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Antioxidant Activity of Aqueous Extract of Ginger (Zingiber Officinale W. Roscoe) and Margosa (Azadirachta Indica A. Juss) in the Districts of Nampula and Angoche

Atividade Antioxidante do Extrato Aquoso de Gengibre (*Zingiber Officinale* W. Roscoe) e Margosa (*Azadirachta Indica* A. Juss) nos Distritos de Nampula e Angoche

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Abstract
Antioxidants are substances that, when present in the body, compromise the harmful action of free radicals. These radicals are considered major cause of various chronic no communicable diseases like inflammation, malignant tumors, cardiovascular diseases, cancer as well as accelerate the aging process. Epidemiological studies state that proper intake of plant products reduces the risk of a variety of chronic diseases caused by these substances. Effect, attributed to compounds that have antioxidant activity in plants: vitamins A, C and E, phenolic compounds, especially flavonoids and carotenoids. The rhizome of the Ginger and the plant of Margosa are vegetables that had the capacity to fight the radicals. From

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this, we aimed to analyze the antioxidant activity of aqueous extract of Ginger and Margosa in the prevention of diseases caused by free radicals. As regards the analysis of the antioxidant property, the hydroalcoholic extract of the leaves of A. indica and of zingiber officinale W. Roscoe method of the phosphomolybdenum ammonium were obtained. The results obtained for ABTS activity (200.37 ± 0.59a and 152.86 ± 0.95b mg VCEAC 100g-1), phenolic compounds (201.48 ± 1.46a and 196.34 ± 0.59b GAE), vitamin A (2322.00 ± 12.00a and 0.00 ± 0.00 b (61.74 ± 1.38a and 82.01 ± 1.74b%) and minerals detected and studied are: calcium presented the highest content in Margosa (180.87 ± 5.40 e 3.60 ± 0.56b mg / 100g) (874.00 mg/L), followed by potassium (271.50 mg/L), magnesium (172.78 mg/L) and sodium (22.81), Ginger showed higher value (412.50 mg/L), zinc and iron (48.00 and 19.01 mg/L). these results show clearly that the extract of Margosa presented good antioxidant capacity when compared with the extracts of Ginger, as it can be verified there were statistically significant differences between the two treatments. These components present in these vegetables are those that showed an interest for the discussion of the results in relation to the prevention of chronic no communicable diseases.

Keywords: *free radicals, Margosa, Ginger, antioxidant activity and Health.*

Resumo

Os antioxidantes são substâncias que inibem os efeitos nocivos dos radicais livres, responsáveis pelo desenvolvimento de doenças crônicas não transmissíveis, como inflamações, tumores malignos, doenças cardiovasculares e cancro, além de acelerarem o envelhecimento. O presente estudo teve como objetivo analisar a atividade antioxidante dos extratos aquosos de Gengibre (*Zingiber officinale* W. Roscoe) e Margosa (*Azadirachta indica*) pelo método do fosfomolibdênio de amônio. Os resultados obtidos foram: atividade antioxidante ABTS (200,37 ± 0,59ᵃ e 152,86 ± 0,95ᵇ mg VCEAC 100 g^{-1}), compostos fenólicos (201,48 ± 1,46ᵃ e 196,34 ± 0,59ᵇ GAE), vitamina A (2322,00 ± 12,00ᵃ e 0,00 ± 0,00ᵇ µg de retinol/L) e vitamina C (180,87 ± 5,40ᵃ e 3,60 ± 0,56ᵇ mg/100 g). A Margosa apresentou teores mais elevados de cálcio (874,00 mg/L), potássio (271,50 mg/L), magnésio (172,78 mg/L) e sódio (22,81 mg/L), enquanto o Gengibre destacou-se pelo potássio (412,50 mg/L), zinco (48,00 mg/L) e ferro (19,01 mg/L). Observou-se maior capacidade antioxidante na Margosa, com diferenças estatisticamente significativas entre os extratos, evidenciando o potencial desses vegetais na prevenção de doenças crônicas não transmissíveis.

Palavras-chave: *radicais livres; Margosa; Gengibre; atividade antioxidante; saúde.*

1. INTRODUCTION

Various biochemical processes that occur in the human body result in the formation of free radicals, which cause cellular damage and contribute to the development of several diseases, such as inflammation, malignant tumors,

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cardiovascular diseases, and cancer, in addition to accelerating the aging process (FERREIRA et al., 2020; RAHMAN; ADEN; KIM, 2023).

According to a report by the World Health Organization (WHO, 2002), high blood pressure, elevated cholesterol levels, physical inactivity, and low intake of fruits and vegetables are the main risk factors for the development of noncommunicable diseases (NCDs), such as cancer, cardiovascular diseases, diabetes, hypertension, and obesity. Currently, NCDs are the leading cause of death in several regions and, if not controlled, will continue to result in economic productivity losses and increased healthcare costs.

With the epidemiological rise of NCDs, there is growing interest in plant-based products that contain nutrients with antioxidant functions, such as ascorbic acid (vitamin C), β-carotene, α-tocopherol, zinc, flavonoids, and selenium. The skin, a highly metabolic tissue, is one of the main targets of damage caused by free radicals, leading to skin aging. Both in vivo and in vitro studies indicate a correlation between aging and the decrease of enzymatic and non-enzymatic antioxidant agents, resulting in an increase in reactive oxygen species (PREVEDELLO & COMACHIO, 2021).

To defend itself from such damage, the body produces antioxidants; however, endogenous production is often insufficient, since exogenous factors such as industrial emissions, vehicle exhaust gases, and cooking processes increase the formation of free radicals. Thus, it becomes necessary to ingest natural or synthetic antioxidants, such as BHA (2,3-tert-butyl-4-hydroxyanisole), BHT (2,6-di-tert-butyl-p-cresol), TBHQ (tert-butylhydroquinone), and propyl gallate. However, studies have reported that these synthetic antioxidants may cause adverse effects, including the development of cancer (PREVEDELLO & COMACHIO, 2021).

In general, antioxidants are natural molecules that prevent the uncontrolled formation of free radicals and reactive oxygen species or inhibit their reaction with biological structures. These compounds interrupt chain reactions, forming low-reactivity radicals and stable products, and can be regenerated by other antioxidants (AFONSO, 2010; VIEIRA, 2015).

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Current studies focus on the identification of natural antioxidants. To achieve efficient protection, tissues possess an integrated antioxidant system composed of liposoluble elements (vitamin E, carotenoids), water-soluble elements (ascorbic acid, glutathione), and enzymatic compounds (glutathione peroxidase, superoxide dismutase, catalase) (DOS SANTOS, M. P. & DE OLIVEIRA, 2014).

Information collected from health professionals in Nampula Province, Mozambique, indicates a high number of patients with problems related to free radicals. Therefore, this research aimed to evaluate the antioxidant activity of aqueous extracts of Ginger (*Zingiber officinale W. Roscoe*) and Margosa (*Azadirachta indica A. Juss*) in preventing diseases caused by free radicals, considering that the body requires adequate levels of antioxidant substances capable of delaying oxidation through radical inhibition or metal complexation (PREVEDELLO & COMACHIO, 2021).

According to the WHO, in 2012 about 16 million people died prematurely from NCDs, with 82% of these deaths occurring in low- and middle-income countries. In these regions, including 54 African countries, an “epidemiological transition” is observed, characterized by a reduction in deaths from infectious causes and an increase in chronic diseases associated with risk factors such as smoking, excessive alcohol consumption, inadequate diets, and physical inactivity.

1.1. Phenolic Compounds

Phenolic compounds are chemical substances characterized by the presence of hydroxyl groups attached to aromatic rings, which may occur in simple or polymeric forms, giving them high antioxidant power. These compounds can be of natural or synthetic origin and, when present in plants, may exist in free forms or complexed with sugars and proteins (ZIMMERMANN; KIRSTEN, 2008).

Among the main phenolic compounds are flavonoids (anthocyanins, flavonols and their derivatives), phenolic acids (benzoic, cinnamic, and their derivatives), simple phenols, coumarins, tannins, lignins, and tocopherols—the most common natural phenolic antioxidants (ROSA, DOS SANTOS PAULO, ERNESTO & MÁRIO, 2025; ZIMMERMANN; KIRSTEN, 2008).

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The anticarcinogenic activity of phenolic compounds is related to the inhibition of several types of cancer, such as colon, esophagus, lung, liver, breast, and skin cancers. Resveratrol, quercetin, caffeic acid, and flavonols are among the most prominent compounds in this effect (ZIMMERMANN; KIRSTEN, 2008).

1.2. Ginger

Ginger (Zingiber officinale W. Roscoe) is a species described in 1807 by William Roscoe and belongs to the family Zingiberaceae. It is widely used as a spice and medicinal plant and is known in Greek as Zinziberi (EMERENCIANO et al., 2013). The part used is the rhizome, which has an ochre and spicy flavor, and is employed in both traditional and modern medicine, being included in several pharmacopeias, such as those of the United Kingdom, Europe, China, and Japan (WOHLMUTH et al., 2005; NAGENDRA et al., 2013).

The bioactive compounds present in ginger have shown efficacy in relieving symptoms of chronic inflammatory diseases, such as ulcerative colitis and rheumatoid arthritis, due to their anti-inflammatory, antitumor, antioxidant, bactericidal, and antiviral properties (NAGENDRA et al., 2013). Furthermore, the plant is traditionally used in the treatment of respiratory diseases, such as asthma, and acts as an expectorant and antispasmodic, also assisting in cases of arthritis and rheumatism (BALIGA et al., 2011; PALATTY et al., 2013).

Ginger phytochemicals reduce the presence of undesirable oxidative agents in the body, preventing the accumulation of nitric oxide, superoxides, hydrogen peroxide, and other free radicals associated with various pathologies (BALIGA et al., 2011).

1.3. Margosa

Margosa (Azadirachta indica A. Juss) belongs to the family Meliaceae, the same as mahogany. It is a medium to large-sized tree, reaching between 15 and 20 meters in height, with a semi-straight or straight trunk ranging from 30 to 80

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centimeters in diameter, exhibiting fissures and reddish-brown scaly bark. The crown can vary between 8 and 12 meters in diameter, reaching up to 15 meters in isolated trees (SILVA, 2010).

It is a species of great medicinal and ecological importance, widely studied for its antibacterial, antifungal, antiparasitic, and antioxidant properties.

1.4. Potential Uses of Azadirachta indica

The potential uses of Azadirachta indica are extensive, encompassing virtually all parts of the plant (MOSSINI; KEMMELMEIER, 2005). The main product derived from this species is the oil extracted from its seeds, which contains various bioactive compounds, with azadirachtin being the most important. In addition to the seeds, the leaves, branches, roots, wood, and bark also have therapeutic and industrial applications (NEVES et al., 2013).

The plant exhibits a wide range of biological functions, attributed to its diverse set of bioactive compounds. Although the exact composition of Margosa extract has not yet been fully determined, the water-soluble components of its leaves have shown efficacy in controlling several diseases, including cancer (EMERENCIANO et al., 2013; AYUSTANINGWARNO et al., 2024). Studies have reported its antiseptic, wound-healing, antiulcer, anti-inflammatory, antifertility, hypolipidemic, and hepatoprotective activities (AZEVEDO et al., 2015).

Among these properties, the hepatoprotective effect of Margosa leaves is noteworthy, demonstrated when administered as a pretreatment before the use of paracetamol. Moreover, the antibacterial action of Margosa oil has been demonstrated in vitro against several pathogenic bacteria, through inhibition of bacterial cell membrane synthesis (EMERENCIANO et al., 2013; AYUSTANINGWARNO et al., 2024).

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2. Materials and Methods

This study was conducted through a quantitative, exploratory, descriptive, and experimental research approach, with the objective of evaluating the antioxidant activity of aqueous extracts of ginger (*Zingiber officinale W. Roscoe*) and Margosa (*Azadirachta indica A. Juss*) in the prevention of diseases caused by free radicals.

Data collection techniques included interviews with the population and healthcare professionals, as well as laboratory analyses of A. indica leaves and Z. officinale rhizomes. The ginger samples were purchased at the Waresta Market in the city of Nampula, while Margosa leaves were collected in the districts of Nampula and Angoche, in August 2018. The analyses were carried out at the Chemical Engineering Department Laboratory of Eduardo Mondlane University, the Biology and Chemistry Laboratory of Pedagogical University of Nampula, and the Food Hygiene and Safety Laboratory of Lúrio University. Data were analyzed using the SISVAR statistical program, adopting a 5% significance level ($\alpha = 0.05$).

2.1. Physicochemical Analyses

Moisture content was determined using 10.0528 g of fresh Margosa leaves, dried at 105 °C until constant weight, following the methodology established by the Portuguese Standard (NP). Ash content was obtained by calcination of the samples at 505 °C for four hours in a muffle furnace, also according to NP protocol (1994).

The pH was determined using 10 g of fresh ginger sample, diluted in 100 mL of distilled water and homogenized for 15 minutes, with direct measurement using a pH meter electrode. Total titratable acidity was determined by titrating 10 g of ground sample with a 0.1 N NaOH standard solution, using phenolphthalein as an indicator (NP, 1994).

For total sugar determination, the method involved acid hydrolysis and neutralization, followed by clarification and centrifugation, according to the protocols described by NP (1994). Water activity (Aw) was measured using 10 g of sample with a specific instrument for this purpose.

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2.2. Antioxidant Activity Analysis Procedures

For the preparation of the hydroalcoholic extract, the plant material (leaves of A. indica and ginger rhizomes) previously dried at 40 °C and ground was subjected to extraction by percolation for 24 hours using an ethanol/water (7:3) solution in a total volume of 5 L. The extract was then filtered and concentrated using a rotary evaporator (EMERENCIANO et al., 2013; AYUSTANINGWARNO et al., 2024).

The determination of antioxidant activity was based on the ammonium phosphomolybdate method, chosen for its simplicity and accessibility of reagents. This method is based on the formation of a phosphomolybdenum complex in an aqueous medium, which exhibits a yellow color when oxidized and gradually turns green as it is reduced by antioxidant substances—the more intense the green coloration, the higher the antioxidant activity of the sample. For comparison, a standard solution of ascorbic acid (vitamin C) was used (EMERENCIANO et al., 2013; AYUSTANINGWARNO et al., 2024).

The reagent for complex formation was prepared using 0.1 mol L^{-1} sodium phosphate (28 mL), 0.03 mol L^{-1} ammonium molybdate (12 mL), and 3 mol L^{-1} sulfuric acid (20 mL), with the final volume completed to 100 mL with distilled water. The samples and standard were prepared at a concentration of 200 µg mL^{-1}, and aliquots of 0.4 mL of each solution were added to 4 mL of reagent. The blank consisted of 0.4 mL of distilled water and 4 mL of reagent. All analyses were performed in triplicate, with incubation at 95 °C for 90 minutes, and antioxidant activity was expressed relative to ascorbic acid (EMERENCIANO et al., 2013).

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Determination of Vitamin C

the determination of vitamin C followed the spectrophotometric method based on the reduction of cupric ions, suitable for quantifying ascorbic acid in pigmented, natural, or processed foods. Samples of 50 g of Margosa leaves were homogenized in a blender with 100 mL of 5% metaphosphoric acid solution. After filtration and successive dilutions, chloroform, buffer solution, and complexing reagent were added.

The samples were shaken, separated into layers, and analyzed at 545 nm using a spectrophotometer, with a blank as reference. The same procedure was applied to ginger samples. The standard curve was prepared using solutions containing 10 to 50 µg of ascorbic acid (ABCAM, Ascorbic Acid Assay Kit Protocol Book, 2023).

2.3. Determination of Minerals

For mineral analysis, 5 g of dried A. indica leaves were incinerated in a muffle furnace at 550 °C for 6 hours. The resulting ashes were dissolved in 5 mL of nitric acid and the volume was completed to 100 mL with distilled water. The resulting solutions were analyzed for the elements calcium (Ca), lead (Pb), copper (Cu), chromium (Cr), iron (Fe), magnesium (Mg), manganese (Mn), nickel (Ni), potassium (K), sodium (Na), and zinc (Zn).

3. Presentation and Discussion of Results

The research was conducted in two complementary stages. The first consisted of interviews with citizens and healthcare professionals to identify the traditional knowledge and use of *Zingiber officinale* (Ginger) and *Azadirachta indica* (Margosa). The second stage involved laboratory analyses of the obtained extracts to characterize the physicochemical parameters and antioxidant capacity of the studied species.

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Table 1. Results of interviews conducted with citizens

No.	Questions	Answers	Percentage (%)
1	What type of food does the population consume most frequently?	Cereals	100
2	Do you know the rhizome of Ginger and the Margosa plant?	Seven (7) respondents stated that they know the Ginger rhizome	70
		Two (2) know both the Ginger rhizome and the Margosa plant	20
		One (1) has never heard of them	10
3	Do you know the health benefits of Ginger and Margosa?	Two (2) respondents stated that they know the health benefits of Ginger and Margosa	20
4	Do health professionals talk about the prevention of non-communicable diseases using vegetables with antioxidant power?	Three (3) respondents stated that they are recommended in critical situations	30
		Seven (7) respondents said that such recommendations were never mentioned, even in critical situations	70

Source: Authors (2018)

Table 02. Results of the questionnaire applied to health professionals

No.	Question	Answer	Percentage (%)
1	How do you interpret the massive emergence of chronic non-communicable diseases?	Lack of adequate nutrition	100
2	Have you ever heard about the antioxidant power of the Ginger rhizome and the Margosa plant?	No	80
		Heard only about the Ginger rhizome	20
3	Is there any program that promotes the use of native plants as food supplements?	None exist	90
		Some exist	10

Source: Authors (2018)

According to the responses to questions two (2) and three (3) of the interviews directed to citizens, combined with question two (2) of the questionnaire addressed to health professionals, it can be inferred that most of the population of Nampula Province particularly the residents of the studied districts does not use ginger or Margosa in their diet, since health professionals demonstrated a lack of information regarding the nutritional value of these plants.

The results from questions four (4) and three (3) of Tables 01 and 02, respectively regarding the encouragement of using native plants as food

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supplements for the prevention of chronic non-communicable diseases show that 70% of respondents reported not knowing the function of these plants in the human body, and most are particularly unfamiliar with Margosa. Furthermore, 90% stated that there are no incentives for the consumption of such plants, especially those analyzed in this study, which clearly demonstrates the insufficient knowledge about vegetables with antioxidant potential.

According to data from the global "5 a Day" campaign, the daily consumption of at least five servings of fruits and vegetables is essential for the prevention of chronic non-communicable diseases, as these foods are important sources of vitamins, phenolic compounds, carotenoids, minerals, and fibers, which effectively contribute to good nutrition and the neutralization of free radicals (RIBEIRO, 2018).

Physicochemical Analysis of the Extracts

Table 03. Results of the physicochemical analysis of the extracts

Variables	Treatments		Cv (%)
	Margosa Extract*	Ginger Extract*	
Moisture (%)	61.74 ± 1.38^a	82.01 ± 1.74^b	2,18
Aw	0.81 ± 0.03^a	0.99 ± 0.02^b	3,08
Ash (%)	6.29 ± 0.41^a	4.09 ± 0.72^b	11,24
pH	6.38 ± 0.06^a	6.14 ± 0.11^b	1,44
Titratable acidity (TA) (g citric acid/100 g)	3.07 ± 0.35^a	4.23 ± 0.12^b	7,16

*Values represent mean ± standard deviation. Means sharing the same letter in the same row are not significantly different (Tukey's test, $p < 0.05$).

Source: Authors (2018)

The physicochemical results (Table 3) showed significant differences between the analyzed extracts. The moisture content was 61.74 ± 1.38% in Margosa and 82.01 ± 1.74% in ginger, suggesting greater susceptibility to deterioration in the latter due to its high-water content. Oliveira et al. (2021) observed similar values in ginger rhizomes cultivated in different regions of Brazil, with moisture contents ranging from 72.3% to 86.2%, corroborating the tendency for high instability of this plant matrix. In the leaves of A. indica, EMERENCIANO et al.

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(2013) reported a moisture content of 68.0%, a value close to that obtained in this study, indicating that this species also exhibits high water activity (Aw = 0.81 ± 0.03).

The ash content was higher in Margosa (6.29 ± 0.41%) compared to ginger (4.09 ± 0.72%), indicating a greater concentration of minerals in the former. Similar results were reported by OLIVEIRA et al. (2021), who found ash contents ranging from 5.49% to 7.66% in ginger rhizomes cultivated under different conditions. These findings reinforce that environmental factor, such as soil and climate, can directly influence the mineral composition of plants.

The pH values observed were 6.38 ± 0.06^a for Margosa and 6.14 ± 0.11^b for ginger, indicating low acidity and, consequently, susceptibility to microbial attack. Titratable acidity showed values of 3.07 ± 0.35^a (Margosa) and 4.23 ± 0.12^b (ginger), consistent with the pH values obtained.

Bioactive Compounds and Antioxidant Capacity

Table 04. Results of the analysis of the antioxidant capacity of the extracts

Variables	Treatments		Cv (%)
	Margosa Extract*	Ginger Extract*	
ABTS (mg VCEAC $100g^{-1}$)	200.37 ± 0.59^a	152.86 ± 0.95^b	0,45
Total phenolics (mg GAE $100g^{-1}$)	201.48 ± 1.46^a	196.34 ± 0.59^b	1,06
Vitamin C (mg ascorbic acid $100g^{-1}$)	180.87 ± 5.40^a	3.60 ± 0.56^b	4,16
Vitamin A (µg de retinol/l)	2322.00 ± 12.00^a	0.00 ± 0.00^b	0,73

*Values represent mean ± standard deviation. Means sharing the same letter in the same row are not significantly different (Tukey's test, $p < 0.05$).

Source: Authors (2018)

The results related to bioactive compounds and antioxidant capacity (Table 4) showed statistically significant differences between the species. The Margosa extract presented higher levels of total phenolic compounds (201.48 ± 1.46 mg GAE/100 g) and antioxidant capacity (200.37 ± 0.59 mg VCEAC/100 g) compared to the ginger extract (196.34 ± 0.59 mg GAE/100 g and 152.86 ± 0.95 mg VCEAC/100 g, respectively). The positive correlation between phenolic content and

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antioxidant activity, also reported by Santos et al. (2023), demonstrates that a higher concentration of phenolic compounds is directly associated with increased reducing power and free radical scavenging capacity.

Although the values obtained for ginger in the present study are notable, they are lower than those reported in other international studies. Kashif Ghafoor et al. (2020) reported 931.94 mg GAE/100 g in freeze-dried ginger rhizomes, while AKULLO et al. (2023) observed up to 2,172.65 mg GAE/100 g in methanolic extracts of local ginger varieties. Such differences may be attributed to factors including extraction method, type of solvent, drying conditions, plant cultivar, and environmental variability.

CRISTINA et al. (2020) highlighted that both aqueous and alcoholic ginger extracts exhibit high antioxidant activity against DPPH• and ABTS•+ radicals, with values of 51.88 ± 0.25 and 67.22 ± 0.25 µmol TE/g (fresh weight basis), and above 1000 µmol TE/g (dry weight basis). These findings corroborate the present results, confirming that even with a lower phenolic content compared to methanolic extracts, ginger retains significant antioxidant potential due to the presence of phenols, flavonoids, and other secondary metabolites.

Regarding vitamins, Margosa showed much higher levels of vitamin C (180.87 ± 5.40 mg/100 g) and vitamin A (2322.00 ± 12.00 µg retinol/L), whereas ginger exhibited much lower values (3.60 ± 0.56 mg/100 g of vitamin C and absence of vitamin A). These values exceed those observed in conventional vegetables such as kale (60 mg/100 g), broccoli (111 mg/100 g), and cauliflower (72 mg/100 g), indicating that Margosa can meet the daily vitamin C requirements with less than 100 g of consumption (OPEÑA et al., 2021).

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Mineral Content

Figure 01. Minerals in Margosa

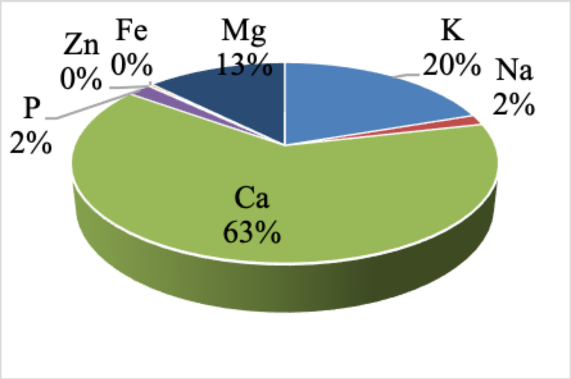
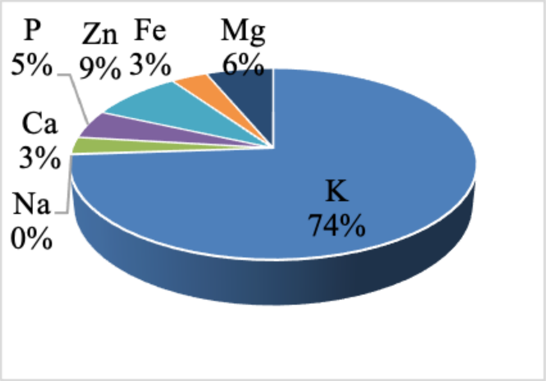


Figure 02. Minerals in Ginger



Source: Author (2018)

Figures 1 and 2 show that Zingiber officinale W. Roscoe (ginger) exhibited higher levels of zinc, iron, and potassium, while Azadirachta indica A. Juss (Margosa) presented greater concentrations of calcium and magnesium. Despite these differences, both species showed approximately similar levels of phosphorus. The lowest mineral contents observed were sodium in ginger and zinc and iron in Margosa.

Comparative studies conducted by KORNDÖRFER, MACIEL, and VOLKEN DE SOUSA (2015) on spinach and cabbage reported lower levels of K, Ca, Mg, Zn, and Fe compared to Margosa. However, the sodium levels in the plants analyzed in the present study were lower (0.6 mg/100 g in ginger and 22.81 mg/100 g in Margosa) than those found in spinach (188.08 mg/100 g) and cabbage (24.73 mg/100 g). The minerals potassium, calcium, phosphorus, zinc, and iron present in ginger are found in adequate amounts for human consumption, according to ANVISA (2005) recommendations. Similarly, in Margosa, the levels of calcium and magnesium fall within the recommended limits.

The significant differences in mineral content observed in comparison with other studies may be attributed to natural factors such as climate, topography, soil type, and the genetic diversity of the species. Variations among different studies can also be explained by edaphoclimatic and genetic factors, which directly influence the mineral composition of plants.

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4. Conclusions

The results obtained in this study highlight the nutritional and functional potential of Azadirachta indica (Margosa) and Zingiber officinale (Ginger), both in the dietary context and in the prevention of non-communicable chronic diseases. Laboratory analyses revealed that the extracts of these plants contain significant levels of bioactive compounds, minerals, and vitamins. Notably, A. indica exhibited higher antioxidant capacity and greater concentrations of total phenolics, vitamin C, and vitamin A.

Z. officinale, in turn, showed substantial levels of zinc, iron, and potassium, as well as phenolic compounds in amounts consistent with high antioxidant activity, confirming its importance as a functional food. The differences observed between the species reflect their physiological and environmental particularities, with both being promising candidates for the formulation of natural supplements, fortified food products, and plant-based complementary therapies.

However, the results of the interviews conducted with citizens and health professionals indicated a low level of knowledge regarding the nutritional and therapeutic value of these plants, as well as the absence of institutional programs that promote their use in daily diets. This gap underscores the need for food and nutrition education strategies that emphasize the sustainable use of native and medicinal species, integrating traditional knowledge with scientific evidence.

It can therefore be concluded that the integration of Azadirachta indica and Zingiber officinale into the diet and public health practices represents a viable, low-cost alternative with proven antioxidant potential, capable of contributing to improved quality of life and to the reduction of the risk of non-communicable chronic diseases. Further studies on the stability, toxicological safety, and formulation of derivative products from these plants are recommended, aiming to strengthen health promotion policies and the valorization of endogenous plant resources.

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