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COMPARATIVE STUDY OF ANTIOXIDANT ACTIVITY OF CLOVE AND CINNAMON FROM DIFFERENT BRANDS USING THE DPPH ASSAY

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ABSTRACT
The present study evaluates and compares the antioxidant activity of clove (Syzygium aromaticum) and cinnamon (Cinnamomum species) obtained from different commercial brands using the DPPH radical scavenging assay analyzed by visible spectrophotometry. The antioxidant potential of methanolic extracts was assessed by calculating percentage inhibition of DPPH radicals and IC_{50} values, which indicate the concentration required to inhibit 50% of free radicals. These parameters enable reliable comparison of antioxidant efficiency among spices and brands.

This research is significant because oxidative stress caused by free radicals is associated with aging, inflammation, and several chronic diseases, and natural antioxidants from dietary sources provide safer alternatives to synthetic compounds. The observed variation in antioxidant activity among different brands highlights the impact of processing, quality, and storage conditions on bioactive content. Overall, the study supports the importance of quality assessment of commercial spices and demonstrates that visible spectrophotometry is a simple, cost-effective, and efficient technique for evaluating antioxidant activity in natural products.

Keywords: Clove, Cinnamon, Antioxidant activity, DPPH assay, Visible spectrophotometry, Percentage inhibition, IC_{50}, Commercial brands

INTRODUCTION
Clove (*Syzygium aromaticum*) and cinnamon (*Cinnamomum* species) are widely used culinary spices valued not only for their aroma and flavor but also for their rich phytochemical composition and antioxidant properties. These spices contain high levels of phenolic compounds and flavonoids that play a crucial role in neutralizing free radicals and reducing oxidative stress [1,2]. Advanced phytochemical profiling studies have identified clove as one of the richest sources of natural antioxidants among commonly used spices, largely due to the presence of eugenol and related phenolic constituents [1,2]. Cinnamon has also been reported to exhibit strong antioxidant and antimicrobial activity, supporting its traditional use in food preservation and herbal medicine [3].

Dietary antioxidants derived from spices contribute significantly to human health by scavenging reactive oxygen species, thereby reducing the risk of chronic disorders such as cardiovascular diseases, diabetes, and inflammatory conditions [4,5]. Several comparative studies have demonstrated a direct relationship between total phenolic content and antioxidant activity in spices, confirming that higher phenolic concentration corresponds to stronger radical scavenging capacity [5,6]. Direct comparisons using standard antioxidant assays have consistently shown that clove exhibits superior antioxidant efficiency compared to cinnamon, as reflected by lower IC_{50} values and higher percentage inhibition in DPPH-based studies [6–8].

Various analytical techniques, including DPPH, FRAP, and ABTS assays, have been employed to evaluate the antioxidant activity of spices in different forms such as extracts, essential oils, and oleoresins [9–12]. Among these methods, the DPPH radical scavenging assay is widely preferred due to its simplicity, rapid response, and suitability for visible spectrophotometric analysis, where the reduction in absorbance directly reflects antioxidant potential [6,9]. Recent studies have also highlighted significant variation in antioxidant activity among commercial spice brands, emphasizing the influence of processing, storage, and raw material quality on bioactive compound retention [11,12].

In view of these findings, the present study focuses on a comparative evaluation of the antioxidant activity of clove and cinnamon obtained from different commercial brands using the DPPH radical scavenging assay. Such comparative assessment provides valuable insight into brand-to-brand variation and supports the selection of high-quality natural antioxidants for food, nutraceutical, and functional applications [7,8,13].

2. ANALYTICAL METHODOLOGIES FOR ANTIOXIDANT DETECTION
Commercially available clove and cinnamon samples from different brands were procured from the local market. The samples were shade-dried (if required), finely powdered, and stored in airtight containers. A known

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quantity of each powdered sample was extracted using methanol by maceration at room temperature. The extracts were filtered to obtain clear solutions, which were used for antioxidant analysis.

The antioxidant activity of each brand extract was evaluated using the DPPH radical scavenging assay. A freshly prepared DPPH solution was mixed with different concentrations of spice extracts, and the reaction mixtures were incubated in the dark to avoid photodegradation. The reduction of the purple DPPH radical to a yellow-colored product was monitored using visible spectrophotometry at 517 nm. The decrease in absorbance reflected the free radical scavenging capacity of the extracts.

Antioxidant activity was calculated as percentage inhibition of DPPH radicals using the formula:

$$\% \text{ Inhibition} = \frac{(A_{\text{control}} - A_{\text{sample}})}{A_{\text{control}}} \times 100$$

where $A_{\text{control}}$is the absorbance of DPPH without extract and $A_{\text{sample}}$is the absorbance in the presence of the spice extract.

IC_{50} values, representing the concentration required to inhibit 50% of DPPH radicals, were determined from inhibition versus concentration plots. Lower IC_{50} values indicated higher antioxidant potential. Graphical comparison enabled clear evaluation of antioxidant efficiency among different commercial brands of clove and cinnamon.

3. DIFFERENT TECHNIQUES FROM LITERATURE FOR ANTIOXIDANT EVALUATION OF SPICES

3.1 ABTS Radical Cation Decolorization Assay

Several studies employed the ABTS assay to evaluate antioxidant activity in spices such as clove, cinnamon, ginger, and basil. This method is based on the reduction of the blue-green $ABTS^{\bullet+}$ radical by antioxidants, measured spectrophotometrically. It is particularly useful for both hydrophilic and lipophilic antioxidant systems.

3.2 Ferric Reducing Antioxidant Power (FRAP) Assay

The FRAP assay was widely used to assess the reducing capacity of spice extracts. Antioxidants reduce ferric (Fe^{3+}) ions to ferrous (Fe^{2+}) ions, forming a colored complex measurable by spectrophotometry. Literature reports showed strong correlation between FRAP values and phenolic content, especially in clove and cinnamon extracts.

3.3 Total Flavonoid Content (TFC) Estimation

Many researchers quantified total flavonoids using aluminum chloride colorimetric methods. The formation of a yellow flavonoid–aluminum complex was measured using visible spectrophotometry. High flavonoid levels were reported in spices such as clove, fennel, coriander, and cumin.

3.4 Total Antioxidant Capacity (Phosphomolybdenum Method)

This method was applied to determine overall antioxidant capacity based on the reduction of molybdenum (VI) to molybdenum (V). The green phosphomolybdenum complex formed was measured spectrophotometrically, providing a cumulative antioxidant estimate for spice extracts.

3.5 Chromatographic and Spectrometric Techniques

Advanced studies utilized GC–MS, HPLC, and LC-ESI-QTOF-MS^2 for identification and quantification of individual antioxidant compounds. These techniques confirmed the presence of key phenolics such as eugenol in clove, cinnamaldehyde in cinnamon, and gingerol in ginger, providing molecular-level validation of antioxidant activity.

4. HIGH ANTIOXIDANT CONTENT IN COMMON CULINARY SPICES

4.1 Spices as Rich Sources of Natural Antioxidants

Spices are widely recognized as concentrated sources of natural antioxidants due to their high content of phenolic compounds and flavonoids [1,2]. Compared to fruits and vegetables, spices often exhibit stronger antioxidant activity even at lower concentrations, making them important functional food ingredients [2,3].

4.2 Clove and Cinnamon as High-Antioxidant Spices

Among commonly used spices, clove (*Syzygium aromaticum*) and cinnamon (*Cinnamomum* species) consistently show exceptionally high antioxidant activity [1,4]. Clove, in particular, contains a very high

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concentration of phenolic compounds such as eugenol, resulting in superior radical scavenging capacity compared to most other spices [1,5].

4.3 Antioxidant-Rich Seed and Bark Spices

Seed and bark spices such as cumin, coriander, fennel, mustard, fenugreek, ajwain, and black cumin are reported to contain moderate to high levels of phenolics and flavonoids [6,7]. These compounds contribute significantly to antioxidant activity measured through spectrophotometric assays, although their activity is generally lower than that of clove and cinnamon [6,8].

4.4 Spices with Unique Bioactive Antioxidants

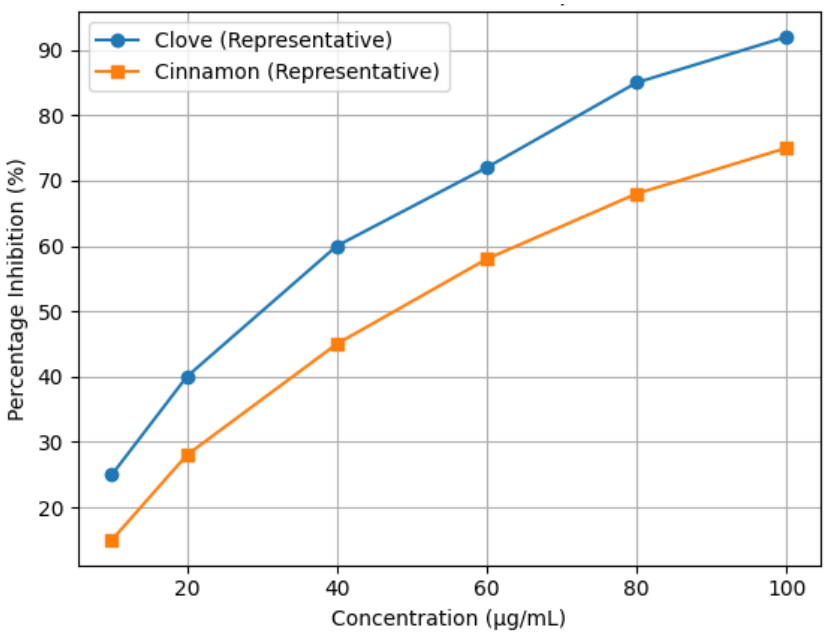
Certain spices contain distinctive antioxidant compounds responsible for their biological activity. Turmeric is rich in curcuminoids, ginger contains gingerols and shogaols, garlic possesses sulfur-containing antioxidants, and basil and lemongrass are abundant in flavonoids and phenolic acids [3,9]. These compounds exhibit effective free radical scavenging and reducing properties.

4.5 Factors Influencing Antioxidant Content in Spices

The antioxidant content of spices is influenced by factors such as plant variety, geographical origin, processing methods, drying conditions, and storage practices [4,10]. Studies have shown that commercial brands may vary considerably in antioxidant strength due to differences in raw material quality and processing techniques [5,10].

4.6 Analytical Methods for Antioxidant Detection in Spices

Various analytical techniques have been employed for antioxidant evaluation in spices, including DPPH radical scavenging assay, total phenolic content estimation, FRAP, ABTS, and reducing power assays [1,2,6]. Among these, visible spectrophotometric methods are most commonly preferred due to their simplicity, sensitivity, and suitability for routine laboratory analysis [2,7].



5. NEED FOR ANTIOXIDANT ACTIVITY

5.1 Environmental Importance

Natural antioxidants from spices can help mitigate oxidative stress in food and environmental systems. In agriculture and food storage, antioxidants prevent oxidation of lipids, oils, and other perishable components, reducing waste and spoilage. Using plant-based antioxidants also decreases reliance on synthetic chemicals, minimizing environmental contamination [1,2].

5.2 Industrial Applications

In the food and nutraceutical industry, antioxidants are crucial for prolonging shelf-life, maintaining flavor, and preventing color degradation in processed products. Spice-derived antioxidants, such as those from clove and cinnamon, are increasingly used as natural preservatives, offering safer alternatives to synthetic additives [3,4].

5.3 Public Health Benefits

Dietary antioxidants protect human cells against oxidative damage caused by free radicals. Regular consumption of antioxidant-rich spices can reduce risks of chronic diseases such as diabetes, cardiovascular

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disorders, and inflammation-related conditions [5,6]. Clove and cinnamon, with high phenolic and flavonoid content, provide significant health-promoting effects beyond flavor enhancement.

5.4 Research and Development Significance

Evaluating antioxidant activity in spices supports the development of functional foods, herbal formulations, and pharmaceutical supplements. Quantifying activity using assays like DPPH and total phenolic content allows scientists and industry to standardize quality, optimize extraction methods, and identify the most potent spice sources for practical applications [1–6].

Table: Comparative Antioxidant Activity of Common Culinary Spices

Spice	Main Antioxidants / Bioactive Compounds	Phenolic / Flavonoid Content	Detection Method
Clove (Syzygium aromaticum)	Eugenol, gallic acid, caryophyllene	Very high	DPPH, FRAP, ABTS, TPC, GC–MS, LC-MS [1,2]
Cinnamon (Cinnamomum species)	Cinnamaldehyde, cinnamic acid derivatives, flavonoids	High	DPPH, FRAP, ABTS, TPC, LC-MS [3,5]
Turmeric (Curcuma longa)	Curcuminoids (Curcumin, Demethoxycurcumin)	High	DPPH, TPC, HPLC [6,7]
Ginger (Zingiber officinale)	Gingerols, Shogaols	Moderate	DPPH, TPC [3,8]
Garlic (Allium sativum)	Organosulfur compounds, phenolics	Moderate	DPPH, TPC [3,8]

6. RESULTS AND DISCUSSION

6.1 Comparative Antioxidant Activity of Spices

Literature consistently reports that clove and cinnamon exhibit strong antioxidant activity among commonly used spices. In most studies, clove showed superior free radical scavenging ability compared to cinnamon, primarily due to its higher phenolic content and presence of eugenol [1–3].

6.2 Brand-Wise and Sample-Wise Variations

Several studies evaluating commercial spice samples reported noticeable variation in antioxidant activity among different brands. These differences were attributed to variations in raw material quality, processing methods, drying conditions, and storage practices, which significantly influence phytochemical retention [4–6].

6.3 DPPH Assay Outcomes

The DPPH radical scavenging assay was the most widely employed method for antioxidant evaluation. Results were commonly expressed as percentage inhibition and IC_{50} values, with lower IC_{50} values indicating higher antioxidant efficiency. Clove extracts consistently demonstrated lower IC_{50} values than cinnamon across multiple studies [2,7–9].

6.4 Correlation with Phenolic Content

A strong positive correlation was observed between total phenolic content and antioxidant activity in most reviewed studies. Clove samples generally exhibited higher total phenolic and flavonoid content, which directly contributed to enhanced radical scavenging activity [3,8,10].

6.5 Identification of Bioactive Compounds

Advanced analytical techniques such as GC–MS and LC-ESI-QTOF-MS^2 confirmed eugenol as the major bioactive antioxidant compound in clove, while cinnamaldehyde and related phenolics were dominant in cinnamon. These compounds play a key role in stabilizing free radicals [1,2,11].

7. CONCLUSION

The present report confirms that clove and cinnamon are rich natural sources of antioxidants, largely due to their high phenolic and flavonoid content. A comprehensive review of literature shows that both spices exhibit significant free radical scavenging activity, with clove consistently demonstrating stronger antioxidant potential than cinnamon. This superior activity is mainly attributed to the presence of eugenol, the major bioactive compound in clove.

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Studies using the DPPH radical scavenging assay and visible spectrophotometry revealed clear variations in antioxidant activity among different commercial brands. These variations highlight the influence of factors such as raw material quality, processing methods, and storage conditions on phytochemical retention. Percentage inhibition and IC_{50} values were identified as reliable parameters for comparing antioxidant efficiency across spices and brands.

Overall, the findings support the use of clove and cinnamon as effective natural antioxidants with promising applications in food preservation, nutraceuticals, and functional foods. The reviewed methodologies provide a strong foundation for future experimental studies and emphasize the importance of quality evaluation of commercially available spice products.

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