials gathering/literature review to the end of assays (July to December, 2024).

Chemicals: Ethanol, methanol, sodium acetate, sodium carbonate and hydrochloric acid (HCl) were bought from Bell, Sons & Co. (England). Folin-Ciocalteu reagent, aluminium trichloride and ascorbic acid were obtained from British Drug House (BDH) Chemicals Ltd. (England), while gallic acid and quercetin were products of Thermo Fisher Scientific Ltd. (USA). All the chemicals and solvents used in this study were of analytical grade.

Collection of plant material: The fruits of *Cucumis sativus* were obtained from a major market in Benin City, Nigeria and authenticated at the herbarium of the Department of Plant Biology and Biotechnology, University of Benin, Benin City, Nigeria, by Dr. Henry Akinnibosun.

Preparation of plant extract: The fruits were washed and shade-dried at room temperature for a period of two weeks and then pulverized using a blender. Aqueous and ethanol extracts of the plant were obtained using cold maceration method[8].

Proximate composition: The powdered plant material was used for the determination of the moisture, crude protein, crude fat, crude fibre, carbohydrate, and ash contents using standard methods[9].

Qualitative and quantitative phytochemical analyses: The powdered plant material was screened for its phytochemical contents according to standard methods[10].

Estimation of total phenolic content (TPC): Total phenolic content was determined according to the Folin and Ciocalteu method[11]. Varied concentrations of gallic acid (0.2-1 mg/mL) were prepared in methanol. Then 0.5 mL of the sample (1 mg/mL) was mixed with 2.5 mL of a ten-fold diluted

Folin-Ciocalteu reagent and 2 mL of 7.5% sodium carbonate. The mixture was allowed to stand for 30 min at room temperature, then the absorbance was read at 760 nm. All determinations were performed in triplicate with gallic acid used as a control.

Determination of total flavonoid content (TFC): Total flavonoid content was determined[12]. Briefly, 2 mL of 2% $AlCl_3$ in ethanol was added to 2 mL of the extracts. A concentration of 1 mg/mL of the extract prepared in methanol was used. A similar concentration of quercetin, the standard control, was used. The absorbance was measured at 420 nm after 1 hr of incubation at room temperature.

Determination of total flavanol content: Flavanol content was determined[12]. The quercetin calibration curve was prepared by mixing 2 mL of a varied concentration of standard quercetin solution (0.2-1.0 mg/mL) with 2 mL of 2% aluminium chloride and 6 mL of 5% sodium acetate. The absorbance was read at 440 nm after 2.5 hrs of incubation at 20°C.

Determination of proanthocyanidin content: The determination of proanthocyanidin was carried out[13]. To 0.5 mL of 1.0 mg/mL of each extract was added 1 mL of 4% methanol solution and 0.75 mL of concentrated hydrochloric acid. The mixture was left undisturbed for 15 min, and the absorbance was read at 500 nm. Ascorbic acid was used as a standard.

RESULTS

Outcome of phytochemical evaluation of *Cucumis sativus*: As presented in Table 1 and 2, the results of phytochemical analyses revealed the presence of alkaloids, tannins, saponins, and other polyphenolics. Phenols and saponins were present in the highest concentration, while glycosides were present in the least amounts.

Results of proximate analysis of *Cucumis sativus*: Results of proximate analysis showed that the medicinal plant contained more Nitrogen-Free Substances (NFS) and protein, but a low level of fibre ($p<0.05$).

Table 1: Phytochemicals detected in *Cucumis sativus*

Phytochemical	Inference
Alkaloids	++
Tannins	+
Phenols	+++
Flavonoids	++
Saponins	+++
Steroids	+
Anthraquinones	++
Protein	+++
Glycosides	+
Carbohydrates	+
Fixed oil	+

+: Detected, ++: Moderately present, and +++: Highly present

Table 2: Phytochemical composition of ground *Cucumis sativus*

Phytochemical	Composition (%)
Alkaloids	6.13±0.02
Tannins	2.60±0.15
Phenols	11.79±0.73
Flavonoids	3.75±0.28
Saponins	8.50±0.37
Glycosides	2.13±0.01
Anthraquinone	2.87±0.12

Data are the percentage composition of phytochemicals and are expressed as Mean±SEM (n = 3)

Table 3: Proximate composition of pulverized *Cucumis sativus*

Parameter	Composition (%)
Moisture (fresh sample)	96.33±0.27
Moisture (dried sample)	7.69±0.34
Ash	3.89±0.22
Fibre	3.00±0.24
Fat	7.91±0.24
Crude protein	24.25±0.80
Nitrogen-free substances	53.59±1.04

Data are percentage proximate composition and are expressed as Mean±SEM (n = 3), on "Dry Weight (DW)" basis

Table 4: Phenolic content of *C. sativus*

Extract	Total phenol (mg GAE/g of extract)	Total flavonoid (mg QE/g of extract)	Total flavanol (mg QE/g of extract)	Proanthocyanidin (mg AAE/g of extract)
Aqueous	554.30±141.45	713.30±79.65	720.00±43.59	366.70±15.28
Ethanol	854.00±76.00	381.00±120.00	104.70±44.20	206.70±6.67

Data are a phenolic composition of aqueous and ethanol extracts of *C. sativus*, and are expressed as Mean±SEM (n = 3)

Phenolic content of *C. sativus*: The ethanol extract had significantly higher total phenol, but total flavonoid, flavanol and proanthocyanidin contents were significantly higher in the aqueous extract than in the ethanol extract ($p<0.05$) (Table 3 and 4).

DISCUSSION

The use of plants for the treatment of diseases remains the oldest and most popular form of healthcare practice[1]. Herbal medicine involves the use of plant parts without isolating specific phytochemicals. The current efforts of modern medicine include a detailed analysis of phytochemical constituents of plant materials. Factors such as species, geographical location, method of extraction, and type of solvent used for extraction determine the levels of phytochemicals in a particular plant[14]. Secondary plant metabolites can be isolated, characterized, and refined to produce drugs[15].

Plants synthesize phytochemicals as part of their regular metabolic processes, primarily to protect themselves from predators. These bioactive, non-nutrient compounds are commonly found in fruits, vegetables, grains, and other plant-based foods[16].

Their ingestion has been linked to reductions in the risk of major chronic diseases. The different compounds are classified according to common structural features as carotenoids, phenolics, alkaloids, and nitrogen-containing and organosulfur compounds. Phenolics, flavonoids, and phytoestrogens are of particular interest because of their potential effects as antioxidants, anti-estrogenic, anti-inflammatory, immunomodulatory, cardioprotective, and anticarcinogenic compounds[16].

Studies suggest that phytochemicals may reduce the risk of coronary heart disease by preventing the oxidation of Low-Density Lipoprotein (LDL) cholesterol, reducing the synthesis or absorption of cholesterol, normalizing blood pressure and clotting, and improving arterial elasticity[24]. The physiological properties of relatively few phytochemicals are well understood. Phytochemicals have been promoted for the prevention and treatment of diabetes mellitus, high blood pressure, and muscular degeneration[17-19].

In the present study, qualitative and quantitative phytochemical screening as well as proximate analysis were performed on *C. sativus*. The results showed that *C. sativus* is rich in important phytochemicals. Phytochemical screening showed that the medicinal plant contains alkaloids, tannins, saponins, and other polyphenols. Studies have shown that environmental factors and time of collection affect the type and quantity of secondary metabolites in a particular part of a plant. Saponins are known to reduce blood cholesterol by preventing its reabsorption and may also be a potent inhibitor of hydroxyl methylglutaryl CoA (HMG-CoA) reductase: an enzyme that catalyzes the conversion of HMG-CoA to mevalonate, an early and rate-limiting step in cholesterol biosynthesis[20]. Medicinal agents containing tannins have been shown to possess antidiabetic properties. Saponins, flavonoids, quercetin, and ferulic acid synergistically reduce blood glucose level via correction of defective insulin secretion and peripheral insulin resistance[21]. The presence of alkaloids in *C. sativus* could make it effective against cardiovascular diseases[22]. Alkaloids are known to possess pharmacological activities such as antihypertensive, antiarrhythmic, and anticancer effects. Some alkaloids are used as drugs, and the best known is quinine, used as an antimalarial[23]. Steroids and cardiac glycosides are presently used for the treatment of cardiac failure. These agents increase the force of contraction in a failing heart by increasing the interaction of actin and myosin filaments of the cardiac sarcomere, thereby increasing calcium concentration in the vicinity of the contractile protein during systole[24-26].

Fruits, vegetables, and seeds are essential dietary sources of antioxidants. Oxidative stress, which results from an imbalance between free radicals and antioxidants in the body, can damage critical biomolecules such as nucleic acids, proteins, polyunsaturated fatty acids, and carbohydrates[27]. The bioactive compounds found in plants significantly contribute to their therapeutic properties[28]. Nutritional antioxidants play a vital role in complementing the body's natural antioxidant systems, helping to neutralize free radicals[29-31]. Among these antioxidants, phenolic compounds and flavonoids are key phytochemicals recognized for their strong antioxidant potential.

Phenolic compounds exhibit diverse biological activities, including anti-inflammatory, antiulcer, antitumor, antioxidant, and antidepressant effects. Their antioxidant activity is largely attributed to their hydroxyl (-OH) groups attached to aromatic rings, which enable them to donate electrons to free radicals, thereby reducing oxidative stress in cells[32]. Numerous studies have demonstrated a direct correlation between the total phenolic content of plant extracts and their ability to scavenge free radicals, with higher phenolic concentrations being associated with greater antioxidant capacities[33-36].

Flavonoids are another group of bioactive compounds with notable antioxidant, anti-inflammatory, and anticancer properties[37]. Proanthocyanidins, a subclass of polyphenols, are oligomeric flavonoids composed primarily of catechin and epicatechin units. These compounds play a role in plant defense mechanisms and possess a wide range of beneficial effects, including vasodilatory, antiallergic, antibacterial, antiviral, cardioprotective, and immunomodulatory activities[38-41].

In this study, it was observed that ethanol extracts contained higher total phenolic content, whereas aqueous extracts had higher concentrations of flavonoids, flavonols, and proanthocyanidins. Both types of extracts demonstrated significant antioxidant properties, consistent with previous findings in the literature[42-46].

CONCLUSION

The findings of this study reveal that *C. sativus* contains significant amounts of phytochemicals, especially phenols and saponins, along with high protein and nitrogen-free substances. The ethanol and aqueous extracts exhibited notable levels of phenolic compounds and flavonoids. These bioactive constituents suggest the plant's potential as a natural source of therapeutic agents. *Cucumis sativus* may serve as a valuable lead in modern drug development and as a natural additive in food and pharmaceutical formulations.

SIGNIFICANCE STATEMENT

This study identified several bioactive and nutritional constituents in *Cucumis sativus*, including phenolic compounds, which could be beneficial for natural drug development and functional food formulation. This study will help researchers uncover critical areas of phytochemical and pharmacological potential in *C. sativus* that have been largely unexplored. Consequently, a new theory on the therapeutic and nutraceutical applications of commonly consumed edible plants may be developed.

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