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Contributions of *Cucumis* L. Genetic diversity to phytochemical bioavailability and its impact on human health: A review

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Abstract

The genus *Cucumis* L., belonging to the Cucurbitaceae family, is home to a diversity of species of economic and nutritional importance, with cucumber (C. *sativus* L.), melon (C. *melo* L.), maxixe (C. *anguria* L.), and kiwano melon or horned cucumber (C. *metuliferus* E.) being the best-known species in Brazil. These fruits represent a significant source of nutrients and ingredients for the food, pharmaceutical, and ethnopharmacological industries. This article provides an overview of the chemical characteristics, nutritional composition, and applications of the genus *Cucumis* L., addressing its diversity, geographical distribution, economic importance, traditional and potential uses, as well as the challenges and future prospects for research and development of new products.

Keywords: Cucurbitaceae; healthiness; antioxidant compounds; dietary fiber; toxicity; safety.

Practical Application: Overview of the main challenges for valuing these vegetables using bibliometric maps.

1 INTRODUCTION

Africa is renowned for its rich biodiversity, with the Cucurbitaceae family standing out prominently, comprising 965 species across 120 genera (Christenhusz & Byng, 2016; Dhiman et al., 2012). These species predominantly thrive in tropical and subtropical regions, where they grow naturally in the wild (Morgia et al., 2017). In southern Africa, approximately 18 genera of Cucurbitaceae are present, many of which are utilized as food sources (Odhav et al., 2007) and as foundations for traditional medicines used to treat a variety of diseases (Watt & Breyer-Brandwijk, 1963).

Within the Cucurbitaceae family, the genus *Cucumis* (L.) is particularly noteworthy, being native to Africa and Asia and primarily cultivated in warm climates (Kimathi et al., 2022). The fruits of *Cucumis* species exhibit a wide range of characteristics, including textures that vary from spiny to smooth and colors that shift at maturity to shades of yellow, green, or orange. The seeds are typically numerous, oval or elongated, smooth in texture, and light brown to yellowish in color (Gomes-Klein et al., 2015).

Scientific literature has shown the diverse chemical constituents present in the *Cucumis* genus, including saponins, coumarins, cardiotonic compounds, cyanogenic substances, alkaloids, tannins, anthraquinones, flavonoids, and volatile oils (Muller et al., 2013). These bioactive compounds contribute significantly to global food security by serving as valuable sources of vitamins, minerals, and dietary fiber (Sousa et al., 2015).

According to Petrus (2014), the *Cucumis* L. genus includes over 32 species, which are economically important due to their fruits, widely consumed fresh, cooked, or used for medicinal purposes. In Brazil, notable species include maxixe (*Cucumis* anguria L.), melon (C. *melo* L.), kiwano (C. *metuliferus* E.), and cucumber (C. s*ativus* L.) (Lima, 2010).

Thus, this review aims to address and synthesize the existing, albeit scattered, literature on the phytochemical uses and safety evaluation of the *Cucumis* L. species, promoting the appreciation of these vegetables as a means to improve the income and health of small farmers and consumers.

1.1 Relevance of the work

Cucumis L. is appreciated worldwide and offers multiple benefits to human health. However, in addition to the pulp, its by-products, such as peels and seeds, can also be used in the production of extracts and flour, and in the extraction of oils, as they contain phytochemicals with high nutritional and functional capacity. This chapter highlights the importance of using the by-products derived from *Cucumis* L., as they have analgesic, anti-inflammatory, antioxidant, anticancer, antimicrobial, diuretic, hepatoprotective, and immunomodulatory activities due to the presence of bioactive compounds. In addition, their use can help minimize environmental impact.

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2 METHODS

The information presented in this review was gathered from reputable scientific literature databases, including Google Scholar, ScienceDirect, PubMed, Web of Science, Scopus, and the Scientific Electronic Library Online (SciELO). The keywords used in the search strategy included *Cucumis* L., traditional medicine, pharmacology, phytochemistry, toxicity, and safety, combined with the scientific name of each plant as the source (Figure 1).

The initial step involved defining the research theme and formulating the guiding question: "To what extent are species of the genus *Cucumis* L. associated with ethnomedicinal, phytochemical, and pharmacological profiles?" Articles were selected based on specific inclusion criteria, which required that they reference *Cucumis* L. along with at least two of the selected keywords. Only articles available online, freely accessible through *Universidade Estadual de Campinas* (UNICAMP) institutional access, and published in Portuguese, English, or Spanish were considered. No time restrictions were applied due to the limited number of published studies on this topic.

Among the 18 species of *Cucumis* L., 4 species are found in Brazil. In this context, 137 studies were selected, of which 96 were included in this review, as they provided research on maxixe, cucumber, melon, and kiwano.

3. RESULTS AND DISCUSSION

3.1 Cucumis L.

3.1.1 Genetic and morphological diversity and geographical distribution of Cucumis L.

The *Cucumis* genus exhibits remarkable genetic diversity, as evidenced by its wide range of varieties, forms, sizes, and fruit colors. Molecular marker studies, such as those utilizing microsatellites (simple sequence repeats—SSRs) and single-nucleotide polymorphisms (SNPs), have played a pivotal role in elucidating phylogenetic relationships among species and identifying genes associated with key agronomic traits (Dar et al., 2017; Schlötterer & Pemberton, 1994). Additionally, morphological analyses of leaves, flowers, fruits, and seeds are extensively employed for taxonomic classification and characterizing genetic diversity (Renner et al., 2007).

The geographical distribution of the *Cucumis* L. genus is illustrated in Figure 2, highlighting its presence in tropical and subtropical regions across the globe (Renner et al., 2007). This widespread distribution further underscores the genus's ecological and agricultural significance.

According to Lima (2022), the genus *Cucumis* L. is not endemic to Brazil; however, there are confirmed occurrences of the species in all regions, as can be seen in Table 1.

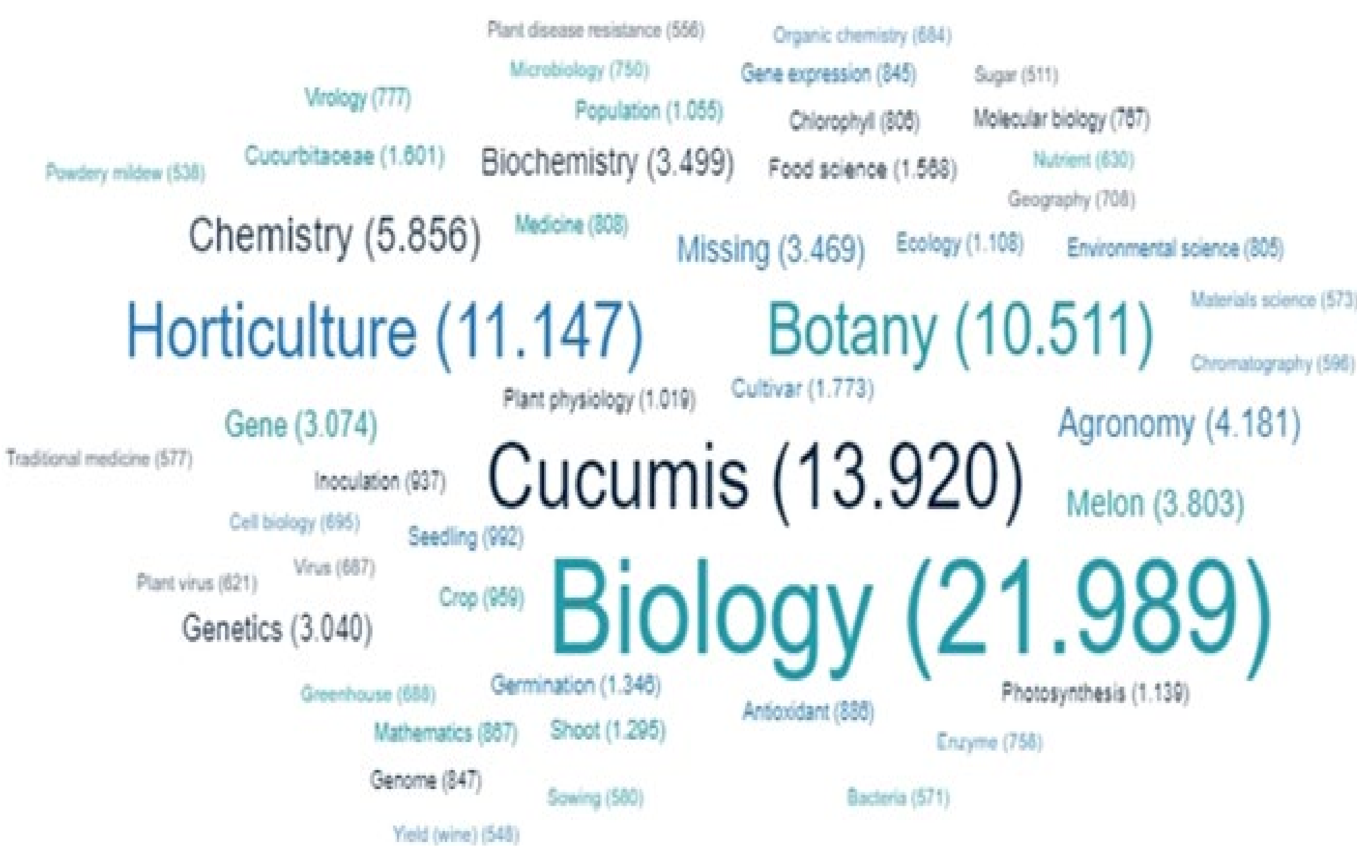

Figure 1. Word cloud with the terms most frequently associated with the genus *Cucumis* L. in scientific literature.
Source: VOSviewer (2024).

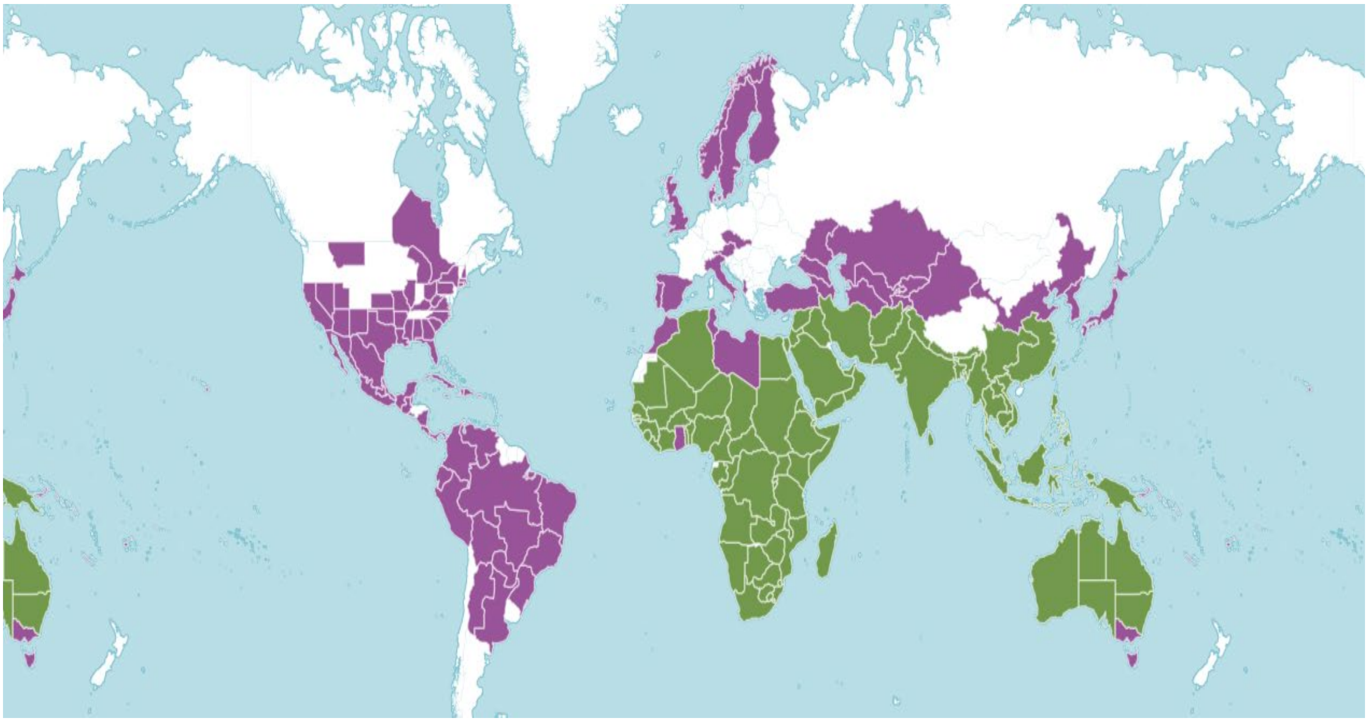

Figure 2. Geographical distribution of the genus *Cucumis* L. (green square), indicating origin (red arrows) and adaptation in Latin America.
Source: Canva (2024).

Table 1. Popular names, scientific names, families, origins, and Brazilian regions that grow *Cucumis* L.

Popular name	Scientific name	Family	Origin	Brazilian region	Reference
Gherkin	*Cucumis anguria* L.	Cucurbitaceae	Africa	North, Northeast, and Southeast	Lima, 2010
Melon	*Cucumis melo* L.	Cucurbitaceae	Africa and Asia	Northeast, South, and Southeast	Camargo et al., 2008
Kiwano	*Cucumis metuliferus* E.	Cucurbitaceae	Africa	North and Northeast	South African National Biodiversity Institute, 2023
Cucumber	*Cucumis sativus* L.	Cucurbitaceae	India's mountain regions	South and Midwest	Lima, 2022

Cucumis L. species are characterized by their fleshy fruits, which have different shapes, sizes, and flavors (Table 2), resulting in a wide variety of uses, from fresh consumption to the production of preserves, juices, and other processed products.

3.1.2 Economic importance and applications

Cucumis L. serves as a valuable source of income for farmers, as its fruits can be utilized not only for fresh consumption but also in the production of preserves, pickles, and juices. Additionally, the genus is gaining recognition for its biotechnological applications, particularly in the extraction of bioactive compounds with promising pharmacological and cosmetic potential (Oboh et al., 2017).

The widespread geographical distribution of *Cucumis* L., ranging from small-scale farms to large commercial plantations, further enhances its economic impact. This distribution supports job creation across various stages of the production chain, from cultivation and harvesting to processing, distribution, and retail, thereby contributing to rural development and economic growth (Robinson & Decker-Walters, 1997).

3.1.3 Nutritional importance

Cucumis L. species play an important role in food security, and their nutritional profile is shown in Tables 3, 4, and 5.

The higher water content, exceeding 80% in *Cucumis* L. species, plays a crucial role in promoting body hydration and supporting various physiological functions. Additionally, these fruits are rich sources of essential vitamins (Table 4), including vitamin C, a potent antioxidant. Vitamin C not only protects cells from oxidative damage but also bolsters the immune system, enhancing the body's ability to fend off infections and maintain overall health.

3.1.4 Potential of bioactive compounds in the food and pharmaceutical industry

The increasing interest in functional foods and the pursuit of natural alternatives for disease treatment have spurred extensive research into the bioactive compounds found in plants, including those in the *Cucumis* genus (Santos et al., 2021). The nutritional richness and pharmacological potential of these

Table 2. Physical characteristics of *Cucumis* L. grown in Brazil.

Popular name	Characteristic	Reference
Gherkin	Oval-shaped fruits with a spiny or smooth skin, light green in color, weighing from 40 to 60 g, with white flesh and a pleasant taste.	Albuquerque et al., 2016
Melon	Fruits with a firm skin and a strong color, pleasant scent, loose seeds, weighing from 1.5 to 2 kg, with fleshy and juicy flesh.	Revista Cultivar, 2015
Kiwano	Large oval-shaped fruits 10 to 15 cm long and weighing 200 to 300 g.	South African National Biodiversity Institute, 2023
Cucumber	Long fruits with a rigid green skin, light-colored pulp, and a mild taste, with flat seeds, weighing an average of 250 g.	Reis et al., 2006

Table 3. Proximate composition of *Cucumis* L. species grown in Brazil.

Plants	Moisture	Dietary fiber (g/100 g)	Available carbohydrates (g/100 g)	Lipids (g/100 g)	Protein (g/100 g)	Ash (g/100 g)	Reference
Gherkin	93.8	2.74	3.73	0.09	1.74	0.61	Tabela Brasileira de Composição dos Alimentos (TBCA), 2020
Melon	93.0	1.22	4.50	0.15	0.61	0.50	TBCA, 2020
Kiwano	80.0	3.10	8.00	1.30	1.80	4.80	United States Department of Agriculture, 2019
Cucumber	96.7	1.04	1.20	0.09	0.70	0.33	TBCA, 2020

Table 4. Vitamin content of species of the *Cucumis* genus L.

Plants	Vitamins (100 g)												Reference
	A (mcg)	B1 (mg)	B2 (mg)	B6 (mg)	B12 (mcg)	C (mg)	D (mcg)	E (mg)	K (mg)	Thiamine (mg)	Riboflavin (mcg)	Niacin (mg)	
Gherkin	2.75	-	-	0.05	0.1	12.0	0.02	0.02	-	0.07	0.03	-	TBCA, 2020
Melon	1.67	-	-	0.02	-	6.97	-	0.08	2.9	-	-	-	TBCA, 2020
Kiwano	8.35	0.09	0.11	0.07	0.10	6.82	5.28	0.42	0.43	-	-	-	Ani and Achikanu, 2021
Cucumber	1.67	-	-	-	-	4.99	-	0.03	-	-	0.03	-	TBCA, 2020

Table 5. Mineral content of species of the *Cucumis* genus L.

Plants	Minerals (100 g)									Reference
	Ca (mg)	Fe (mg)	Na (mg)	P (mg)	K (mg)	Zn (mg)	Cu (mg)	Se (mcg)	Mg (mg)	
Gherkin	38.4	0.59	22.9	31.2	163	0.17	0.03	0.10	9.50	TBCA, 2020
Melon	2.53	0.19	8.96	8.14	173	0.07	0.03	0.20	4.93	TBCA, 2020
Kiwano	13.00	1.10	2.00	-	123	-	-	-	4.00	Ferrara, 2018
Cucumber	9.62	0.23	-	8.14	173	0.13	0.04	0.20	9.34	TBCA, 2020

compounds present significant opportunities for innovation in the food and pharmaceutical industries (Chung et al., 2017).

According to Yoon et al. (2015), various parts of plants, including vegetables, contain essential metabolites and exhibit activities that combat free radicals and pathogenic organisms, evidencing their therapeutic and biochemical importance. However, according to the author, many studies have focused only on the root rather than on the fruit, which is the part most consumed.

3.1.5 Food industry

The food industry has been studying the potential of bioactive compounds from *Cucumis* L. to develop innovative products with added value. Some of the most promising applications include:

- Development of functional foods: The addition of *Cucumis* extracts to various foods, such as yogurts, juices, and cereal bars, can enrich these products with antioxidants, vitamins, and minerals, conferring health benefits (Busuioc et al., 2023).
- Food preservation: Some substances present in *Cucumis* L. have antimicrobial properties, which can be used as natural preservatives, extending the shelf life of food (Jeyakumar et al., 2014).

3.1.6 Pharmaceutical industry

The pharmaceutical industry is increasingly interested in the bioactive compounds of *Cucumis* L. due to their therapeutic potential. Some of the applications include the development of:

- New drugs: The bioactive compounds of *Cucumis* L. can serve as a basis for the development of new drugs for the treatment of various diseases, such as cancer, cardiovascular diseases, and neurodegenerative diseases (Milind & Kulwant, 2011).

- Food supplements: *Cucumis* L. extracts can be used in the formulation of food supplements to provide an additional supply of antioxidants and other nutrients (Milind & Kulwant, 2011), as well as in cosmetic products such as creams and lotions, due to their antioxidant and moisturizing properties (Ajuru & Nmom, 2017).

The prospects for utilizing bioactive compounds from *Cucumis* L. are highly promising. With ongoing advancements in research and the development of innovative technologies, it is likely that the coming years will see the emergence of a new generation of food and pharmaceutical products derived from these compounds (Figure 3).

3.2 C. **anguria** *L. (Gherkin)*

Gherkin (C. *anguria* L.) is cultivated in regions such as Africa, Brazil, Cuba, India, the United States, and Zimbabwe (Yoon et al., 2015). This vegetable is a rich source of protein, calcium, phosphorus, iron, and vitamin C, making it highly nutritious (Thiruvengadam & Chung, 2014).

According to Yoon et al. (2015), various parts of the gherkin (Figure 4) contain essential metabolites with significant therapeutic and biochemical importance. These compounds exhibit activities that combat free radicals and pathogenic organisms, highlighting the vegetable's potential in promoting health and preventing disease.

Maxixe (C. *anguria* L.) is valued in various communities worldwide for its medicinal properties, including its use in relieving stomach pain, treating jaundice, and preventing kidney stone formation (Jeyakumar et al., 2014). Its phytochemical profile is rich, featuring compounds such as cucurbitacin B, known for its potential in cancer prevention, as well as cucurbitacin D and cucurbitacin G (Promkan et al., 2013). Additional bioactive constituents include phenolics, flavonoids, tannins, alkaloids, saponins, steroids, and anthraquinones (Kumar & Kamaraj, 2010).

Despite its promising therapeutic potential, scientific research on C. *anguria* L. is scarce. Studies are geographically limited, and the number of publications is sparse, with only 22 recorded entries in SCOPUS in 2023. Nevertheless, existing research spans diverse fields, including agricultural sciences,

Figure 4. Image of gherkin (*Cucumis anguria* L.).
Source: The authors (2024).

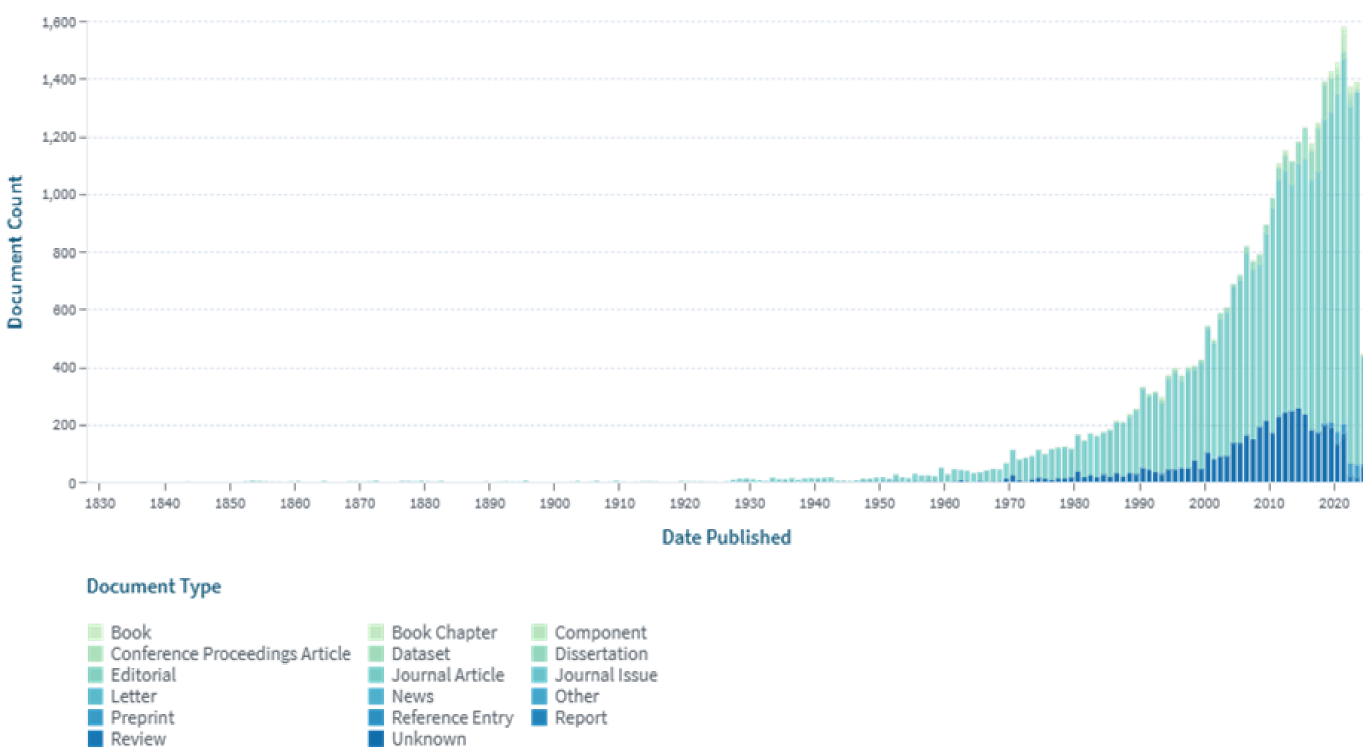

Figure 3. Distribution of scientific studies of bioactive compounds in *Cucumis* L.
Source: VOSviewer (2023).

biochemistry, environmental science, pharmacology, neuroscience, medicine, and toxicology (Figure 5).

3.2.1 Botanical aspects

Gherkin (C. *anguria* L.) was introduced to Brazil during the slavery period, which explains its predominant cultivation in the North, Northeast, and Southeast regions of the country (Robinson & Decker-Walters, 1997). While widely known as "maxixe," it is also referred to by several colloquial names, including Indian cucumber, wild cucumber, northern cucumber, maxiceiro, tomato gherkin, maxiso, chestnut cucumber, donkey cucumber, spiny cucumber, cornichon, and Antilles cornichon (Moretoni, 2008).

This plant is easy to cultivate, hardy, pest-resistant, and characterized by long fruiting periods, which allow for staggered harvests (Brasil, 2011). It has a prostrate or climbing stem covered with bristly trichomes and alternate leaves with petioles, tendrils, and hairy laminae. The flowers grow in clusters, displaying yellow petals. The fruits are fleshy, with cylindrical or globular shapes and spiny projections, showing considerable diversity in form and the presence or absence of spicules, presenting a mild flavor (Moreira & Bragança, 2011).

3.2.2 Popular use

The gherkin species is a staple in traditional cuisine (Table 6), where it is consumed both raw in salads and cooked in dishes such as "maxixada." Additionally, its versatility extends to its potential use in canning, further enhancing its value as a culinary ingredient (Barroso, 2021; Sousa et al., 2015).

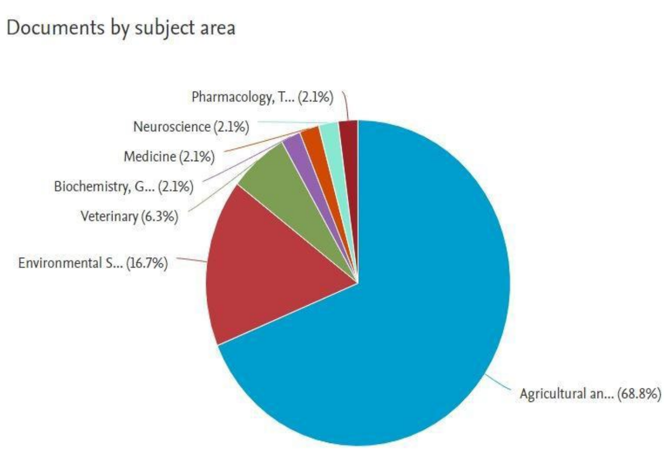

Figure 5. Diverse fields addressing the gherkin (*Cucumis* anguria L.) in 16.05% of 137 studies.
Source: VOSviewer (2024).

3.2.3 Pharmacological studies

C. *anguria* L. exhibits a promising pharmacological profile, although further in-depth studies are still needed. Several studies have identified the presence of bioactive compounds with antioxidant, anti-inflammatory, and antimicrobial activities. Its antioxidant properties, primarily attributed to phenolic compounds, show potential in preventing cellular damage caused by free radicals. The anti-inflammatory activity may be beneficial in treating chronic inflammatory conditions. Lastly, its antimicrobial activity suggests potential applications in combating infections.

In vitro studies using ethanolic extract from gherkin seeds demonstrated the ability to scavenge free radicals at a dose of 200 μg/mL.

Moretoni (2008) tested aqueous extracts of gherkin in vitro and in vivo studies, revealing antioxidant and hypoglycemic activities, with negative results in toxicity tests.

Dzomba and Mupa (2012) reported potent antioxidant activity in gherkin extracts, attributed to the presence of flavonoids and saponins.

Extracts from gherkin stems showed antimicrobial activity against pathogenic bacteria (*Escherichia coli*, *Streptococcus aureus*, *Klebsiella pneumoniae*, *Salmonella paratyphi*, *Pseudomonas aeruginosa*) and five fungi (*Candida albicans*, *Fusarium oxysporum*, *Aspergillus niger*, A. *fumigatus*, and A. *flavus*) (Yoon et al., 2015).

3.2.4 Phytochemical profile

Gherkin has phytochemicals with health benefits, such as different types of antioxidants that fight free radicals and compounds with anti-inflammatory properties that can contribute to the body's general well-being.

Yoon et al. (2015) quantified flavonols, hydroxycinnamic acids, hydroxybenzoic acids, seven flavonoid compounds, five hydroxycinnamic compounds, and nine hydroxybenzoic acids in the extract of the fruit and leaves of gherkin.

Kumar et al. (2010) identified nine fatty acids and one diterpene in the ethanolic extract of the fruit of the species.

Table 6. Ethnomedicinal survey of the genus *Cucumis anguria* L.

Disorder	Part used	Form of consumption	Reference
Pneumonia	Raw whole fruit	Juice	Bieski et al., 2015
Warts	Raw whole fruit	Paste	Magalhães et al., 2019
Mycosis	Raw whole fruit	Paste	Omokhua-Uyi and Van Staden, 2020
Complementary therapy for hyperglycemia	Raw whole fruit	Juice	Moretoni, 2008
Prevention of prostate problems, dyslipidemia, and aid in wound healing	Whole fruit	Raw/cooked	Silva et al., 2023
Emollient, anthelmintic, antiemetic, and laxative	Whole fruit	Juice, raw or cooked fruit	Santos et al., 2021

Moretoni (2008) reported that the fruit of C. *anguria* L. contains polysaccharides and the monosaccharides arabinose, xylose, and mannose, as well as amino acids such as L-arginine, L-alanine, L-leucine, isoleucine, glutamine, flavonoids expressed as rutin, and phenolic compounds expressed as gallic acid.

Dzomba and Mupa (2012) reported the presence of alkaloids, flavonoids, tannins, carotenoids, steroids, and anthocyanins in the hydroalcoholic extracts of C. *anguria* L. leaves.

Salama et al. (1994) analyzed the ethanolic extract of the stem, leaf, and fruit and observed the presence of tannins, sterols, and triterpenes.

3.3 C. metuliferus E. (Kiwano)

C. *metuliferus* E. (Figure 6) is commonly referred to as African horned cucumber, jelly melon, or kiwano (Wannang, Kwanashie, & Ede, 2010). It is native to Africa and is also cultivated in Brazil, Australia, New Zealand, Chile, and California. The fruit is bright orange when ripe and covered in pointed tips, with bright green, gelatinous flesh. Its flavor is a combination of cucumber and banana (Abubakar et al., 2011).

It is an annual climbing species with ellipsoid–cylindrical fruit, featuring a triangular structure approximately 60 mm long and 30 mm in diameter, with scattered spines (Zhu et al., 2021) and an extremely strong rind measuring 10 x 2–5 mm. The base is broad, with a deep grayish-green hue, maturing to shades of yellow and reddish-orange, adorned with longitudinal stripes and small spots (Anon, 2009).

3.3.1 Phytochemical profile

Kiwano is a promising source of bioactive compounds, including ascorbic acid, carotenoids, phenolic compounds, and flavonoids, which exhibit antioxidant and anti-inflammatory effects (Vieira et al., 2020). According to Busuioc et al. (2023), kiwano can be used as an ingredient in the development of new food products, such as beverages and ice creams.

Although kiwano is becoming an increasingly popular fruit with significant commercialization potential, research on its peels remains scarce. The peels are by-products of the juice extraction process, representing about a quarter of the fruit's total weight. Studies have reported that kiwano peels exhibit strong iron-chelating capacity (Matsusaka & Kawabata, 2010), indicating relevant biological activity that still needs further exploration.

3.3.2 Pharmacological studies

Recent studies highlight the promising health benefits of C. *metuliferus* E., commonly known as kiwano. The fruit has been shown to enhance blood parameters, including hemoglobin levels, red and white blood cell counts, and cell volume. Additionally, it has demonstrated a range of bioactivities, such as in vitro antibacterial effects against *Salmonella gallinarum* (Usman et al., 2014), antiviral properties (Wannang, Gyang et al., 2010), anti-ulcer effects (Omale et al., 2011), and potential impacts on male fertility (Wannang et al., 2008). Moreover, it exhibits a dose-dependent anti-hyperglycemic action in diabetes mellitus (Gotep, 2011; Jimam et al., 2010) and antimalarial activity (Mzena et al., 2018).

Although kiwano is gaining popularity and has significant commercialization potential, research on this fruit remains limited. Notably, its peels have been reported to exhibit strong ferrous ion chelating capacity, suggesting promising biological activity that warrants further investigation (Matsusaka & Kawabata, 2010).

3.4 C. melo *L. (Melon)*

C. *melo* L., the melon (Figure 7), is among the most cultivated and best-known species (Xin et al., 2022) and is one of the most consumed vegetables worldwide. Although the plant is botanically classified as a vegetable, it is marketed as a tasty and juicy fruit (Figueirêdo et al., 2017), known for its nutritional properties (Nascimento et al., 2023).

Melons are cultivated in over 52 countries, spanning an area of 843,000 hectares and yielding 22.9 million tons as of 2013 (Food and Agriculture Organization of the United Nations [FAO], 2020). China leads global productions, contributing 63.02% of the

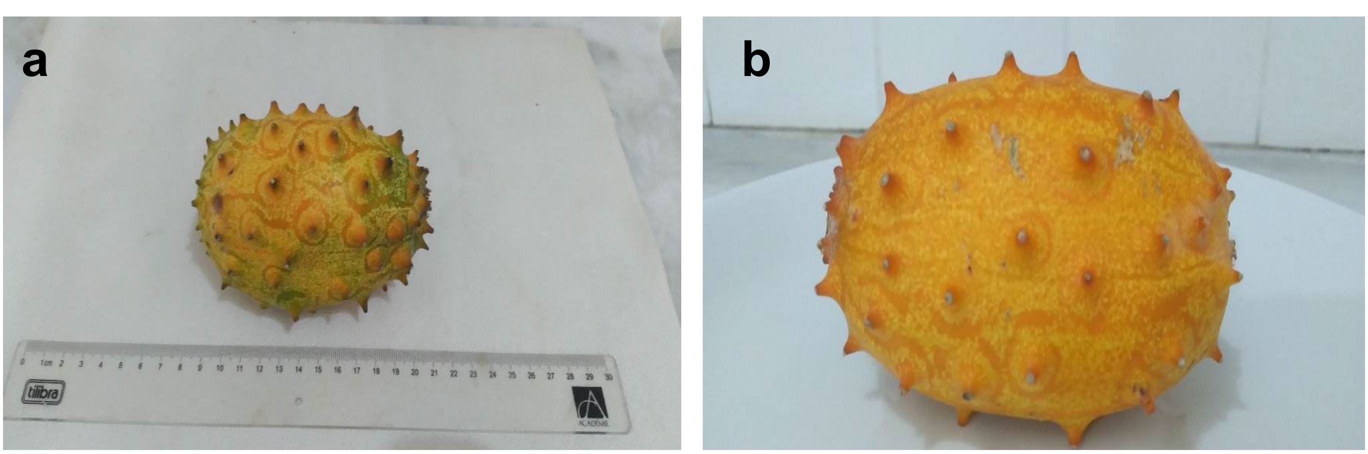

Figure 6. *Cucumis metuliferus* E. (Kiwano) (a) green fruit; (b) mature.
Source: The authors (2024).

total, followed by Iran (6.57%), India (4.38%), and Spain (3.75%). Brazil ranks 7th globally, producing 565,000 tons annually and accounting for 2.48% of global production (FAO, 2023).

Melons are primarily consumed fresh and are commonly used in juices, salads, and desserts. They are rich in essential nutrients, serving as excellent sources of vitamins A and E, magnesium, and potassium (Medeiros et al., 2024). Additionally, they contain bioactive compounds such as polyphenols, organic acids, lignans, and other polar substances, which may provide various health benefits (Rodríguez-Pérez et al., 2013).

There is notable phenotypic diversity among melon species, particularly regarding fruit quality attributes (Kaleem et al., 2022). These include variations in pulp color (orange, light orange, pink, white, and green) and rind color (green, white, orange, yellow, and reddish-gray) (Kesh & Kaushik, 2021).

In Brazil, the most commonly traded melon varieties include yellow melon, Pele de Sapo, Honey Dew, Cantaloupe, Galia, and Charentais (Figueirêdo et al., 2017). Table 7 summarizes the key characteristics of these commercial melon varieties.

3.4.1 Growing and marketing melons in Brazil

The Northeast of Brazil is the country's largest producer and exporter of melons, a distinction attributed to favorable climatic conditions and the adoption of advanced agricultural technologies. This activity generates significant employment and income, making it a cornerstone of the regional economy (Nascimento et al., 2023). The state of Rio Grande do Norte leads national production, accounting for over half of the country's output, with approximately 513,723 tons produced in 2023. In the same year, total Brazilian melon production reached about 862,387 tons (Instituto Brasileiro de Geografia e Estatística [IBGE], 2024; Kaleem et al., 2022).

Figure 7. Image of yellow melon (*Cucumis melo* L.)
Source: The authors (2024).

The melon development cycle varies from 80 to 120 days, with fruit ripening occurring 35–45 days after flowering (Nagashima et al., 2021). Throughout this cycle, quality is influenced by factors such as shape, appearance, soluble solids content, hardness, acidity, size, color, texture, flavor, ripeness, and nutritional profile (Kaleem et al., 2022). For marketing purposes, the fruit's weight and ripeness are crucial parameters (Qian et al., 2022).

Melons are sold both domestically and internationally. On the domestic market, they are distributed locally, regionally, and nationally, often in bulk and as lower-quality produce. The peak supply period for this market is from October to February, coinciding with the peak harvest in major producing municipalities (Empresa Brasileira de Pesquisa Agropecuária [EMBRAPA], 2017).

In contrast, the foreign market has seen remarkable growth in Brazilian melon exports in recent years. Melons are now considered one of Brazil's most iconic export fruits, with over 40% of production directed to international markets in some harvests. Nearly all exported melons originate from production centers in Rio Grande do Norte, with the European Union being the primary destination, accounting for approximately 90% of Brazil's melon exports (EMBRAPA, 2017).

3.4.2 Phytochemical and pharmacological characteristics of melons

Melons are indicated for the treatment of cardiovascular diseases, diuretics, stomach problems, reducing the risk of cancer and chronic diseases (Milind & Kulwant, 2011), obesity, diabetes, osteoporosis, eye diseases, and Alzheimer's (Fathalipour et al., 2020). Its bark and seeds can be used in the food industry as nutraceutical products, as they are sources of flavonoids and tannins (Vella et al., 2019).

In addition, it can also promote other biological properties, including increased immunity, anti-mutagenesis activity, antitumor activity, neuroprotection, self-defense, and photoprotection (Pereira et al., 2021; Swapnil et al., 2021), antihypertensive, antioxidant, and antimicrobial properties (Ravindranath et al., 2021).

Table 7. Characteristic aspects of each melon variety marketed in Brazil.

Variety	Origin	Aspects		
		Peel	Pulp	Format
Yellow	Spanish	Yellow	Creamy white	Oval
Pele de Sapo	Spanish	Green with dark green spots	Greenish-white	Oval
Honey Dew	American	Smooth, greenish-white to cream	Light green or salmon, with a high sugar content, firmer flesh with longer storage time	Rounded or relatively oval
Cantaloupe	American	Light green	Salmon-colored and very aromatic	Rounded, slightly flattened
Galia	Israeli	Light green to yellowish	White or greenish-white	Rounded

Source: Figueirêdo et al. (2017).

3.4.3 General aspects of the chemical composition of melons

Studies have shown that consumers prefer melons with orange flesh (Ayres et al., 2019; Park et al., 2018). According to Philippi (2018), melons are an excellent source of vitamin C (42.2 mg) and provitamin A (322 mg).

It also contains carbohydrates, dietary fiber, proteins, fatty acids, vitamins B1, B3, B6, B9, E, and K, and minerals such as magnesium, potassium, iron, calcium, phosphorus, zinc, and copper (Lecholocholo et al., 2022). The energy value is considerably low, ranging from 20 to 62 kcal per 100 g of fresh pulp (EMBRAPA, 2017; Hashemi et al., 2019; Morais et al., 2017). In addition, the fruit contains considerable amounts of carotenoids, mainly β-carotene, which contributes to the orange color of the pulp (Medeiros et al., 2019).

3.5 C. **sativus** *L. (Cucumber)*

C. *sativus* L. (cucumber, Figure 8) is a plant that can grow between 1 and 3 m in length. Originally from India, it is now cultivated in various regions worldwide. Although it thrives in tropical climates, it can also be grown in areas with mild weather, provided there is no exposure to cold or frost (Zhang et al., 2019).

Classified as a berry, cucumbers exhibit a wide variety of sizes, shapes, and colors. The fruits can range from small (10–12 cm) to large, with some varieties reaching an average length of 50 cm. They are characterized by their soft flesh, smooth texture, and dark green skin (Mondal et al., 2019).

3.5.1 Phytochemical and pharmacological characteristics of cucumber

Cucumber (C. *sativus* L.) exhibits a wide range of pharmacological activities, including antibacterial, antifungal, cytotoxic, antacid, anti-ulcerative colitis, hepatoprotective, hypoglycemic, hypolipidemic, and wound-healing properties. According to Shrivastava and Roy (2013), it is highly recommended as a dietary food due to its higher water content (96%) and low energy value. Additionally, its soothing, refreshing, and healing properties make it beneficial for skin health, helping to alleviate skin problems and serving as a common ingredient in natural soaps (Ajuru & Nmom, 2017). Cucumber is also known to reduce swelling under the eyes and even promote hair growth.

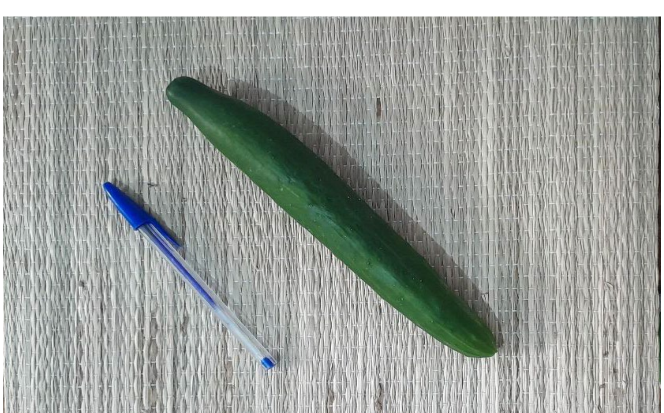

Figure 8. Image of cucumber (*Cucumis sativus* L.).
Source: The authors (2024).

Historically, cucumber was used to dissolve uric acid stones and was believed to benefit the intestines, kidneys, lungs, and skin. It was also used by individuals with respiratory problems and was recognized for its healing properties in cases of headache, bleeding, and dizziness (Sood et al., 2012).

Nutritionally, cucumber is a good source of potassium, vitamins C, K, and A, along with minerals, amino acids, phytosterols, phenolic acids, fatty acids, and cucurbitacin. It also contains traces of essential oils, pectin, starch, and sugars, further enhancing its value as a versatile and health-promoting food (Ajuru & Nmom, 2017).

4 CONCLUSION

The *Cucumis* L. genus represents an important source of nutritious and versatile food, with a great diversity of species that hold significant economic and cultural importance in some regions of Brazil. Further research will be crucial to ensuring sustainable production and the full utilization of the potential of these vegetables.

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