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Comparative phytochemical profiling of healthy and stem-spotted diseased stems of *Solanum lycopersicum*: Insights into primary and secondary metabolite alterations

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Abstract
Biochemical responses in plants are strongly influenced by pathological stress, often resulting in measurable changes in metabolite composition. The present study examines the phytochemical differences between healthy and stem-spotted diseased stems of *Solanum lycopersicum*. Stem samples were collected from field-grown plants and subjected to methanolic extraction using a controlled sonication process (25-40°C, 40-45 minutes). Qualitative screening revealed the presence of alkaloids, carbohydrates, flavonoids, and carboxylic acids in both healthy and diseased tissues, while tannins were detected only in diseased stems. A semi-quantitative interpretation based on visible intensity differences suggested a relative decline in carbohydrate levels and an increase in defense-related compounds under diseased conditions. These observations indicate a shift from primary metabolism towards secondary metabolite synthesis during stress. The findings contribute to understanding biochemical adaptation in plant tissues and support the potential of tomato stems as a source of bioactive compounds.

Keywords: *Solanum lycopersicum*, phytochemical variation, plant stress response, secondary metabolites, stem disease

Introduction

Tomato (*Solanum lycopersicum L.*) is widely cultivated and valued not only as a food crop but also for its diverse biochemical composition (Kumar *et al.,* 2020) [15]. Plant tissues of tomato contain several classes of metabolites, including sugars, alkaloids, flavonoids, and organic acids, which are involved in growth, development, and defense (Paolo *et al.,* 2018) [18].

When plants encounter pathogens, internal metabolism does not remain static (Sisodia *et al.,* 2025a) [8]. Instead, there is a noticeable shift in resource allocation, where energy and substrates are redirected from growth-related processes towards protective responses (Saha *et al.,* 2023) [20]. This often leads to increased synthesis of certain secondary metabolites that can restrict pathogen spread or reduce cellular damage (He *et al.,* 2022).

Tomato fruits have been extensively studied, stem tissues have received comparatively less attention despite being metabolically active and responsive to stress (Nicolas and Pattison, 2023) [17]. Disease symptoms such as stem spotting provide a visible indication of physiological disturbance and offer an opportunity to examine biochemical changes in plant tissues (Elangovan *et al.,* 2024) [3].

The present study aims to compare the phytochemical composition of healthy and diseased tomato stems, with particular attention to changes associated with stress conditions (Chaudhary and Sharma, 2018) [2].

Materials and Methods

1. Sample Collection

Stem samples showing no visible symptoms (healthy) and those exhibiting stem spotting (diseased) were collected from cultivated fields in the Jobner region of Rajasthan. Care was taken to ensure that both types of samples were obtained from similar environmental conditions to reduce external variability.

2. Sample Preparation

Collected stems were rinsed with water to remove surface contaminants and then dried under shade at room temperature. This step helped preserve heat-sensitive compounds. Once dried, the material was ground into a uniform powder to facilitate extraction (Sisodia *et al.,* 2025b) [8].

3. Extraction Procedure

For extraction, 20 g of powdered sample was mixed with 200 ml methanol. The mixture was subjected to sonication at a temperature range of 25-40°C for 40-45 minutes. This method enhances extraction efficiency by improving solvent penetration into plant tissues (Islam and Malakar, 2023) [12]. The resulting mixture was filtered, and the filtrate was stored for subsequent analysis.

4. Phytochemical Screening

Standard qualitative tests were used to identify major phytochemical groups. Alkaloids were confirmed through precipitation using Mayer's reagent (Sisodia *et al.,* 2025c) [10]. Carbohydrates were detected using the Molisch reaction, which produces a characteristic ring. Flavonoids were identified through alkaline treatment followed by acidification (Khan and Sisodia, 2025) [14].

Tannins were examined using ferric ion-based detection, while carboxylic acids were identified through effervescence after reaction with sodium bicarbonate (Parveen *et al.,* 2025) [19]. Observations were recorded not only for presence or absence but also for relative intensity, allowing a comparative assessment between samples.

Fig 1: Extract filtrate of healthy stem **Fig 2:** Extract filtrate of diseased stem

Results

1. Comparative Phytochemical Profile

Both healthy and diseased stems contained several common phytochemical groups; differences were observed in their relative abundance and occurrence.

Table 1: Comparative Phytochemical Profile of Healthy and Diseased Stems

Phytochemical	Test Method	Healthy Stem	Diseased Stem	Observation
Alkaloids	Mayer's Test	Present	Present	Similar levels
Carbohydrates	Molisch Test	High	Moderate	Reduced in diseased
Flavonoids	NaOH Test	High	High	No major change
Tannins	$FeCl_3$ Test	Absent	Present	Induced in diseased
Carboxylic acids	Effervescence Test	Moderate	High	Increased

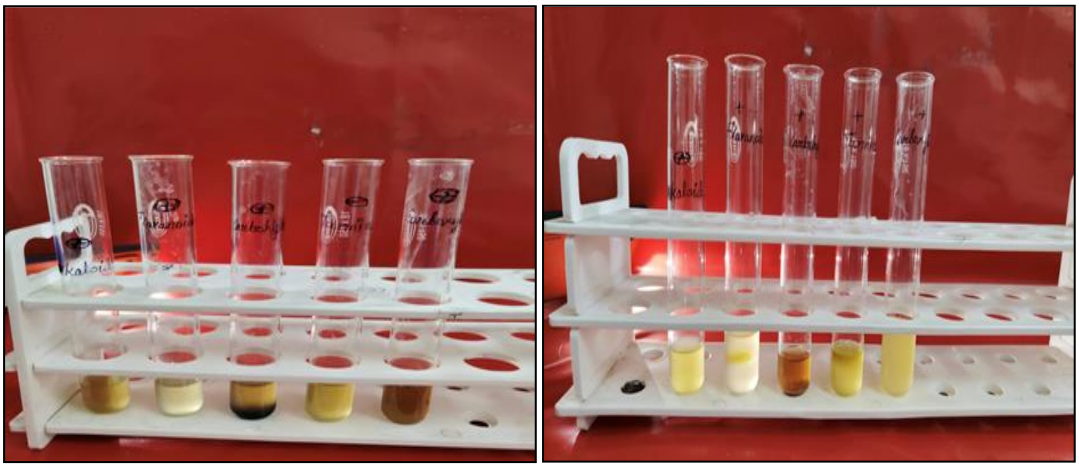

Fig 3: Final detection test results of (A) Healthy stem sample and (B) Diseased stem sample after phytochemical screening

Phytochemical variations were interpreted using a semi-quantitative scoring system (0-3 scale) and represented graphically.

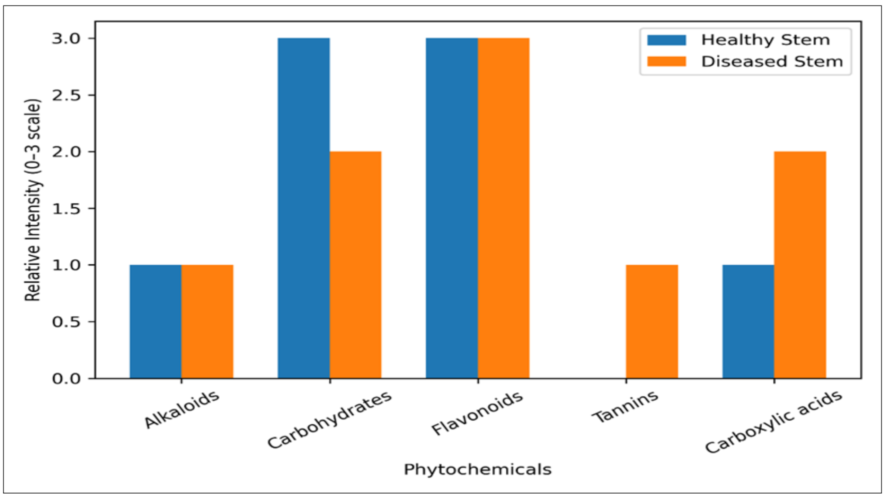

Fig 4: Comparative bar chart showing variation in phytochemical intensity between healthy and diseased stems of *Solanum lycopersicum*

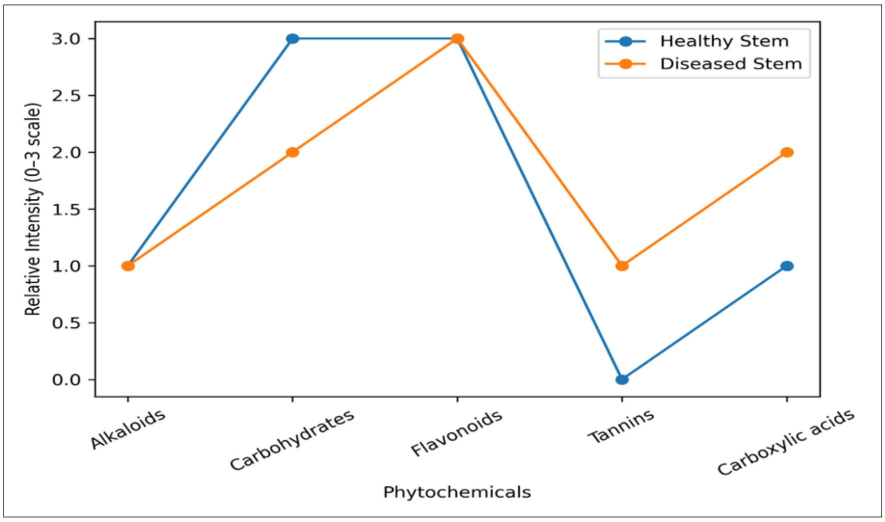

Fig 5: Line graph representing trends in phytochemical variation under healthy and diseased conditions.

2. Interpretation

Healthy stems showed higher carbohydrate levels, reflecting normal metabolic activity. Diseased stems exhibited a reduction in carbohydrate intensity, which may be linked to increased metabolic demand during stress (Li *et al.,* 2019) [11].

The appearance of tannins only in diseased samples suggests activation of protective biochemical pathways. These compounds are often associated with plant defense and may help in limiting pathogen spread (Gurjar and Sisodia, 2026) [4].

Carboxylic acids appeared more prominent in diseased stems, indicating altered metabolic processes. Flavonoid levels remained relatively stable, suggesting their consistent role in maintaining cellular balance (Chai *et al.,* 2026) [1].

Discussion

The differences observed between healthy and diseased stems highlight the adaptive nature of plant metabolism. Under stress conditions, plants appear to prioritize the synthesis of compounds associated with defense (Isah *et al.,* 2019) [11].

The reduction in carbohydrates may reflect their utilization as an energy source during stress response (Hartmann and Trumbore, 2016) [6]. At the same time, the induction of tannins supports their role as protective compounds. Increased levels of carboxylic acids may be linked to changes in metabolic activity associated with stress adaptation (Haghpanah *et al.,* 2024) [5].

Rather than a complete shift, the data suggest a redistribution of metabolic resources, where defense-related compounds become more prominent without completely suppressing baseline metabolites (Kerezoudis *et al.,* 2025) [13].

Conclusion

The study demonstrates that stem tissues of *Solanum lycopersicum* undergo noticeable phytochemical changes under disease conditions. Several metabolites are present in both healthy and diseased stems, certain compounds such as tannins appear specifically under stress.

These observations indicate that plant tissues adjust their biochemical composition in response to external challenges. The findings also suggest that tomato stems may serve as a useful source of bioactive compounds for further study.

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