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# PHYTOCHEMICAL CHARACTERIZATION OF *BRASSICA JUNCEA* L. GROWN UNDER HYDROPONIC CONDITIONS

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## ABSTRACT

Hydroponic systems involve plant cultivation without soil, using inert support media such as coir pith, vermiculite, gravel and peat moss to provide mechanical support to plant roots. Compared with conventional soil-based cultivation, hydroponics has progressed significantly and offers several advantages, including efficient nutrient utilization, conservation of natural fertilizers, and reduced environmental impact**,** thereby promoting sustainable agricultural practices. *Brassica juncea* L. belonging to the family Brassicaceae, is an important horticultural crop widely consumed as a vegetable and valued for its medicinal properties. The plant is rich in essential nutrients, including carbohydrates, fats, proteins, lipids, phosphorus, calcium, and vitamins A, B, and C. Traditionally, *B. juncea* has been used to treat ailments such as headaches and coughs and to improve kidney function and digestion. In the present study, hydroponic cultivation was employed to produce healthier plants with minimal accumulation of harmful chemicals. The objective was to evaluate the morphological characteristics and phytochemical composition of hydroponically grown *Brassica juncea* L. using both qualitative and quantitative analytical methods. All seeds exhibited 100% germination in the nutrient solution, accompanied by significantly enhanced root growth. Phytochemical screening of the ethanolic extract revealed the presence of 18 classes of phytoconstituents**.** Quantitative analysis showed that the reducing sugar content was 1.3 mg/g**,** total phenolic content was 0.28 mg/g and total protein content was 2.5 mg/g**.** These findings support the traditional medicinal use of *Brassica juncea* and underscore its phytochemical potential. Further investigations are recommended to identify, isolate, and characterize the bioactive compounds responsible for its therapeutic effects, as well as to elucidate the underlying mechanisms of action of these phytochemical extracts.

**KEYWORDS:** Hydroponics system, *Brassica juncea*, morphological parameters, ethanolic extract, phytochemical constituents.

## INTRODUCTION

Hydroponic systems are used to cultivate crops without soil under controlled environmental conditions. This method is based on growing plants artificially using mineral nutrient solutions, primarily in water and is increasingly considered a viable alternative to conventional agriculture. During the twentieth century, rapid advancements in agricultural practices led to the development of modern cultivation techniques, among which hydroponics has emerged as one of the most promising systems for both commercial and biological applications. A wide variety of crops are commercially produced using hydroponic systems, including tomatoes, peppers, cucumbers, strawberries and several leafy vegetables.[1] Hydroponic cultivation is widely adopted by farmers, professionals, entrepreneurs and particularly by urban populations due to its suitability for limited spaces. One of the major advantages of hydroponics is the continuous availability of fresh, healthy vegetables, seedlings and herbs for daily consumption.[2] Hydroponic systems are also known for their efficient use of water, as water is filtered, recycled, recovered and replenished throughout the cultivation process. In this method, plant roots are directly exposed to nutrient solutions, ensuring adequate hydration and nutrient uptake. Compared to soil-based cultivation, hydroponics offers several advantages, including reduced labour requirements, as practices such as soil fumigation, extensive irrigation, and tillage are not required.[3] Furthermore, plants grown hydroponically often exhibit faster growth rates, increased biomass and higher yields than those grown using traditional agricultural methods.[4] The genus *Brassica* comprises nearly 150 species, many of which are valued for their nutritional and medicinal properties. The seeds and leaves of *Brassica* species are widely used in traditional medicine and are cultivated globally for their therapeutic and nutritional benefits. The seeds have been traditionally used in the treatment of jaundice, vomiting and rheumatism and are known to possess diuretic, laxative and hepatoprotective properties. When combined with *Moringa oleifera*, *Brassica* seeds are used as remedies for liver and spleen disorders. Additionally, these plants are employed in the treatment of backache, paralysis and arthritis, and their seeds serve as a source of edible vegetable oil. The present study aims to cultivate *Brassica juncea* L. under hydroponic conditions and to identify phytochemical constituents of potential therapeutic significance through qualitative and quantitative phytochemical screening.

## MATERIALS AND METHODS

### Collection of Seeds of *Brassica juncea* L.

Seeds of *Brassica juncea* L. were procured from the Agricultural Society, Tiruchirappalli. Healthy and viable seeds were selected and surface-sterilized using 0.1% mercuric chloride for 1 minute, followed by thorough rinsing with distilled water several times to remove any residual sterilant. The sterilized seeds were then soaked in distilled water for 24 hours. A predetermined number of seeds were subsequently placed on the growth medium for hydroponic cultivation.

### Growing Media for Hydroponics

In hydroponic systems, various inert media are used to provide mechanical support to plant roots and to maintain an optimal water–oxygen balance. In the present study, coco coir and coco pith were employed as the growing media.

### Coco Coir

Coco coir, also known as coconut fibre, is derived from the outer husk of coconuts. Although once considered an agricultural waste product, it is now widely recognized as an excellent hydroponic growing medium. Coco coir is an organic material that decomposes slowly and does not supply nutrients to plants, making it suitable for hydroponic systems where nutrient availability is precisely controlled. It is pH-neutral, has high water-holding capacity, and provides good aeration to plant roots. Coco fibre is commonly available in two forms: coco coir (fibre) and coco chips.

### Nutrient Solution

For optimal plant growth, a balanced supply of macro- and micronutrients including nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, boron, zinc, copper, molybdenum and chlorine is essential. Within certain limits of composition and total concentration, a wide range of nutrient solutions can support healthy plant growth. The mineral content naturally present in the water supply is generally negligible. However, deficiencies or excesses of nutrients can adversely affect plant development.

In the present investigation, Hoagland’s nutrient solution was used for hydroponic cultivation. The composition of the modified Hoagland nutrient solution employed in this study is presented in Table 1.

**Table 1: Composition of Nutrient Solution.**

| Compounds | | Concentration of stock solution (mM) | Vol. of stock solution per litre of final solution (ml) |
|---|---|---|---|
| Macronutrients | $KNO_3$ | 1000 | 6 |
| | $Ca(NO_3)_2 \cdot 4H_2O$ | 1000 | 4 |
| | $KH_2PO_4$ | 1000 | 2 |
| | $MgSO_4 \cdot 7H_2O$ | 1000 | 1 |
| Micronutrients | KCL | 25 | 2 |
| | $H_3BO_3$ | 12.5 | |
| | $MnSO_4$. | 1 | |

| | | | |
|---|---|---|---|
| | $H_2O$ | | |
| | $ZnSO_4 \cdot 7H_2O$ | 1 | |
| | $CuSO_4 \cdot 5H_2O$ | 0.25 | |
| | $MoO_3$ | 0.25 | |
| | Fe Na EDTA | 64 | 1 |

**Deep Water Culture System**

The deep water culture (DWC) system is one of the simplest hydroponic methods. In this system, plants are supported on a floating platform made of Styrofoam or similar material, which rests on the surface of the nutrient solution. An external oxygen supply is continuously provided to the plant roots using aquarium air pumps to ensure adequate aeration.

**Soilless Cultivation of Plants**

A hydroponic system was established separately for *Brassica juncea* L. and wheatgrass using 7 L plastic containers filled with 3 L of modified Hoagland's nutrient solution (initial pH 6.5 ± 0.3; electrical conductivity 1.60 mS $cm^{-1}$). Each container was fitted with two plastic baskets.

Approximately 20 g of *Brassica juncea* L. seeds were weighed, thoroughly washed, and soaked in water for 4 hours. Moistened coco coir was placed at the base of each basket, over which filter paper was laid. The soaked seeds were evenly distributed on the prepared medium. The setup was maintained under shaded conditions, protected from direct sunlight.

The nutrient solution was replaced every two days to maintain optimal nutrient availability. Aeration was provided using Bluestone air pumps (Model RS-180) connected to each hydroponic container. Seed germination and sprout emergence were observed after three days. The plants were allowed to grow for 15 days, after which the leaves were harvested and used for further analyses.

## MATERIALS AND METHODS

**Plant Morphology and Growth Characteristics**

**Germination Percentage**

Germination was assessed on the 15th day after sowing for all treatments. The germination percentage was calculated using the formula.[5]

$$\text{Germination Percentage} = \frac{\text{Total Number of Seeds Germinated}}{\text{Total Number of seeds}} \times 100$$

**Root and Shoot Length**

Ten seedlings of *Brassica juncea* L. were randomly selected and carefully uprooted to avoid damage. The root and shoot lengths were measured and the mean values were recorded in cm per seedling.

**Fresh and Dry Weight**

The fresh and dry weights of the same ten randomly selected seedlings were measured. Dry weight was obtained after oven-drying the seedlings to a constant weight.

**Determination of Moisture Content**

Moisture content was determined according to the Official Methods of the Association of Official Analytical Chemists.[6] Samples were dried in aluminum trays in an oven until constant weight was achieved. Moisture content was calculated using the formula:

Moisture content was calculated as:

$$\%\ \text{Moisture} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

**Preparation of Plant Extracts**

Hydroponically grown *Brassica juncea* L. plants were washed thoroughly to remove coco pith and debris. Leaves were ground with 80% ethanol and filtered through Whatman No. 1 filter paper. The filtrate was stored in airtight containers for further qualitative and quantitative phytochemical analyses.

**Qualitative and Quantitative Phytochemical Analysis**

Phytochemical screening of the ethanolic extract was performed using standard precipitation and coloration methods to identify various bioactive compounds and quantify key constituents.

## RESULTS AND DISCUSSION

**Nutrient Management in Hydroponics**

Successful hydroponic cultivation depends on careful regulation of pH, temperature, electrical conductivity and nutrient solution replenishment**.** In this study, modified Hoagland's nutrient solution was used for deep water culture. The nutrient solution pH was maintained between 5.8 and 6.5, and electrical conductivity was set at 1.60 mS $cm^{-1}$. Sprouts appeared three days after sowing, and plants were harvested after 15 days for growth and phytochemical analyses.

**Morphological Parameters**

**Germination Percentage**

All *Brassica juncea* L. seeds exhibited 100% germination in the nutrient solution. Hydroponically grown seedlings showed markedly enhanced root development.

**Root and Shoot Length**

On the 15th day, the mean root length of ten seedlings was 5.06 cm and the mean shoot length was 8 cm, indicating improved growth under hydroponic conditions.

**Fresh and Dry Weight**

The fresh weight of seedlings was 1.42 g, and the dry weight was 1.35 g**.**

**Moisture Content**

Moisture content of the hydroponically grown plants was 72%**.** High moisture content is essential for fresh vegetable quality, shelf life and safety.[7] Compared to soil-grown plants, hydroponic crops exhibited lower transpiration and reduced water usage**.**

**Phytochemical Analysis of *Brassica juncea* L.**

**Qualitative Analysis**

Ethanolic extracts revealed the presence of 18 phytoconstituents**,** including terpenoids, flavonoids, saponins, tannins, alkaloids, steroids, glycosides, phlobatannins, proteins, coumarins, emodin, anthraquinones, anthocyanins, carbohydrates, leucoanthocyanins, cardiac glycosides, xanthoproteins and phenols. These compounds possess significant pharmacological potential. The detailed phytochemical composition is presented in Table 2**.**

Comparable studies on *Hypochaeris radicata* reported similar findings, identifying alkaloids, cardiac glycosides, phenols, resins, steroids, saponins, tannins, terpenoids and triterpenoids in leaf and root sections, supporting the medicinal relevance of secondary metabolites.[8–11]

**Table 2: Qualitative Phytochemical Analysis of Ethanolic Extract of *Brassica Juncea* L.**

| S.NO | PHYTOCHEMICAL ANALYSIS | RESULT |
|---|---|---|
| **1** | Terpenoid | +++ |
| **2** | Flavanoid | +++ |
| **3** | Saponin | +++ |
| **4** | Tannin | +++ |
| **5** | Alkaloids | +++ |
| **6** | Steroids | +++ |
| **7** | Glycosides | +++ |
| **8** | Phlobotannin | ++ |
| **9** | Proteins | +++ |
| **10** | Cowmarin | +++ |
| **11** | Emodin | +++ |
| **12** | Anthroquinone | +++ |
| **13** | Anthocynanin | + |
| **14** | Carbohydrate | +++ |
| **15** | Levcoanthocyanin | + |
| **16** | Cardiacglycoisides | +++ |
| **17** | Xanthoprotein | +++ |
| **18** | Phenol | ++ |

**Quantitative Phytochemical Analysis of *Brassica juncea* L.**

The quantitative estimation of secondary metabolites in the ethanolic extract of *Brassica juncea* L. included reducing sugars, total phenols, and total proteins**.** The results are summarized in Table 3**.**

**Table 3: Quantitative Phytochemical Analysis of Ethanolic Extract of *Brassica Juncea* L.**

| S.NO | PHYTOCHEMICALS | RESULT (mg/g) |
|---|---|---|
| **1.** | Reducing Sugar | 1.3 |
| **2.** | Total Phenol | 0.28 |
| **3.** | Total Protein | 2.5 |

The study revealed that the reducing sugar content was 1.3 mg/g, total phenol was 0.28 mg/g, and total protein was 2.5 mg/g. These findings are consistent with previous studies.[12–17]

For instance, research on *Nagara beans* reported that the oligosaccharide fraction could be quantified by measuring reducing and total sugars, with extraction optimized using Response Surface Methods (RSM) under varying ethanol concentrations.[12] Similarly, the methanolic extract of *Fagonia cretica* contained flavonoids and reducing sugars, while the n-hexane extract primarily contained terpenoids.[13]

In *Punica granatum*, the methanol/chloroform extract exhibited the highest phenolic content, highlighting the importance of phenolic-rich plants in treating inflammatory conditions and aiding wound healing.[14] In addition, comparative studies of 33 commonly used edible plant leaves showed variations in protein content using the Lowry method, with *Psidium guajava* leaves exhibiting the highest protein concentration (98.51 mg BSA Equivalent/g fresh weight).[15]

Phytochemical screening of the rhizome of *Marsilea minuta* using five organic solvents (acetone, DMSO, ethanol, chloroform, and petroleum ether) confirmed the presence of major secondary metabolites including terpenoids, flavonoids, sugars, quinones, coumarins, tannins, saponins, phenols and anthraquinones.[16 &17]

The quantitative data from the present study demonstrate that *Brassica juncea* L. contains notable levels of reducing sugars, phenolic compounds and proteins**,** supporting its nutritional and therapeutic potential.

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