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PHYTONUTRIENT COMPOSITION OF *ZINGIBER OFFICINALE* AND *CINNAMOMUM VERUM*, IN VARIED DOSES FOR THERAPEUTIC POTENTIAL

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Abstract

Hypertension is a significant global health concern, contributing to cardiovascular morbidity and mortality. This study explores the phytonutrient profiles of two widely used spices, ginger (*Zingiber officinale*) and cinnamon (Cinnamomum verum), to assess their potential synergestic strength in varied dosses. Various ratios of ginger and cinnamon (50:50, 70:30, and 30:70) were analyzed for their bioactive compounds, including tannins, cardiac glycosides, flavonoids, saponins, steroids, phenols, reducing sugars, and alkaloids using standard methods. Qualitative analysis confirmed the presence of these compounds across all ratios, with quantitative results indicating that the (50:50) ratio yielded the highest concentrations of tannins, flavonoids, and phenols, while the (30:70) ratio maximized cardiac glycosides and alkaloids. The findings suggest that the synergistic effects of ginger and cinnamon can enhance antioxidant and anti-inflammatory properties, offering promising avenues for dietary interventions in chronic disease prevention. Additionally, this study highlights the necessity of standardizing phytonutrient assessments to facilitate the development of targeted supplements and functional foods tailored for individual health needs. As the consumption of herbal supplements rises, understanding the interactions between these spices and conventional therapies will be crucial for optimizing hypertension management strategies.

Keywords: Phytonutrients, *Zingiber officinale, Cinnamomum verum*, Qualitative analysis and Quantitative analysis

1.0 Introduction

There is growing interest in natural products, particularly plant-based nutrients known as

phytonutrients, for their potential health benefits. Ginger (Zingiber officinale) and cinnamon (Cinnamomum verum) are rich in bioactive compounds contributing to their antioxidant, anti-inflammatory, and antidiabetic properties (Akilen et al., 2010). Ginger is acclaimed for its traditional medicine and culinary applications. Its main active components, gingerols, shogaols, and paradol, exhibit anti-inflammatory, antioxidant, and vasodilatory properties. These compounds reduce inflammation, improve blood vessel health, and lower oxidative damage, supporting its potential benefits in managing metabolic disorders (Akilen et al., 2010). Cinnamon contains bioactive compounds, including cinnamaldehyde, cinnamic acid, and polyphenols. It's believed to help lower blood pressure through multiple pathways, including its action on vascular endothelial function, reduction of oxidative stress, and enhancement of nitric oxide availability (Ranasinghe et al., 2013).

Figure 1.1: Ginger (*Zingiber officinale*) (Akilen *et al*., 2010).

The phytonutrient content of ginger and cinnamon can vary significantly depending on factors like plant variety, geographical origin, processing methods, and storage conditions. Ginger and cinnamon contain various phytochemicals, particularly phenolic compounds, contributing to their health benefits. Key phenolic compounds in ginger include gingerols, shogaols, and paradols, while cinnamaldehyde is predominant in cinnamon (Rasool, 2021; Nouri et al., 2023). These compounds have antioxidant, anti-inflammatory, and antimicrobial properties. Cinnamon (Figure 1.2) contains bioactive compounds, including cinnamaldehyde, cinnamic acid, and polyphenols. It's believed to help lower blood pressure through multiple pathways, including its action on vascular endothelial function, reduction of oxidative stress, and enhancement of nitric oxide availability (Ranasinghe et al., 2013).

Figure 1.2: Cinnamon (Cinnamomum verum) (Ranasinghe *et al*., 2013).

Ginger and cinnamon contain various phytochemicals, particularly phenolic compounds, contributing to their health benefits. Phenolic compounds are secondary metabolites produced by plants to protect against environmental stress. Key phenolic compounds in ginger include gingerols,

shogaols, and paradols, while cinnamaldehyde is predominant in cinnamon (Rasool, 2021; Nouri et al., 2023). Gingerols and shogaols are the main phenolic compounds in ginger, recognized for their antioxidant and anti-inflammatory properties. They reduce inflammatory agents and exhibit antimicrobial properties. Cinnamaldehyde is the primary phenolic compound in cinnamon, known for its antioxidant, anti-inflammatory, and antimicrobial properties. It inhibits bacterial growth and has been studied for its potential to lower blood sugar levels. In addition to these compounds, ginger and cinnamon contain other bioactive compounds, including terpenes, cinnamic acid, and coumarin, which contribute to their health benefits. Tannins are polyphenolic compounds with antioxidant effects and potential health benefits, including anti-inflammatory and anti-cancer properties.

Cardiac glycosides regulate heart function and are used to treat heart disorders. Flavonoids are a diverse category of phytonutrients recognized for their antioxidant effects and potential to decrease the risk of chronic illnesses. Saponins boost the immune system and help reduce cholesterol levels. They have antioxidant, anti-inflammatory, and anticancer effects. Steroids in plants have various biological activities, including anti-inflammatory effects. Phenolic compounds have antioxidant properties and potential health benefits, including anti-cancer effects (Jaremko et al., 2020; NCBI, 2021). Reducing sugars influence the sweetness of extracts and can enhance flavor profiles. Alkaloids have therapeutic properties, including pain relief and anti-inflammatory effects.

Anthraquinones have laxative effects and potential anti-inflammatory and anticancer properties. Overall, ginger and cinnamon have anti-inflammatory, analgesic, antioxidant, anti-diabetic, antimicrobial, and anticancer properties, making them valuable for preventing and managing chronic diseases. While the potential health benefits of individual herbs and spices such as ginger and cinnamon have been well documented, the synergistic effects of combining these phytonutrients have not been extensively studied.

Research has indicated that while both ginger and cinnamon possess unique anti-inflammatory and antioxidant properties (Rahmani et al., 2020; Gupta et al., 2016), investigations into their combined effects are limited. For instance, a study by Roussell et al. (2013) highlights that while individual components can lower blood pressure, conclusive evidence on the enhanced efficacy of their combination remains scant. Further research is necessary to elucidate the potential synergistic effects between cinnamon and ginger and how this interaction may contribute to better management of conditions such as hypertension. Combining phytonutrients from different plants can have synergistic effects, leading to enhanced health benefits. For example, cinnamon and garlic together can lower blood pressure more effectively than either alone. This study explores the potential synergy between cinnamon and ginger, which could lead to new strategies for managing hypertension.

2.0 Materials and Methods

Ginger (*Zingiber officinale*) and cinnamon (*Cinnamomum verum J. Presl*) of an

unspecified variety were sourced from Mushin, and Fowa naturals, Ayobo-Ishefun, Ipaja, Lagos. The species *Zingiber officinale* and *Cinnamomum verum J. Presl* were authenticated with reference numbers LUH 100299 and LUH 100300, respectively, by the Department of Botany Herbarium at the University of Lagos.

2.1 Qualitative Analysis of Phytochemical Compounds

A qualitative analysis was conducted to identify the various phytochemical compounds present in the extract. The extracts underwent thin-layer and paper chromatography in the laboratory to separate the components into individual compounds, allowing for accurate identification of all extract constituents. Preliminary phytochemical analysis was performed following standard methods of Sofowora (1998) and Evans (2009), with slight mofications by Talabi, et al., (2024).

2.1.1 Detection of Alkaloids: The extracts were individually dissolved in dilute hydrochloric acid and filtered. The resulting filtrates were then tested for alkaloids using Dragendorff's test. In this test, the filtrates were treated with Dragendorff's reagent (a solution of potassium bismuth iodide). The formation of a red precipitate indicates the presence of alkaloids.

2.1.2 Detection of Flavonoids: For flavonoid detection, the extracts were treated with a few drops of lead acetate solution. The appearance of a yellow precipitate suggests the presence of flavonoids in the extracts.

2.1.3 Detection of Steroids: To detect steroids, 2 ml of acetic anhydride was added to 5 mg of each extract, followed by the addition of 2 ml of concentrated sulfuric acid. A color change from violet to blue or green in some samples indicates the presence of steroids.

2.1.4 Detection of Terpenoids: Using Salkowski's test, 5 mg of the leaf, flower, and seed extracts were mixed with 2 ml of chloroform, and 3 ml of concentrated sulfuric acid was carefully added to form a distinct layer. The appearance of a reddish-brown color at the interface indicates the presence of terpenoids.

2.1.5 Detection of Phenols: The presence of phenols was assessed using the ferric chloride test, where 5 ml of the extracts were treated with a few drops of ferric chloride solution. The formation of a bluish-black color indicates the presence of phenolic compounds.

2.1.6 Detection of Saponins: To detect saponins, 0.5 mg of the extract was shaken with 5 ml of distilled water. The formation of froth, characterized by a creamy mass of small bubbles, indicates the presence of saponins.

2.1.7 Detection of Tannins: To detect tannins, a small amount of the extract was mixed with water and heated in a water bath. The mixture was then filtered, and iron (III) chloride was added to the filtrate. The appearance of a dark green color indicates the presence of tannins.

2.1.8 Detection of Reducing Sugars: For the detection of reducing sugars, Benedict's test was performed. Equal volumes (2 ml each) of Benedict's solution and the aqueous extract were combined in a test tube and heated in a boiling water bath for 10 minutes. The resulting color changes to yellow, green, or red indicate the presence of reducing sugars.

2.1.9 Detection of Phlobatannins: To test for phlobatannins, 1 ml of the extract was mixed with 2 ml of 1% sulfuric acid. The formation of a red precipitate indicates the presence of phlobatannins.

2.2 Quantitative Phytochemical Screening

2.2.1 Estimation of Alkaloids: To determine the total alkaloid content, we utilized a modified method described by Shamsa et al. (2007). We began by mixing 1 ml of the plant extract with 5 ml of a phosphate buffer at pH 4.7 and adding 5 ml of Bromocresol Green (BCG) solution. This mixture was then shaken with 4 ml of chloroform to facilitate the extraction of alkaloids. The resulting solution was collected in a 10-ml volumetric flask, and additional chloroform was added to adjust the volume. The absorbance of the chloroform solution was measured at 470 nm, using a blank prepared in the same manner but without the extract. Atropine was used as the standard for comparison, and the results were expressed in terms of Atropine equivalents using a calibration curve.

2.2.2 Preparation of Standard Curve: To prepare the standard curve, aliquots of atropine standard solution (0.4, 0.6, 0.8, 1, and 1.2 mL) were accurately measured and placed into separate separatory funnels. We added 5 ml of the pH 4.7 phosphate buffer and 5 ml of BCG solution to each funnel. After shaking the mixtures with different volumes of chloroform (1, 2, 3, and 4 ml), the extracts were collected in a 10 ml volumetric flask and diluted to the mark with chloroform. The absorbance of each chloroform complex was measured at 470 nm, using a blank prepared in the same way but without atropine. This procedure enabled us to create a standard curve for precise quantification.

2.2.3 Estimation of Steroids: To measure the total steroid content, we adapted a method from Salomi et al. (2019). We transferred 1 ml of the steroid test extract into a 10 ml volumetric flask, then added 2 ml of 4N sulfuric acid and 2 ml of 0.5% w/v iron (III) chloride. Following that, 0.5 ml of 0.5% w/v potassium hexacyanoferrate (III) solution was added. The mixture was heated in a water bath at 70±2°C for 30 minutes, with occasional shaking, and then diluted to the mark with distilled water. The absorbance was measured at 780 nm against a reagent blank. The total steroids in the extracts were expressed as cholesterol equivalents (mg of CHO/g of extract).

2.2.4 Estimation of Flavonoids: For the determination of flavonoid content, we utilized a modified aluminum chloride colorimetric method based on Chang et al. (2002). We mixed 1 ml of the plant extract in methanol with 1 ml of methanol, 0.5 ml of 1.2% aluminum chloride, and 0.5 ml of 120 mM potassium acetate. This mixture was allowed to stand for 30 minutes at room temperature, after which the absorbance was measured at 415 nm. Quercetin was used as the standard, and the flavonoid content was expressed as quercetin equivalents (mg g^{-1} of extracted compound).

2.3 Estimation of Total Phenols: To determine the phenol content, we followed the Folin-Ciocalteu method described by Pearson (1979). We placed 1 ml of the extract into a test tube, then added 2.5 ml of 10% Folin-Ciocalteu's reagent and 2.5 ml of a 7.5% $NaHCO_3$ solution. The samples were incubated in a thermostat at 45°C for 45

minutes. Absorbance was measured using a spectrophotometer at 765 nm. Each sample was prepared in triplicate, and the average absorbance was calculated. The same procedure was performed for a standard solution of gallic acid to construct a calibration curve. The concentration of phenols was expressed as gallic acid equivalents (mg of GA/g of extract).

2.4 Tannin Content Determination: The tannin content was assessed using the Folin-Denis colorimetric method as outlined by Kirk and Sawyer (1998). A 5 g sample was dispersed in 50 ml of distilled water and shaken. The mixture was allowed to stand for 30 minutes at 28°C before being filtered through Whatman No. 42 filter paper. We then transferred 2 ml of the extract into a 50 ml volumetric flask. For the standard, 2 ml of a tannic acid solution and 2 ml of distilled water were placed in separate volumetric flasks. Saturated Na_2CO_3 solution (2.5 ml) was added to each flask, and the contents were brought to a final volume of 50 ml with distilled water. The flasks were incubated at 28°C for 90 minutes. Absorbance was measured at 765 nm using a spectrophotometer, calibrating with a reagent blank.

2.5 DNS Reducing Sugar Assay: This assay followed the modified protocols of Hussain et al. (2018) and Miller (1978). We took 1 ml of the plant sample and added 3 ml of DNSA, then boiled the mixture for 10 minutes. Absorbance was measured at 540 nm, with glucose (100 mg/ml) serving as the standard. The DNS reagent was prepared by dissolving 1.6 g of NaOH and 1.0 g of dinitrosalicylic acid (Sigma) in 70 ml of distilled water, heating until fully dissolved. Subsequently, 3.0 g of Na_2K tartrate (Sigma) was added, and the solution was swirled until dissolved, then diluted to 100 ml with distilled water. The reagent was stored in a dark place at room temperature. For the assay, 1 ml of the plant sample was again mixed with 3 ml of DNSA, boiled, and absorbance was recorded at 540 nm, using glucose as the standard.

2.6 Statistical Analysis: Data were statistically analyzed with descriptive statistics, Independent T test and Analysis of Variance (ANOVA) to determine significant difference at 5% level of acceptance. All data were expressed as mean ± Standard error of the mean.

3.0 Result

The results shown in Tables 4.1 along with Figure 4.1 as well as Table 4.2, highlight the qualitative and quantitative composition of dried powdered ginger (G) and cinnamon (C) in varied proportions. Each column offers important insights into the bioactive compounds present in these extracts.

G/C (g): This column indicates the ratio of ginger to cinnamon used in the extraction process. The ratios are (50:50), (70:30), and (30:70), denoting the proportion of ginger to cinnamon in grams. This ratio is crucial as it influences the extraction efficiency and the concentration of phytochemicals in the final product. The varying ratios allow for an assessment of how the balance of these two botanicals affects the yield of specific bioactive compounds.

4.0 Qualitative analysis

The results shown in Tables 4.1 along with Figure 4.1, highlight the qualitative composition of dried powdered ginger (G) and cinnamon (C) in varied proportions.

Table 4.1 presents the results of the qualitative analysis for both ginger and cinnamon. All three ratios (50:50, 70:30, and

30:70) contain tannins, as indicated by the "+" symbol. The (70:30) and (30:70) ratios show the presence of cardiac glycosides, while the (50:50) ratio does not. All three ratios (50:50, 70:30, and 30:70) are found to contain flavonoids. All three ratios (50:50, 70:30, and 30:70) also contain saponins. The table indicates that all three ratios (50:50, 70:30, and 30:70) include steroids. The (50:50) and (30:70) ratios demonstrate the presence of phlobatannins, whereas the (70:30) ratio does not. Table 4.1 shows that all three ratios (50:50, 70:30, and 30:70) contain phenols. The (50:50) and (70:30) ratios indicate the presence of reducing sugars, while the (30:70) ratio does not. The (70:30) and (30:70) ratios show the presence of anthraquinones, whereas the (50:50) ratio does not. All three ratios (50:50, 70:30, and 30:70) contain alkaloids.

The results shown in Tables 4.2, highlight the quantitative composition of dried powdered ginger (G) and cinnamon (C) in varied proportions.

Tannin (mg/100g). Table 4.2 indicates that the (50:50) ratio has the highest tannin concentration at 59.35±3.35 mg/100g ($p < 0.05$), followed closely by the (30:70) ratio at 55.07±3.35 mg/100g. The (70:30) ratio has the lowest concentration at 45.28±0.01 mg/100g ($p < 0.05$).

Cardiac Glycoside (mg/100g): The (30:70) ratio exhibits the highest ($p < 0.05$) concentration of cardiac glycosides at 93.91±0.38 mg/100g. The (50:50) and (70:30) ratios show lower ($p < 0.05$) levels at 90.21±1.31 mg/100g and 88.18±0.02 mg/100g, respectively ($p < 0.05$).

Flavonoid (mg/100g): Flavonoid concentrations for the (50:50) and (30:70) ratios are quite similar, measuring 20.42±0.01 mg/100g and 19.14±1.74 mg/100g, respectively. In contrast, the (70:30) ratio shows a lower ($p < 0.05$) concentration of 17.59±1.48 mg/100g.

Saponin (mg/100g): The (70:30) ratio has the highest ($p < 0.05$) saponin concentration at 15.01±0.02 mg/100g, followed closely by the (30:70) ratio at 14.96±0.17 mg/100g. The (50:50) ratio has a lower concentration of 12.06±0.0 mg/100g ($p < 0.05$).

Steroid (mg/100g): The (70:30) ratio displays the highest ($p < 0.05$) steroid content at 142.38±4.57 mg/100g, while the (50:50) and (30:70) ratios have slightly lower ($p < 0.05$) levels at 142.21±0.80 mg/100g and 140.44±5.27 mg/100g, respectively.

Phenol (mg/100g): The (50:50) ratio shows the highest ($p < 0.05$) phenol concentration at 88.10±2.67 mg/100g, while the (30:70) and (70:30) ratios have lower ($p < 0.05$) levels at 82.52±3.18 mg/100g and ND (not detected), respectively.

Reducing Sugar (mg/100g):The (50:50) and (70:30) ratios display similar levels of reducing sugars at 24.01±0.01 mg/100g and 24.01±1.16 mg/100g, respectively. The (30:70) ratio has a slightly higher concentration at 25.52±0.29 mg/100g ($p < 0.05$).

Alkaloid (mg/100g): In Table 4.2; Figure 4.1, the (70:30) ratio shows a high concentration of alkaloids at 15.01±0.02 mg/100g ($p < 0.05$), while the (50:50) and (30:70) ratios have lower ($p < 0.05$) levels at 12.06±0.0 mg/100g and 14.96±0.17 mg/100g, respectively.

Table 4.1: Qualitative Composition of Dried Powdered Ginger and Cinnamon in Varied Concentration*

G/C (g)	TANNIN	CARDIAC CALYEOSID	FLAVONOID	SAPONIN	STEROID	PHLOBA	PHENOL	REDUCING SUGAR	ANTHRAQUINONE	ALKALOID
50:50)	+	+	-	+	+	+	+	+	-	+
(70:30)	+	+	+	+	+	-	+	+	+	+
(30:70)	+	+	+	+	+	+	+	-	+	+

*Mean ± SEM, n= 6. Values with different superscripts are significantly different across column. $p < 0.05$ G= Ginger, C= Cinnamon

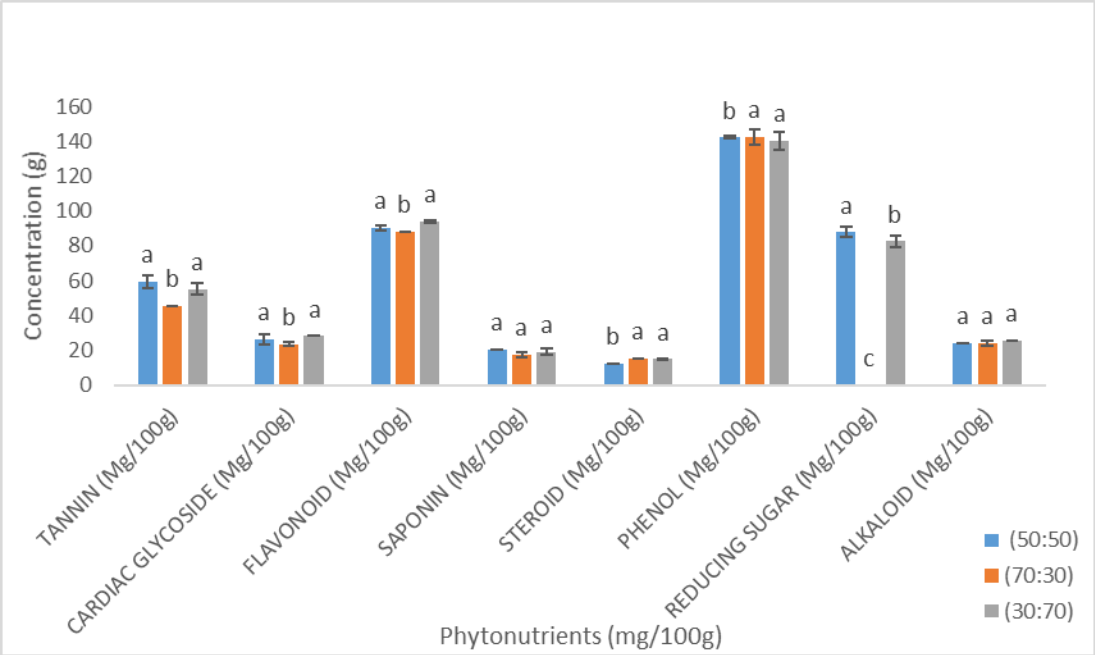

Figure 4.1: Quantitative Composition of Dried Powdered Ginger and Cinnamon in Varied Proportions*. *Mean ± SEM, n= 6. Values with different superscripts are significantly different across column. $p < 0.05$ G= Ginger, C= Cinnamon

Table 4.2: Quantitative Composition of Dried Powdered Ginger and Cinnamon in Varied Proportions*

G/C (g)	TANNIN (Mg/100g)	CARDIAC GLYCOSIDE (Mg/100g)	FLAVONOID (Mg/100g)	SAPONIN (Mg/100g)	STEROID (Mg/100g)	PHENOL (Mg/100g)	REDUCING SUGAR (Mg/100g)	ALKALOID (Mg/100g)
(50:50)	59.35±3.35^{a}	26.20±2.91^{a}	90.21±1.31^{a}	20.42±0.01^{a}	12.06±0.0^{b}	142.21±0.80^{b}	88.10±2.67^{a}	24.01±0.01^{a}
(70:30)	45.28±0.01^{b}	23.51±1.33^{b}	88.18 ±0.02^{b}	17.59±1.48^{a}	15.01±0.02^{a}	142.38±4.57^{a}	ND	24.01±1.16^{a}
(30:70)	55.07±3.35^{a}	28.10±0.02^{a}	93.91±0.38^{a}	19.14±1.74^{a}	14.96±0.17^{a}	140.44±5.27^{a}	82.52±3.18^{b}	25.52±0.29^{a}

*Mean ± SEM, n= 6. Values with different superscripts are significantly different across column. $p < 0.05$ G= Ginger, C= Cinnamon

5.0 Discussion

The ginger to cinnamon ratio can influence the concentration and presence of various phytochemicals in the extracts. The present results indicated by adjusting the ratio, it is possible to enhance or reduce the content of specific compounds, such as cardiac glycosides, phlobatannins, reducing sugars, and anthraquinones. Adjusting these ratios enables researchers and formulators to maximize the health benefits of these spices. Current studies suggest that the combined effects of ginger and cinnamon can boost their antioxidant and anti-inflammatory properties. This synergy makes them particularly valuable in dietary supplements and functional foods designed to help prevent chronic diseases (Shah *et al.*, 2023).

The presence of tannins (Table 4.1) across all ratios suggests that both ginger and cinnamon extracts can provide antioxidant benefits. The consistent presence of tannins in all formulations indicates their potential role in enhancing the therapeutic properties of ginger and cinnamon, as supported by studies showing that tannin-rich diets can contribute to improved health outcomes (Phung *et al.*, 2020). This suggests that regardless of the ginger to cinnamon ratio, the extracts will contain tannins, which may contribute to their therapeutic potential.

The detection of cardiac glycosides in the (70:30) and (30:70) ratios underscores the potential cardiovascular benefits of cinnamon, especially when it is used in larger amounts. This finding is consistent with research indicating that cinnamon can lower blood pressure and improve lipid profiles, thereby supporting cardiovascular health (Cheung *et al.*, 2020).

The presence of flavonoids (Table 4.1) in all ratios emphasizes the potential of ginger and cinnamon extracts to provide significant antioxidant protection. The consistent presence of flavonoids acropss the ratios suggest that both spices can be effective in promoting overall health, aligning with findings that a diet rich in flavonoids is associated with lower mortality rates (Jaremko et al., 2020). Suggesting that regardless of the ginger to cinnamon ratio, the extracts will have flavonoids, which are essential for maintaining overall health.

Saponins presence in all ratios (Table 4.1) indicates that ginger and cinnamon extracts can enhance immune response and potentially reduce cholesterol levels, contributing to cardiovascular health. This is supported by studies showing that saponins can lower serum cholesterol and improve lipid metabolism (Shalaby *et al.*, 2023). This suggests that the extracts could potentially enhance the immune system and help lower cholesterol levels, regardless of the ratio of ginger to cinnamon used. The consistent presence of steroids in the extracts (Table 4.1) indicates their potential role in managing inflammatory conditions, as supported by research demonstrating the anti-inflammatory effects of both ginger and cinnamon (Srinivasan, 2017). This suggests that the extracts may have anti-inflammatory effects due to the presence of steroids, which could be beneficial for various health issues and agrees with the report of Talabi, et al., (2024).

Phlobatannins are a type of tannin that can be found in plants. The presence of phlobatannins in the (50:50) and (30:70) ratios (Table 4.1) suggests that these extracts may have additional health benefits. Their presence indicates that a balanced ratio of ginger and cinnamon may enhance the overall therapeutic potential of the extracts.

The presence of phenolic compounds in all ratios indicates that both ginger and cinnamon extracts may offer substantial antioxidant protection, potentially lowering the risk of chronic diseases. This is consistent with existing research highlighting the health benefits of phenolic compounds in combating disorders related to oxidative stress (Ghasemzadeh & Ghasemzadeh, 2011; Talabi, et al., 2024). This suggests that the extracts may have antioxidant properties and potential anti-cancer effects due to the presence of phenolic compounds.

The presence of reducing sugars in the (50:50) and (70:30) ratios indicates that these extracts may have potential applications in food science, particularly in enhancing flavor and sweetness without adding significant calories. However, the absence of reducing sugars in the (30:70) ratio suggests that a higher proportion of ginger may be necessary to maintain sweetness, which could influence consumer preferences.

The presence of anthraquinones in the (70:30) and (30:70) ratios (Table 4.1) highlights their potential therapeutic applications. This indicates that raising the cinnamon content may enhance the therapeutic effects of the extracts, improving their effectiveness in products aimed at promoting digestive health (Wang *et al.*, 2011).

The consistent presence of alkaloids across all ratios (Table 4.1) indicates that both ginger and cinnamon may offer analgesic and anti-inflammatory benefits.This aligns with current findings that highlight the therapeutic potential of alkaloids in managing pain and inflammation (Parajuli *et al.*, 2022).

The result of the quantitative analysis (Table 4.2; Figure 4.1) further lent credence to the earlier observations of the qualitative analysis. The ratio of ginger to cinnamon significantly influenced the concentration of various photochemical in the extracts. The (50:50) ratio appeared to optimize the levels of tannins, flavonoids, and phenols, while the (30:70) ratio enhances cardiac glycosides and alkaloids. These findings suggest that specific ratios can be tailored to maximize the health benefits associated with ginger and cinnamon extracts, making them valuable for nutritional and therapeutic applications. The significance of differences in the concentrations across the ratios (indicated by different superscripts) emphasizes the importance of formulation in herbal preparations.

The significant difference ($p < 0.05$) in tannin levels suggests that a balanced ratio of ginger and cinnamon may enhance the extraction of these beneficial compounds. The significant difference in tannin levels suggests that a balanced ratio of ginger and cinnamon may enhance the extraction of these beneficial compounds. A review by Phung et al., (2020), highlights that tannins can prevent cardiovascular diseases, cancer, and osteoporosis due to their antioxidant capacity. Moreover, studies in animals have demonstrated that tannins can enhance the quality of meat and milk, indicating their wide-ranging biological functions (Jiang *et al.*, 2020). This aligns with the findings that a balanced ratio of ginger and cinnamon can enhance tannin extraction, potentially maximizing their health benefits.

Variations in cardiac glycoside content indicate that increasing the proportion of cinnamon relative to ginger may enhance the cardiac glycoside content, which could be

beneficial for cardiovascular health. Literature indicates that cardiac glycosides, such as digoxin, are used to treat conditions like atrial fibrillation and heart failure (Cheung et al., 2020). The ability of cardiac glycosides to enhance cardiac contractility makes them critical in cardiovascular therapy. The observed increase in cardiac glycosides with higher cinnamon content suggests that cinnamon may be a valuable addition to formulations aimed at cardiovascular health.

The flavonoid data suggests that a balanced ratio of ginger and cinnamon may be more effective in preserving flavonoid content, which is essential for maintaining overall health. Research highlights the health benefits of flavonoids, suggesting that a diet high in these compounds may reduce the risk of cardiovascular disease and certain types of cancer (Chembioagro, 2023). The findings that a balanced ratio preserves flavonoid content are consistent with literature emphasizing the importance of diverse flavonoid intake for optimal health benefits (Jaremko *et al.,* 2020). The results on Saponin indicate that increasing the amount of cinnamon in the mixture may enhance saponin levels, which could contribute positively to health benefits associated with these extracts. Current literature highlights the cholesterol-lowering effects of saponins and their potential anticancer properties (Shalaby *et al.,* 2023). Saponins are known to boost the immune system and may help in the prevention of chronic diseases. The rise in saponin levels associated with higher cinnamon content indicates that cinnamon might enhance the health benefits of a ginger-cinnamon blend.

The similar steroid concentrations across the ratios suggest that both ginger and cinnamon extracts are rich in steroid compounds, which may contribute to their therapeutic effects. Literature indicates that plant steroids play crucial roles in various body functions, including hormone production and maintaining cellular integrity (Axe, 2023). The presence of steroids in ginger and cinnamon extracts may enhance their anti-inflammatory and overall health-promoting properties, supporting the findings that these extracts are beneficial for health.

The significant presence of phenolic compounds in the (50:50) ratio highlights the potential of this combination for health-promoting effects. Studies indicate that phenolic compounds can help shield the body from oxidative stress and inflammation, both of which are associated with chronic diseases (Jaremko *et al.,* 2020; NCBI, 2021). The high phenolic content in the balanced ginger-cinnamon ratio suggests that this combination could be particularly effective in promoting health and preventing disease.

The results indicate that varying the ginger and cinnamon ratio may have a minimal effect on reducing sugar levels. While reducing sugars are essential for energy metabolism, their levels in herbal extracts may not significantly impact the health benefits of ginger and cinnamon. However, the presence of reducing sugars can affect the flavor and palatability of these extracts, which is important for consumer acceptance (NCBI, 2021).

The current results suggest that a higher proportion of cinnamon may enhance the alkaloid content, potentially increasing the therapeutic value of the extract. Research suggests that alkaloids have diverse physiological effects and are utilized in many medicinal applications (Parajuli *et al.,*

2022). The enhancement of alkaloid levels with increased cinnamon content suggests that this herb could contribute additional therapeutic benefits, supporting the use of ginger and cinnamon extracts in traditional medicine.

These findings suggest that specific ratios can be tailored to maximize the health benefits associated with ginger and cinnamon extracts, making them valuable for nutritional and therapeutic applications. The significance of differences in the concentrations across the ratios (indicated by different superscripts) emphasizes the importance of formulation in herbal preparations.

6.0 Conclusion

Ginger and cinnamon extracts' ratios impact phytochemical levels, offering tailored health benefits. Optimizing these ratios could enhance therapeutic potential, supporting dietary and therapeutic uses.

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Declaration of Conflict of Interest

The authors declare no conflict of interest.

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