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Comparative study of phytochemical composition and antioxidant activity of two spices consumed in korhogo region (Côte d'ivoire): Ginger (*Gingiber officinale*) and Black Pepper (*Piper nigrum*)

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Abstract
Ginger (*Zingiber officinale*) and black pepper (*Piper nigrum*) are two widely used spices in Côte d'Ivoire, valued both for their aromatic qualities and their medicinal properties. These plants are rich in bioactive phytochemical compounds such as polyphenols, flavonoids, known for their health benefits, particularly their antioxidant potential. The objective of this study is to evaluate and compare the phytochemical composition and antioxidant activity of ginger and black pepper consumed in Korhogo.
Samples of ginger and black pepper were collected from local markets, dried, ground into powder, and subjected to methanolic and hydroethanolic extractions. Total phenolic content, total flavonoids, and condensed tannins were determined using standard spectrophotometric methods. Antioxidant activity was assessed using DPPH assay.
The results show that ginger contains a higher level of total phenolic compounds (243.03 ± 0.60 mg GAE/gE) and condensed tannins (16.32 ± 0.74 mg CE/gE), whereas black pepper is richer in flavonoids (57.10 ± 0.85 mg QE/gE). Both spices exhibit significant antioxidant activity, although ginger demonstrated a higher free radical scavenging capacity. These differences may be attributed to their specific chemical compositions and the agroecological conditions of the Korhogo region.
This study highlights the potential of local spices as natural sources of antioxidants and underscores their relevance in functional nutrition and the prevention of oxidative stress-related diseases.

Keywords: Ginger, black pepper, antioxidant activity, functional foods

Introduction

Spices have à long history of both culinary use and health benefits [1]. In Cote d'Ivoire Ginger (*Zingiber officinale*) and black pepper (*Piper nigrum*) are two plants used as spices. Ginger is commonly referred to as "gnanmankou" [2] and widely distributed in markets and streets. *Piper nigrum* is one of the most commonly used spices and considered as ''The King of spices'' among various spices [3].

Natural products have been used in traditional medicines for thousands of years, and have shown promise as à source of components for the development of new drugs [4, 5]. According to Braga *et al*. (2018) [6], Bioactive compounds are natural constituents of plant materials that promote health, contribute to the proper functioning of the body and act in the prevention and/or control of disease. The consumption of these compounds favors the organism either by its antioxidant and cytotoxic activity or by action on the immune system, diabetes, cancer or coronary diseases [7]. Due to the possible toxicity of synthetic antioxidants, the potential of plant products to serve as antioxidants to protect against various diseases induced by free radicals has been explored [8]. They found literally thousands of phytochemicals from plants as safe and broadly effective alternatives with less adverse effect [9]. Korhogo, a city located in the Poro region in northern Côte d'Ivoire, is an important area for the production and consumption of ginger and black pepper. However, there are still few specific studies on the phytochemical profiles and antioxidant properties of these spices from this particular region. A better understanding of their bioactive profiles would not only enhance the scientific value of these local resources but also promote their use in nutritional and health interventions.

This study thus aims to carry out a comparative analysis of the phytochemical composition and antioxidant activity of ginger and black pepper consumed in Korhogo, in order to better understand their functional potential and health benefits.

Materials and Methods

1. Plant Materials

The samples of *Zingiber officinale* (ginger rhizome) and *Piper nigrum* (black pepper fruits) were procured from the local market in Korhogo (Côte d'Ivoire). The plant materials were cleaned, air-dried at room temperature (25 ± 2 °C) for 10 days, and ground into fine powder using a mechanical grinder. The powders were stored in airtight containers at 4 °C until extraction.

Methods

1. Preparation of Extracts

Hydroethanolic extracts were prepared by maceration. 20 g of powdered sample was mixed with 200 mL of 70% ethanol (v/v) and stirred for 48 hours at room temperature. The mixture was then filtered through Whatman No.1 filter paper, and the filtrate was concentrated under reduced pressure at 40 °C using a rotary evaporator (Buchi, Switzerland). The dry extracts were stored at −20 °C until further analysis.

2. Total polyphenol content determination

The total polyphenol content was determined using the Folin-Ciocalteu colorimetric method [10]. To 1 ml of each

extract, 1.5 ml of Na_2CO_3 (17%, w/v) and 0.5 ml of Folin-Ciocalteu reagent (0.5N) were added. The mixture was incubated at 37°C for 30 minutes ; absorbance was read at 760 nm against a blank without extract as the reference. Quantification of total polyphenols was based on a linear calibration curve (y = ax + b) prepared using gallic acid standard at various concentrations (0 to 1000 µg/ml) under the same conditions as the sample. Results are expressed in milligrams of gallic acid equivalents per gram of sample (mg GAE/gE).

The total polyphenol content (Q) is calculated using the following formula :

Q = Cf * d / Ci (mg GAE/gE)

Cf : concentration of the extract in gallic acid equivalent (mg GAE/ml) ; d : dilution factor ; Ci : concentration of the analyzed extract (g/ml)

3. Total flavonoid content determination

This assay was performed according to the method used by Arvouet-Grand *et al*. (1994) [11]. 500 µL of 2% aluminum chloride ($AlCl_3$) in methanol were added to an equal volume of extract. After 10 minutes of incubation, absorbance was measured at 415 nm using a spectrophotometer. Quercetin (0-100 µg/L), used as the standard, allowed for the preparation of the calibration curve. Three (3) tests were performed for each extract, and the result is the average of the three readings. Results are expressed in milligrams of quercetin equivalent per gram of sample (mg QE/gE), determined using the following formula :

Q = Cf * d / Ci (mg QE/gE)

Cf : concentration of the extract in quercetin equivalent (mg/ml) ; d : dilution factor ; Ci : concentration of the analyzed extract (g/ml)

4. Condensed tannin content determination

Condensed tannin content in the various extracts was determined using the method described by Heimler *et al*. (2006) [12]. For 400 µL of each sample or standard, 3 ml of a 4% methanolic vanillin solution and 1.5 ml of concentrated hydrochloric acid were added. The mixture was incubated for 15 minutes, and absorbance was read at 500 nm. Condensed tannin concentrations were calculated using standard curves prepared with catechin (0-300 µg/ml), and results are expressed in milligrams of catechin equivalent per gram of sample (mg CE/gE).

Q = Cf * d / Ci (mg CE/gE)

Cf : concentration of the extract in catechin equivalent (mg CE/ml) ; d : dilution factor ; Ci : concentration of the analyzed extract (g/ml)

5. Evaluation of Antioxidant Activity by Spectrophotometry

The method used was that of Blois *et al*. (1958) [13], with slight modifications. DPPH was dissolved in absolute ethanol to obtain a 0.03 mg/ml solution. Various concentrations of each extract were prepared in absolute ethanol. In dry and sterile tubes, 1 ml of the extract solution was mixed with 2 ml of DPPH solution. After shaking, the tubes were kept in the dark for 30 minutes. Absorbance was measured at 517 nm against a blank consisting of 2 ml of DPPH solution + 1 ml of ethanol. The positive control used was ascorbic acid (vitamin C), prepared under the same conditions as the samples.

The percentage of DPPH inhibition was calculated using the following formula :

% Inhibition = [(A_control - A_sample) / A_control] × 100

6. Statistical Analysis

All analyses were performed in triplicate. Results are expressed as mean ± standard deviation. Statistical comparisons were carried out using Statistica 7.1 software. One-way ANOVA followed by Tukey's post-hoc test was used to compare the means ($p < 0.05$ was considered statistically significant).

Results

1. Total phenolic content

The total phenolic content for ginger and black pepper extracts is presented in Table 1. The values are 243.03 ± 0.60 mg GAE/g extract and 127.09 ± 1.43 mg GAE/g extract respectively for ginger and black pepper extracts.

2. Total Flavonoid Content

As shown in Table 1, The values are 46.33 ± 0.85 mg QE/g extract and 57.10 ± 0.85 mg QE/g extract respectively for ginger and black pepper extracts.

3. Condensed tannin content

The condensed tannin content for ginger and black pepper extracts is presented in Table 1. The values are 16.32 ± 0.74 mg CE/g extract and 1.58 ± 0.25 mg CE/g extract respectively for ginger and black pepper extracts.

Table 1 : Total Phenolic, Flavonoid and Condensed Tannin Content of Ginger and Black Pepper Extracts

Phytochemical compounds	Ginger	Black pepper
Total Phenolic Content (MgGAE/gE)	243.03 ± 0.60^a	127.09 ± 1.43^b
Total Flavonoid Content (MgQE/gE)	46.33 ± 0.85^b	57.10 ± 0.85^a
Condensed tannin content (mg CE/gE)	16.32 ± 0.74^a	1.58 ± 0.25^b

Data are represented as means ± SD (n=3). Means in the lines with no common superscript differ significantly ($p < 0.05$).

DPPH Radical Scavenging Activity

The DPPH assay results (Figure 1 and 2) show that as concentrations increase, inhibition percentages increase. However, at the same concentration, the inhibition percentage of ginger extract is higher than that of black pepper.

Discussion

The present study aimed to compare the phytochemical composition and antioxidant activity of ginger (*Zingiber*

officinale) and black pepper (*Piper nigrum*) consumed in Korhogo, Côte d'Ivoire. The results revealed that both spices Are rich in bioactive compounds, but they exhibit different phytochemical profiles and antioxidant potentials. Ginger extract showed a significantly higher phenolic content (243.03 ± 0.60 mg GAE/g extract) compared to black pepper extract (127.09 ± 1.43 mg GAE/g extract) ($p < 0.05$). These results align with previous studies reporting high phenolic content in ginger due to the presence of gingerols and shogaols, which contribute to its antioxidant properties [14]. On the other hand, The flavonoid content was higher in black pepper (57.10 ± 0.85 mg QE/g extract) ($p < 0.05$) than in ginger (46.33 ± 0.85 mg QE/g extract) corroborating the observations of Singh *et al*. (2021) [15], who highlighted the abundance of flavonoids and the alkaloid piperine in *Piper Nigrum* as major contributors to its bioactivity. Flavonoids Are important antioxidants that can scavenge free radicals and chelate metal ions. Antioxidant activity assay (DPPH) results (Figure 1 and 2) show that ginger extract exhibited stronger radical scavenging activity compared to black pepper. This superior activity of ginger may be attributed to the higher concentration of polyphenols in ginger, as well as the presence of potent bioactives like 6-gingerol [16]. Phenolic compounds are effective hydrogen donors and can neutralize free radicals [17]. The results show that the phenolic compounds in ginger play a more decisive role than the flavonoids in black pepper in neutralizing DPPH radicals. These results are consistent with previous reports that ginger has a notable ability to neutralize free radicals [18].

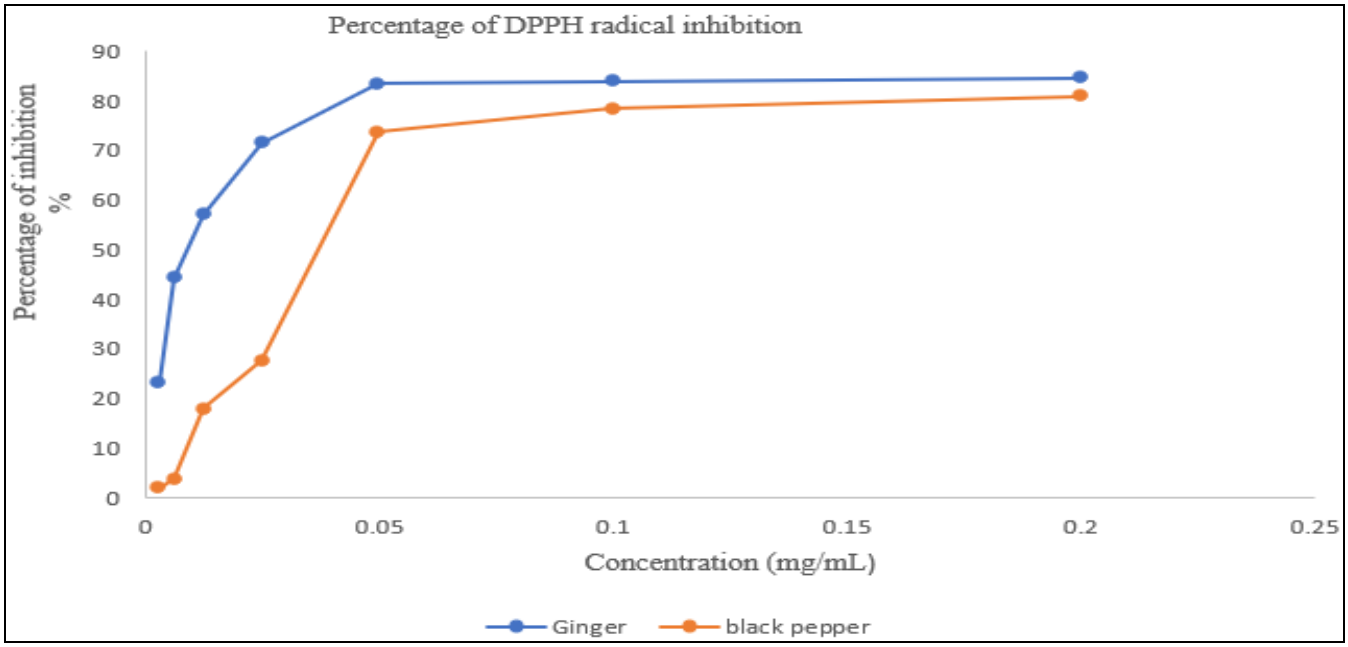

Fig 1 : Percentage of DPPH radical inhibition

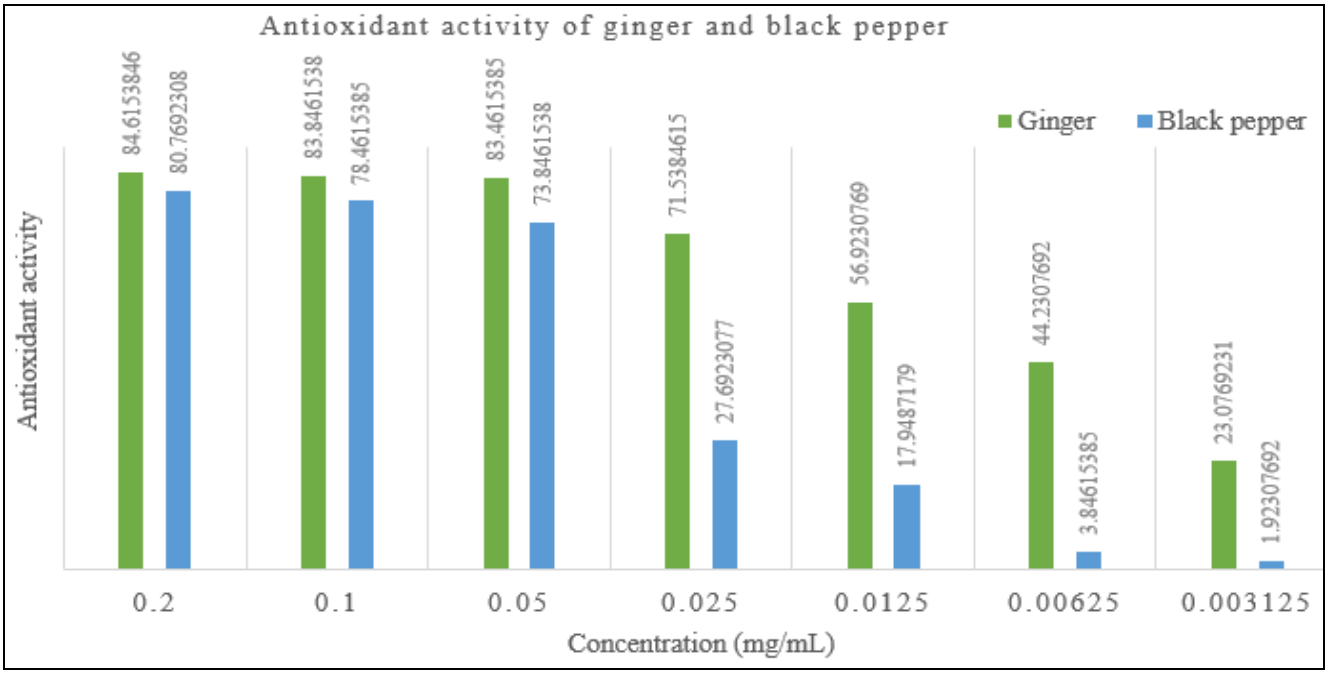

Fig 2 : Antioxidant activity of ginger and black pepper

Conclusion

This comparative study highlighted the richness of ginger (*Zingiber officinale*) and black pepper (*Piper nigrum*) in bioactive compounds, particularly phenolic compounds and flavonoids, and evaluated their antioxidant activity. The results showed that ginger contains significantly higher concentrations of total phenolic compounds. Ginger also Demonstrated superior antioxidant activity in the DPPH test. These results confirm that ginger is an important source of natural antioxidants, thanks to the presence of molecules such as 6-gingerol and 6-shogaol. Black pepper, although less rich in antioxidants, still has significant potential, mainly attributable to piperine.

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