Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

Comprehensive Evaluation of Phytochemical Composition, Nutritional Value, and Potential Health Benefits of Sprouted Cucumber Seeds

Beautlin Mistica Paul[1], Dr. M. Velvizhi[2*]

[1]PG and Research Department of Nutrition and Dietetics, Muslim Arts College, Affiliated to ManonmaniamSundaranar University, Tirunelveli, Tamil Nadu India, beautlinmd@gmail.com
[2]PG and Research Department of Nutrition and Dietetics, Muslim Arts College, Affiliated to ManonmaniamSundaranar University, Tirunelveli, Tamil Nadu India, velvizhi21nutri@gmail.com

Cucumber (Cucumis sativus) seeds, often discarded as waste, are a rich source of bioactive compounds with potential health benefits. This study evaluated the phytochemical composition of sprouted cucumber seeds through qualitative and quantitative analyses using aqueous, chloroform, ethyl acetate, hexane, and petroleum ether extracts. All experiments were conducted in triplicates, and results were statistically analyzed. The aqueous extract revealed flavonoids, phenolics, polyphenols, anthocyanins, lignins, tocopherols, and phytoestrogens, while the chloroform extract showed alkaloids, terpenoids, and phytosteroids. Ethyl acetate extract contained flavonoids, alkaloids, isoflavones, and terpenoids, whereas hexane and petroleum ether extracts predominantly showed terpenoids, tocopherols, and phytosteroids. Quantitative analysis indicated significant levels of key compounds, such as 51.3 mg/g flavonoids in the aqueous extract and 89.7 mg/g alkaloids in the chloroform extract. These findings highlight the nutritional and functional potential of sprouted cucumber seeds, supporting their application in health, food, and nutraceutical industries.
Keywords: Sprouted Cucumber Seeds, Phytochemical Analysis, Phenolic Compounds.

1. Introduction

Cucumber, belonging to the Cucurbitaceae family, is the third most commonly produced fruit vegetable crop in the world. According to Statista.com data, in 2019 and 2020, world

cucumber production was over 87 and 91 million metric tons, respectively. (Statistica World Vegetable Production by Type 2020) Cucumber seeds contain a large number of essential fatty acids, plant sterols, glycosides, volatile oils, and Calcium, Magnesium, and other inorganic elements. Cucumber seed oil has good UV absorption effect because it is rich in an unsaturated functional group structure. Plant sterol present in the cucumber seed oil shows strong permeability towards the skin. This plant sterol promotes skin metabolism and inhibits skin inflammation. β-sitosterol in plant sterols can also effectively protect the peroxide of low-density lipoprotein, so they have an antioxidant effect. (Wang et al., 2022)

Sprouted seeds are gaining attention for their enhanced nutritional profile and health benefits, attributed to biochemical changes during germination. Cucumber (Cucumis sativus), a widely cultivated vegetable crop, has seeds rich in bioactive compounds, including phenolics, flavonoids, and essential fatty acids. Sprouting these seeds is known to increase the bioavailability of phytochemicals, which are associated with antioxidant, antimicrobial, and anti-inflammatory properties (Bajaj et al., 2020). Additionally, sprouted seeds are considered a functional food due to their potential role in preventing chronic diseases (El-Adawy, 2002). This study aims to evaluate the phytochemical composition of sprouted cucumber seeds, emphasizing their nutritional value and possible applications in health and food sciences. The findings can contribute to sustainable food practices and the development of health-promoting products.

In this study, evaluated the phytochemical composition and quantified the phytochemicals present in the aqueous extract, chloroform extract, ethyl acetate extract, hexane extract, and petroleum ether extract of sprouted cucumber seeds (Cucumis sativus). Both qualitative and quantitative analyses of phytochemicals were conducted.

2. Methods and Materials

2.1.1 Plant Materials

Cucumber seeds were selected for the analysis of Phytochemicals qualitatively and quantitatively. Fresh cucumbers were purchased from nearby stall in Nagercoil, Kanniyakumari District, India.

2.2.1 Sample Preparation

The seeds were handpicked and cleaned in running tap water and the seed were kept in shadow drying for two days. Then seeds were soaked overnight and on the next day it was removed from the soaked water and washed in normal tap water. Finally, the soaked seeds were wrapped in damp white cotton cloth for 2 days. Once in every 12 hours the seeds were checked for sprouting. After the required amount of sprout was obtained, it was taken for the analysis.

2.2.2 Extraction of Sample

The extract of the seeds was prepared using various extracts such as aqueous, chloroform, ethyl acetate, hexane and petroleum ether as solvents. Take approximately 100 to 150 gm of the sample in to 1000ml round bottom flask. Add 500ml of the required solvant in to the flask. Keep it on heating mantle, and reflux it at 70°c to 80°c for 2-3 hrs using reflux condensor. After the extraction over, keep it for cooling at room temperature. Filter the extract using

funnel with filter paper. Wash the residue with the solvant for complete recovery. Combine the extract and keep it in the hot plate to evaporate the solvant and dry it in hot air oven at 60°c to 70°c till completely evoporate the solvant. After evaporate the solvant, keep the residue for the required testing.

2.2.3 Tests for Flavonoids

Alkaline Reagent Test. 2 ml of 2.0% NaOH mixture was mixed with sample; concentrated yellow color was produced, which became colorless when we added 2 drops of diluted acid to mixture. This result showed the presence of flavonoids.

2.2.4 Presence of flavanols/flavones/Flavanones & Iso-flavanones

The reaction mixture consists of 1 mg of sample and 4 ml of distilled water was taken in a 10 ml volumetric flask. To the flask, 0.30 ml of 5 % sodium nitrite was treated and after 5 minutes, 0.3 ml of 10 % aluminium chloride was mixed. After 5 minutes, 2 ml of 1M Sodium hydroxide was treated and diluted to 10 ml with distilled water.

A set of reference standard solutions of Kaempherol/ Apigenin/ hesperitin/ daidzens were prepared separately in the same manner as described earlier. The absorbance for test and standard solutions were determined against the reagent blank at 510 nm with an UV/Visible spectrophotometer. The above compounds were compared separately for each standard.

2.2.5 Test for Terpenoids

2.0 ml of chloroform was added with the sample and evaporated on the water path and then boiled with 3 ml of H_2SO_4 concentrated. A grey color formed which showed the entity of terpenoids.

2.2.6 Test for Alkaloids

The sample is dissolved in dilute Hydrochloric acid and filtered.

Mayer's Test: Filtrates were treated with Mayer's reagent (Potassium Mercuric Iodide). Formation of a yellow coloured precipitate indicates the presence of alkaloids.

2.2.7 Test for Phenolic Compounds

2 ml of distilled water followed by few drops of 10% ferric chloride was added to sample. Formation of blue or green color indicates presence of Phenolic compounds.

2.2.8 Anthocyanin/Anthocyanidins

Preparation of Extract

1. The extract of the given sample was obtained from 5 g of the ground material with 50 mL of solvent.

2. Two solvents were used: 70% ethanol solution with 1.5 mol·L $^{-1}$ HCl (85:15, v/v) and 70% ethanol.

3. The suspension was allowed to stand in the absence of light and under refrigeration (7 ± 1 °C) for 24 hours.

4. After 24 hours, the samples were filtered on Whatman N°. 1 paper under vacuum in a Buchner funnel and the volume was completed to 50 mL.

Anthocyanins in the above extracts were done using a UV-Vis spectrophotometer according to the method proposed by Lees & Francis, 1972. The extracts were subjected to a reading in a spectrophotometer at 535 nm. The absorbance value showed the presence of anthocyanin/anthocyanidins.

2.2.9 Test for Polyphenols

Test for phenols A small amount of the extract was taken with 1 mL of water in a test tube and 1 to 2 drops of Iron III chloride (FeCl3) was added. A blue, green, red or purple color is a positive test.

2.2.10 Test for Tocopherols

Add 1 ml of phenanthroline solution to the samples, stopper the flasks and mix the solutions well. Carry out the next two stages of the determination by covering the flasks with aluminium foil and working in subdued light. Add 1 ml of iron (II1) chloride solution and mix thoroughly. Exactly 2 minutes later, add 1 ml of phosphoric acid solution and mix again. The flasks can now be brought into the light. phenanthroline gives a somewhat deeper colour if Tocopherols present.

2.2.11 Test for Phytosteroids

Sample was mixed with 20 ml of ethanol; the component was extracted for 2 hours. To the ethanolic extract of each sample extract was added 2 ml acetic anhydride followed with 2 ml of concentrated sulphuric acid. A violet to blue or green colour change in sample(s) indicates the presence of steroids.

2.2.12 Test for Lignans

In extract, 2 ml of distilled water followed by few drops of 10% ferric chloride was added. Formation of blue or green color indicates presence of Lignans.

2.2.13 Phytoestrogens

A colorimetric procedure, based on the formation of an azo dye by condensation of diazotized 5-chloro-2,4-dinitroaniline with ethinyl estradiol, was developed. An alkaline solution of ethinyl estradiol is reacted with the reagent, and the resulting color is measured at 450 nm. If the Phytoestrogens are detected based on the OD value compare to standard.

2.2.14 Determination of Flavonoid Content

Flavonoid content was measured by the aluminium chloride colorimetric assay. The reaction mixture consists of 1 mg of sample and 4 ml of distilled water was taken in a 10 ml volumetric flask. To the flask, 0.30 ml of 5 % sodium nitrite was treated and after 5 minutes, 0.3 ml of 10 % aluminium chloride was mixed. After 5 minutes, 2 ml of 1M Sodium hydroxide was treated and diluted to 10 ml with distilled water. A set of reference standard solutions of quercetin (20, 40, 60, 80 and 100 μg/ml) were prepared separately in the same manner as described earlier. The absorbance for test and standard solutions were determined against the reagent blank at 510 nm with an UV/Visible spectrophotometer. The flavonoid content was calculated

from the calibration graph of the standard.

2.2.15 Determination of flavanols

The reaction mixture consists of 1 mg of sample and 4 ml of distilled water was taken in a 10 ml volumetric flask. To the flask, 0.30 ml of 5 % sodium nitrite was treated and after 5 minutes, 0.3 ml of 10 % aluminium chloride was mixed. After 5 minutes, 2 ml of 1M Sodium hydroxide was treated and diluted to 10 ml with distilled water.

A set of reference standard solutions of Kaempherol were prepared separately in the same manner as described earlier. The absorbance for test and standard solutions were determined against the reagent blank at 510 nm with an UV/Visible spectrophotometer. The above compounds were compared separately for each standard.

2.2.16 Determination of flavones

The reaction mixture consists of 1 mg of sample and 4 ml of distilled water was taken in a 10 ml volumetric flask. To the flask, 0.30 ml of 5 % sodium nitrite was treated and after 5 minutes, 0.3 ml of 10 % aluminium chloride was mixed. After 5 minutes, 2 ml of 1M Sodium hydroxide was treated and diluted to 10 ml with distilled water.

A set of reference standard solutions of Apigenin were prepared separately in the same manner as described earlier. The absorbance for test and standard solutions were determined against the reagent blank at 510 nm with an UV/Visible spectrophotometer. The above compounds were compared separately for each standard.

2.2.17 Determination of Flavanones

The reaction mixture consists of 1 mg of sample and 4 ml of distilled water was taken in a 10 ml volumetric flask. To the flask, 0.30 ml of 5 % sodium nitrite was treated and after 5 minutes, 0.3 ml of 10 % aluminium chloride was mixed. After 5 minutes, 2 ml of 1M Sodium hydroxide was treated and diluted to 10 ml with distilled water.

A set of reference standard solutions of hesperitin were prepared separately in the same manner as described earlier. The absorbance for test and standard solutions were determined against the reagent blank at 510 nm with an UV/Visible spectrophotometer. The above compounds were compared separately for each standard.

2.2.18 Determination of Iso-flavanones

The reaction mixture consists of 1 mg of sample and 4 ml of distilled water was taken in a 10 ml volumetric flask. To the flask, 0.30 ml of 5 % sodium nitrite was treated and after 5 minutes, 0.3 ml of 10 % aluminium chloride was mixed. After 5 minutes, 2 ml of 1M Sodium hydroxide was treated and diluted to 10 ml with distilled water.

A set of reference standard solutions of daidzens were prepared separately in the same manner as described earlier. The absorbance for test and standard solutions were determined against the reagent blank at 510 nm with an UV/Visible spectrophotometer. The above compounds were compared separately for each standard.

2.2.19 Determination of Terpenoid

Preparation of the reference solution: Linalool reference substance (10mg) was accurately

weight, added in a 10ml volumetric flask, diluted with ethyl acetate to the marked line to afford a concentration of 1.0mg/ml standard solution.

Preparation of the test solution: The sample was precisely measured and placed in a 10ml volumetric flask, diluted with ethyl acetate to the marked line.

Chromogenic method: The color developing agent applied on this experiment was prepared by the procedure as follows, 5% vanillin-acetic acid solution plus 2mL of perchloric acid were heated at 65℃ for 20min, then cooled in ice water and warmed up to room temperature after being shaken. Vanillin (500mg) was dissolved in acetic acid (10ml) to prepare the vanillin solution.

The standard curve 0.0,0.2,0.4,0.8,1.2,1.6,2.0 ml Linalool standard solution were precisely measured, placed in a 10 ml flask with ethyl acetate to volume marked line, The sample solution and standard mixture was then shaken, coloured according to the chromogenic method. The absorbance (A) of each solution was measured at 210nm wavelength, a blank solution as the control reference. The total terpenoids content was expressed as mg of Linalool/g.

2.2.20 Determination of Alkaloid

The sample was dissolved in dimethyl sulphoxide (DMSO), added 1ml of 2 N HCl and filtered. This solution was transferred to a separating funnel, 5 ml of bromocresol green solution and 5 ml of phosphate buffer were added. The mixture was shaken with 1, 2, 3 and 4 ml chloroform by vigorous shaking and collected in a 10-ml volumetric flask and diluted to the volume with chloroform. A set of reference standard solutions of atropine (20, 40, 60, 80 and 100 μg/ml) were prepared in the same manner as described earlier. The absorbance for test and standard solutions were determined against the reagent blank at 470 nm with an UV/Visible spectrophotometer. The total alkaloid content was expressed as mg of AE/g.

2.2.21 Determination of Total Phenolic Compounds

The concentration of phenolics in the sample was determined using spectrophotometric method. Folin-Ciocalteu assay method was used for the determination of the total phenol content. The reaction mixture consists of 0.5-1g of sample and 9 ml of distilled water was taken in a volumetric flask (25 ml). One millilitre of Folin-Ciocalteu phenol reagent was treated to the mixture and shaken well. After 5 minutes, 10 ml of 7 % Sodium carbonate (Na2CO3) solution was treated to the mixture. The volume was made up to 25 ml. A set of standard solutions of gallic acid (20, 40, 40, 60, 80 and 100 μg/ml) were prepared in the same manner as described earlier. Incubated for 90 min at room temperature and the absorbance for test and standard solutions were determined against the reagent blank at 550 nm with an Ultraviolet (UV) /Visible spectrophotometer. Total phenol content was expressed as mg of GAE/g.

2.2.22 Determination of Anthocyanin and Anthocyanidins

The extract of the given sample was obtained from 5 g of the ground material with 50 mL of solvent. Two solvents were used: 70% ethanol solution with 1.5 mol·L $^{-1}$ HCl (85:15, v/v) and 70% ethanol. The suspension was allowed to stand in the absence of light and under refrigeration (7 ± 1 °C) for 24 hours. After 24 hours, the samples were filtered on Whatman

Nº. 1 paper under vacuum in a Buchner funnel and the volume was completed to 50 mL. Anthocyanins in the above extracts were done using a UV-Vis spectrophotometer according to the method proposed by Lees & Francis, 1972. The extracts were subjected to a reading in a spectrophotometer at 535 nm. The anthocyanin and anthocyanidins content was calculated from the calibration the graph.

2.2.23 Determination of Polyphenol Content

The concentration of phenolics in plant extracts was determined using spectrophotometric method. Folin-Ciocalteu assay method was used for the determination of the total phenol content. The reaction mixture consists of 1 ml of extract and 9 ml of distilled water was taken in a volumetric flask (25 ml). One millilitre of Folin-Ciocalteu phenol reagent was treated to the mixture and shaken well. After 5 minutes, 10 ml of 7 % Sodium carbonate (Na_2CO_3) solution was treated to the mixture. The volume was made up to 25 ml. A set of standard solutions of gallic acid (20, 40, 40, 60, 80 and 100 µg/ml) were prepared in the same manner as described earlier. Incubated for 90 min at room temperature and the absorbance for test and standard solutions were determined against the reagent blank at 550 nm with an Ultraviolet (UV) /Visible spectrophotometer. Total phenol content was expressed as mg of GAE/g.

2.2.24 Determination of Tocopherols by UV-VIS spectrophotometer

Measure 0.5 g of the analysed sample into the test-tube I (centrifugal) with a tight stopper, add 0.5 ml of anhydrous ethanol and shake vigorously the plugged test tube for 1 minute. Add 3 ml xylene, plug the test tube and shake vigorously for another 1 minute. Centrifuge the tube to separate the extract (1500×g, 10 minutes); simultaneously measure 0.25 ml solution of batophenanthroline into a usual test-tube II

Collect 1.5 ml of the extract (upper layer), transfer to the test-tube II and mix the content. Add 0.25 ml of $FeCl_3$ solution to the test tube II, mix, add 0.25 ml of H_3PO_4 solution and mix again. This way a test sample is obtained for spectrophotometric measurements. Prepare the standard sample (0.5 ml of the standard solution instead of the analyzed sample): using Trolox.

Prepare as the test sample, using α-tocopherol

Add 0.5 ml of DI water instead of anhydrous ethanol at the beginning of the analysis; do not centrifuge this sample. Measure absorbance of the test sample and of the standard sample at 539 nm against the blank test (preparation – as the test sample but using water instead of the analysed liquid). Calculate concentration of tocopherols in the analysed sample, using the calibration curve of the standard.

2.2.25 Estimation of Lignans

Standard compounds, sesamol and sesamin (0.01 g) were dissolved separately in 100 ml of hexane + chloroform mixture (7:3, v/v) and 10 ml of the solution was further diluted to 100 ml to give a 0.001 % solution, the uv-spectra were recorded. The absorbance of standard sesamol and sesamin at 288 nm was also read in a 1cm cell. Specific extinction (E1% 1cm) values of 231.1 for sesamin and 230.1 for sesamol were determined using this approach. The sample (0.01 g), in triplicate, were dissolved in 10 ml of hexane + chloroform mixture (7:3, v/v) and the absorbance at 288 nm was determined.

The lignans content was calculated by using the formula:

% Lignans (as sesamol) = [(A/W) x (100/230.1)](1)

% Lignans (as sesamin) = [(A/W) x (100/231.1)](2)

Where,

A Absorbance of the Sample,

W Weight of the Sample in gram / 100 ml,

230.1 $E^{1\%}_{1cm}$ for Sesamol

231.1 $E^{1\%}_{1cm}$ for Sesamin

2.2.26 Estimation of Phytosteroids

1mg of sample extract and different concentration of Prednisone standard steroid solution was transferred into 10 ml volumetric flasks.

2ml of 4N Sulphuric acid was added and 2ml of 0.5% of iron (III) chloride was added followed by 0.5ml of 0.5% potassium hexacyanoferrate (III) solution.

The mixture was heated in a water-bath maintained at 70±20 C for 30 minutes with occasional shaking and diluted to the mark with distilled water. The absorbance was measured at 780 nm against the reagent blank. Total PhytoSteroid content was expressed as mg of Prednisone/gm of extract.

2.2.27 Estimation of Phytoestrogens

A colorimetric procedure, based on the formation of an azo dye by condensation of diazotized 5-chloro-2,4-dinitroaniline with ethinyl estradiol, was developed. An alkaline solution of ethinyl estradiol is reacted with the reagent, and the resulting color is measured at 450 nm. Phytoestrogens was calculated from the standard graph.

2.3 Statistical Analysis

The data obtained were analyzed using Microsoft Excel and the results were expressed as mean ± standard deviation.

3. Result and Discussion

3.1 Phytochemical Analysis

3.1.1 Qualitative Analysis

The aqueous extract of the sprouted cucumber seeds showed the presence of flavonoids, flavanols, anthocyanidins, anthocyanins, phenolic compounds, polyphenols, lignins, tocopherols and phytoestrogens whereas flavones, flavanones, isoflavones, alkaloids, terpinoids and phytosteroids were absent. The chloroform extract of the sprouted cucumber seeds showed the presence of alkaloids, terpinoids, lignins, tocopherols, phytoestrogens and phytosteroids whereas flavonoids, flavanols, flavones, flavanones, isoflavones, anthocyanidins, anthocyanins, phenolic compounds and polyphenols were absent. The ethyl

acetate extract of the sprouted cucumber seeds showed the presence of flavonoids, flavanols, flavones, flavanones, isoflavones, alkaloids, terpinoids, lignins, tocopherols phytoestrogens and phytosteroids whereas anthocyanidins, anthocyanins, phenolic compounds and polyphenols were absent. The hexane extract of the sprouted cucumber seeds showed the presence of terpinoids, lignins, tocopherols, phytoestrogens and phytosteroids whereas flavonoids, flavanols, flavones, flavanones, isoflavones, anthocyanidins, anthocyanins, alkaloids, phenolic compounds and polyphenols were absent. The petroleum ether extract of the sprouted cucumber seeds showed the presence of terpinoids, lignins, tocopherols, phytoestrogens and phytosteroids whereas flavonoids, flavanols, flavones, flavanones, isoflavones, anthocyanidins, anthocyanins, alkaloids, phenolic compounds and polyphenols were absent. Table 1 shows the qualitative analysis of cucumber seeds.

3.1.2 Quantitative Analysis

The aqueous sample of the sprouted cucumber seeds has showed 51.3 mg/g of flavonoids, 13.2 mg/g of flavanols, 0.06 mg/g of anthocyanidins, 0.16 mg/g of anthocyanins, 190 mg/g of phenolic compounds, 167 mg/g of polyphenols, 5.8 mg/g of lignins, 1.6 mg/g of tocopherols and 1.1 mg/g of phytoestrogens respectively. The chloroform extract of the sprouted cucumber seeds has showed 89.7 mg/g of alkaloids, 57.5 mg/g of terpinoids, 11.1 mg/g of lignins, 25.2 mg/g of tocopherols, 10.3 mg/g of phytoestrogens and 6.6 mg/g of phytosteroids respectively. The ethyl acetate extract of the sprouted cucumber seeds has showed 73.7 mg/g of flavonoids, 16.4 mg/g of flavanols, 5.8 mg/g of flavones, 4.4 mg/g of flavanones, 2.8 mg/g of isoflavones, 126.3 mg/g of alkaloids, 23.6 mg/g of terpinoids, 6.6 mg/g of lignins, 8.2 mg/g of tocopherols, 6.1 mg/g of phytoestrogens and 3.7 mg/g of phytosteroids respectively. The hexane extract of the sprouted cucumber seeds has showed 51.1 mg/g of terpinoids, 9.8 mg/g of lignins, 30.2 mg/g of tocopherols, 8.6 mg/g of phytoestrogens and 9.1 mg/g of phytosteroids respectively. The petroleum ether extract of the sprouted cucumber seeds has showed 50.2 mg/g of terpinoids, 10.4 mg/g of lignins, 22.7 mg/g of tocopherols, 8.2 mg/g of phytoestrogens and 6.1 mg/g of phytosteroids respectively. Table 2 shows the quantitative analysis of sprouted cucumber seeds. Results of the quantitative analysis of sprouted cucumber seeds is represented in figure 1.

Table 1: Qualitative Phytochemical Analysis of Sprouted Cucumber Seeds

Si. No.	Parameters	Result				
		Aqueous	Chloroform	Ethyl Acetate	Hexane	Petroleum Ether
1	Flavonoids	+	-	+	-	-
2	Flavanols	+	-	+	-	-
3	Flavones	-	-	+	-	-
4	Flavanones	-	-	+	-	-
5	Isoflavones	-	-	+	-	-
6	Anthocyanidins	+	-	-	-	-
7	Anthocyanins	+	-	-	-	-
8	Alkaloids	-	+	+	-	-
9	Terpenoids	-	+	+	+	+

10	Phenolic Compounds	+	-	-	-	-
11	Polyphenols	+	-	-	-	-
12	Lignins	+	+	+	+	+
13	Tocopherols	+	+	+	+	+
14	Phytoestrogens	+	+	+	+	+
15	Phytosteroids	-	+	+	+	+

(+) shows the presence (-) shows the absence

Table 2: Quantitative Phytochemical Analysis of Sprouted Cucumber Seeds

Si. No.	Parameters	Mean ± SD				
		Aqueous (mg/g)	Chloroform (mg/g)	Ethyl Acetate (mg/g)	Hexane (mg/g)	Petroleum Ether (mg/g)
1	Flavonoids	51.3 ± 0.1	-	73.7 ± 0.1	-	-
2	Flavanols	13.2 ± 0.1	-	16.4 ± 0.1	-	-
3	Flavones	-	-	5.8 ± 0.1	-	-
4	Flavanones	-	-	4.4 ± 0.1	-	-
5	Isoflavones	-	-	2.8 ± 0.1	-	-
6	Anthocyanidins	0.06 ± 0.01	-	-	-	-
7	Anthocyanins	0.16 ± 0.01	-	-	-	-
8	Alkaloids	-	89.7 ± 0.1	126.3 ± 1.5	-	-
9	Terpenoids	-	57.5 ± 0.1	23.6 ± 0.1	51.1 ± 0.1	50.2 ± 0.1
10	Phenolic Compounds	190 ± 0.5	-	-	-	-
11	Polyphenols	167 ± 1	-	-	-	-
12	Lignins	5.8 ± 0.1	11.1 ± 0.1	6.6 ± 0.1	9.8 ± 0.05	10.4 ± 0.1
13	Tocopherols	1.6 ± 0.1	25.2 ± 0.1	8.2 ± 0.1	30.2 ± 0.1	22.7 ± 0.1
14	Phytoestrogens	1.1 ± 0.1	10.3 ± 0.1	6.1 ± 0.1	8.6 ± 0.1	8.2 ± 0.1
15	Phytosteroids	-	6.6 ± 0.1	3.7 ± 0.1	9.1 ± 0.1	6.1 ± 0.1

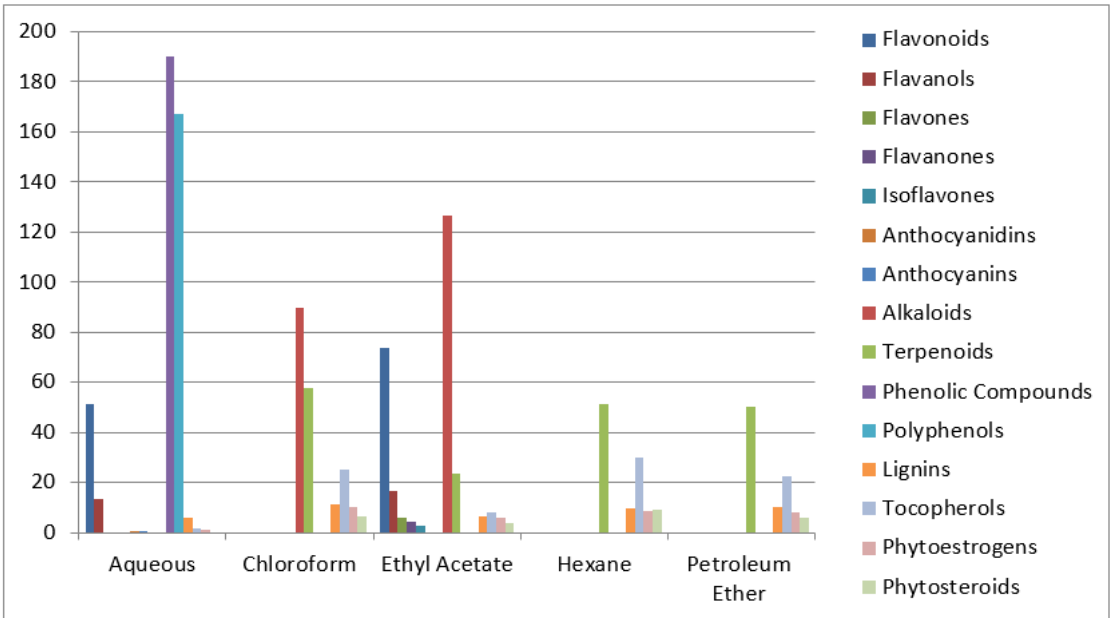

Figure 1: Quantitative Phytochemical Analysis of Sprouted Cucumber Seeds

3.3. Discussion

In this research study, we have evaluated the phytochemicals present in the freshly sprouted seeds of Cucumis sativus (cucumber). The phytochemicals were evaluated qualitatively and quantitatively with five different extracts. The proximate qualitative phytochemicals composition of sprouted cucumber seeds is shown in Table 1. The aqueous sample of the sprouted cucumber seeds showed the presence of flavonoids, flavanols, anthocyanidins, anthocyanins, phenolic compounds, polyphenols, lignins, tocopherols and phytoestrogens and ethyl acetate sample of the sprouted cucumber seeds showed the presence of flavonoids, flavanols, flavones, flavanones, isoflavones, alkaloids, terpinoids, lignins, tocopherols phytoestrogens and phytosteroids. Ethyl acetate showed more phytochemicals components compared to other 4 extracts. Hexane and Petroleum ether showed the least phytochemicals components.

Table 2 shows the quantitative analysis of phytochemicals of the sprouted cucumber seeds. In aqueous sample, phenolic compounds are the highest phytochemicals (190 ± 0.5 mg/g), polyphenols are the second highest phytochemicals (167 ± 1 mg/g) and flavonoids are the third highest phytochemicals (51.3 ± 0.1 mg/g). In chloroform sample, alkaloids are the highest phytochemicals (89.7 ± 0.1 mg/g), terpinoids are the second highest phytochemicals (57.5 ± 0.1 mg/g) and tocopherols are the third highest phytochemicals (25.2 ± 0.1 mg/g). In ethyl acetate sample, alkaloids are the highest phytochemicals (126.3 ± 0.1 mg/g), flavonoids are the second highest phytochemicals (73.7 ± 0.1 mg/g) and terpinoids are the third highest phytochemicals (23.6 ± 0.1 mg/g). In hexane sample, terpinoids are the highest phytochemicals (51.1 ± 0.1 mg/g), and tocopherols are the second highest phytochemicals (30.2 ± 0.1 mg/g). In petroleum ether sample, terpinoids are the highest phytochemicals (50.2 ± 0.1 mg/g), and tocopherols are the second highest phytochemicals (22.7 ± 0.1 mg/g).

Aqueous sample of sprouted cucumber seeds shows high amount of phenolic compounds and it is absent in the other four extracts. Some studies have reported the benefits of phenolic compounds which include anti-inflammatory activity, anti-aging activity, antioxidant activity and anti-proliferative activity (Shukitt-Hale B. et al., 2008; Moo-Huchin V.M. et al., 2015). Phenolic compounds can also prevent the development of long-term diabetes complications, including cardiovascular disease, retinopathy, neuropathy and nephropathy (Iwai K. et al., 2006; Iwai K. 2008).

Lignins, tocopherols and phytoestrogens are visible in all extracts. Lignins are involved in many different biological activities such as reducing the serum cholesterol by binding to the bile acids in the intestine (Banard D.L. and Heaton K.W. 1973), and preventing tumor development in rats exposed to an intestinal carcinogen 3,2-dimethyl-4-ami-nobiphenyl and fed a lignin diet (Reddy B.S. et al., 1983). Tocopherols are the most important lipid-soluble antioxidants in food and in the human and animal tissues. Tocopherols are found in lipid-rich regions of cells such as mitochondrial membranes, fat depots, and lipoproteins such as low-density lipoprotein cholesterol. Phytoestrogens are naturally occurring compounds in plants. Fruits, vegetables, legumes and some other grains contain phytoestrogens. Phytoestrogens may respond as similar to the estrogens which is present in our bodies.

4. Discussion

The phytochemical analysis of sprouted cucumber seeds (Cucumis sativus) revealed the presence of various bioactive compounds, including phenolics, flavonoids, alkaloids, tannins, and saponins. These compounds are known for their potential health benefits, including antioxidant, antimicrobial, and anti-inflammatory properties (Gupta et al., 2021). The qualitative and quantitative differences observed across the various extracts—aqueous, chloroform, ethyl acetate, hexane, and petroleum ether—can be attributed to the polarity of the solvents used, which influences the extraction efficiency of specific phytochemicals (Ahmed et al., 2018).

Among the extracts, the aqueous extract showed the highest concentration of phenolics and flavonoids, aligning with studies indicating water as an efficient solvent for extracting polar phytochemicals (Kumar & Pandey, 2013). These compounds are key contributors to the antioxidant activity of plant-based extracts, suggesting the potential of sprouted cucumber seed extracts in mitigating oxidative stress-related conditions. Similarly, the chloroform and ethyl acetate extracts demonstrated notable amounts of non-polar and semi-polar compounds, such as alkaloids and sterols, which are reported to exhibit antimicrobial and anticancer activities (Raghavendra et al., 2020).

The enhancement of phytochemical content during the sprouting process is consistent with findings from previous research, where germination was shown to trigger the activation of enzymes that degrade anti-nutritional factors and increase the synthesis of bioactive compounds (Bajaj et al., 2020). This biochemical transformation not only improves the nutritional quality of seeds but also enhances their potential application as a functional food ingredient.

The comparative analysis of extracts provides insights into the selective extraction of bioactive compounds for targeted applications. For instance, aqueous and ethyl acetate extracts may serve as potent antioxidant agents, while hexane and petroleum ether extracts could be explored for their lipid-soluble bioactives with specific pharmacological properties. Further investigation into the biological activities of these extracts, such as antimicrobial and anti-inflammatory assays, would strengthen their potential use in nutraceuticals and pharmaceuticals (El-Adawy, 2002).

5. Conclusion

In this study, the phytochemicals compositions of fresh sprouted Cucumis sativus seeds were analyzed qualitatively and quantitatively. Cucumber seeds contain beta-carotene, which helps in building immunity, skin, eyes and the preventions of cancer. Cucumbers are rich in many phytochemicals such as flavonoids, flavanols, anthocyanidins, anthocyanins, phenolic compounds, polyphenols, lignins, tocopherols and phytoestrogens. A handful of cucumber seeds provide enough benefits for the health.

ACKNOWLEDGEMENT

Conflicts of Interest

The authors have no conflict of interest.

Sources of Funding

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

References

1. Ahmed, M., Hussain, M., & Ishtiaq, S. (2018). Influence of solvent polarity on extraction yield and antioxidant activity of phytochemicals. Journal of Pharmaceutical Sciences, 82(4), 123–130.
2. Bajaj, S., Bhatt, R., & Pandey, R. (2020). Bioactive compounds in sprouted seeds: A review. Journal of Food Science and Technology, 57(12), 4500–4510.
3. Bajaj, S., Bhatt, R., & Pandey, R. (2020). Bioactive compounds in sprouted seeds: A review. Journal of Food Science and Technology, 57(12), 4500–4510.
4. Banard D.L., Heaton K.W. Bile acids and vitamin A absorption in man: The effect of two bile acid-binding agents, chloestyramine and lignin. Gut. 1973;14:316–318. doi: 10.1136/gut.14.4.316.
5. El-Adawy, T. A. (2002). Nutritional composition and anti-nutritional factors of chickpea (Cicer arietinum L.) undergoing different cooking methods and germination. Food Chemistry, 78(1), 85–92.
6. El-Adawy, T. A. (2002). Nutritional composition and anti-nutritional factors of chickpea (Cicer arietinum L.) undergoing different cooking methods and germination. Food Chemistry, 78(1), 85–92.
7. Gupta, R., Mehta, P., & Thakur, P. (2021). Phytochemicals and their role in health promotion. Plant Science Today, 8(2), 147–158.
8. Iwai K. Antidiabetic and antioxidant effects of polyphenols in brown alga Ecklonia stolonifera in genetically diabetic KK-A(y) mice. Plant Foods Hum. Nutr. 2008;63:163–169. doi: 10.1007/s11130-008-0098-4.
9. Iwai K., Kim M.Y., Onodera A., Matsue H. Alpha-glucosidase inhibitory and antihyperglycemic effects of polyphenols in the fruit of Viburnum dilatatum Thunb. J. Agric. Food Chem. 2006;54:4588–4592. doi: 10.1021/jf0606353.
10. Kumar, S., & Pandey, A. K. (2013). Chemistry and biological activities of flavonoids: An overview. The Scientific World Journal, 2013, 1–16.
11. Moo-Huchin V.M., Moo-Huchin M.I., Estrada-León R.J., Cuevas-Gloryc L., Estrada-Motaa I.A., Ortiz-Vázquezc E., Betancur-Anconad D., Sauri-Duchc E. Antioxidant compounds, antioxidant activity and phenolic content in peel from three tropical fruits from Yucatan, Mexico. Food Chem. 2015;166:17–22. doi: 10.1016/j.foodchem.2014.05.127.
12. Raghavendra, M. P., Satish, S., & Raveesha, K. A. (2020). Phytochemical analysis and biological activities of medicinal plant extracts. Indian Journal of Traditional Knowledge, 19(1), 56–64.
13. Reddy B.S., Maeura Y., Wayman M. Effects of dietary corn bran and autohydrolyzed lignin on 3,2′-dimethyl-4-aminobiphenyl-induced intestinal carcinogénesis in male F344 rats. J. Natl. Cancer Inst. 1983;71:419–423.
14. Shukitt-Hale B., Lau F.C., Joseph J.A. Berry fruit supplementation and the aging brain. J. Agric. Food Chem. 2008;56:636–641. doi: 10.1021/jf072505f.
15. Statistica World Vegetable Production by Type 2020|Statista. Available online: https://www.statista.com/statistics/264065/global-production-of-vegetables-by-type/
16. Wang, Xiyue, Man Teng, Xinhui Pan, and Xiaoda Yang. 2022. "Preparation and Evaluation of Cucumber Seed Extract Sunscreen" Medical Sciences Forum 14, no. 1: 47. https://doi.org/10.3390/ECMC2022-13314