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The Use of *Hibiscus sabdariffa* L. in human health, its chemical, nutritional and functional characteristics. A bibliographical review

Luciane do Socorro Nunes dos Santos Brasil
SENIOR Fellow - CNPq, PPGCTA, UFPA, Brazil
Adjunct Professor IV UEPA, Brazil
Address: Universidade do Estado do Pará, Campus V, CCNT.
Tv. Enéas Pinheiro, 2626. Neighborhood: Marco. ZIP CODE: 66.095.015
luciane.brasil@uepa.br
Tel: (91)99314-8039

Ana Jéssica da Silva Costa
Master's student, UFPA, Brazil
ajcnutricionista@outlook.com

Davi do Socorro Barros Brasil
Associate Professor II, ITEC, PPGEQ, UFPA, Brazil
davibb@ufpa.br

Alessandra Santos Lopes
Associate Professor IV, ITEC, PPGCTA, UFPA, Brazil
alessalopes@ufpa.br

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SUMMARY

Hibiscus sabdariffa L. was introduced to Brazil for the production of wines and vinegars and is now known as an unconventional food plant. It has chemical and nutritional potential due to its antioxidant properties and its representative value of anthocyanins, vitamin C and polyphenols. The aim of this research was to carry out a systematic review with a qualitative narrative analysis of studies in the literature on the chemical, functional and nutritional knowledge of vinagreira. The methodology used a qualitative narrative analysis of studies published in journals indexed in the Google Scholar, Science Direct, Scielo and PubMed databases. Articles published up to 2023 were included. The advantages and difficulties of using this raw food material were addressed. The results found from 2000 to 2023 show that Hibiscus sabdariffa L. has a large number of benefits associated with this species, identifying that the aqueous and ethanolic extracts made mainly from the calyx of the plant are very promising and can be used efficiently to compose food products or in other industries such as pharmaceuticals and cosmetics to make different formulations that can be used for the benefit of the world's population. It can be concluded that vinagreira is a plant used for medicinal purposes, with a functional property claim, which could be an important aid in the nutritional balance of the diet plan of patients with comorbidities such as obesity, dyslipidemia, hypertension and some types of cancer, possessing therapeutic properties such as diuretic, analgesic, antihypertensive and antioxidant effects.

KEYWORDS: Hibiscus, Amazon, antioxidant.

1 INTRODUCTION

Hibiscus (Hibiscus Sabdariffa L.) is a plant species known as a food with a functional property claim, with nomenclatures such as: Hibiscus, Roselle, Azedinha, Groselha, Caruru-azedo, Quiabo-azedo according to the region in which it is grown (KINUPP, LORENZI, 2014; KINUPP, 2007; ZANNOU et al., 2020). It has more than 300 species worldwide and the parts of the Hibiscus most studied in the literature are the calyxes and flowers, mainly due to the color and flavor that have shown promise for use by the food industry in the preparation of food formulations such as sauces, jellies, vinegars, juices; in the cosmetics, pharmaceutical, and dye industries (GOMES, 2017; DA COSTA-ROCHA et al., 2014).

The Hibiscus plant is edible, found on different continents in diverse climates, adapting excellently to hot climates in tropical and subtropical regions with lots of rain (FREITAS, SANTOS, MOREIRA, 2013). There is controversy over whether the plant originated in Africa or India, Sudan and Malaysia, and that it was only later introduced to Southeast Asia, Central America, South America and Brazil (BARBOSA et al., 2020).

In China, the seeds of the vinagreira are used to obtain oil and the plant is used for its medicinal properties. In West Africa, the leaves and powdered seeds can be consumed in meals, as well as being used by the pharmaceutical and food industries (DA COSTA-ROCHA et al., 2014). In countries such as Brazil, vinagreira is known as a PANC (non-conventional food plant), as its use is less common in the population's diet, with medicinal, ornamental and textile uses (HONEYWELL, CULBERT, 2005). Its use is noteworthy in the northeastern states of Brazil, where the leaves are eaten fresh in salads, for their citrus flavor, and are added to cooked or fried culinary formulations. It is rich in non-heme iron, magnesium, calcium, vitamins A and C (MARCH, 2009).

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This vegetable has antioxidants, phytocompounds and polyphenols with the ability to sequester free radicals with good performance (DA SILVA, RANOLFI, 2022). It also contains compounds such as quercetin, ascorbic acid, reducing sugars such as glucose and fructose and non-reducing sugars such as maltodextrin and sucrose (WHO, 2015).

Reports of ethnobotanical information in studies by Alarcon-Aguillar et al. (2007) on the species Hibiscus sabdariffa L. explain medicinal uses as a diuretic, diaphoretic, uricosuric, antibacterial agent, antifungal agent, mild laxative, sedative, antihypertensive, antitussive, treatment of gastrointestinal disorders, treatment of hypercholesterolemia, treatment of kidney stones, treatment of liver damage, as an agent to decrease blood viscosity and an agent to treat the after-effects of drunkenness (AKINDAHUNSI, OLALEYE, 2003; HERRERA-ARELLANO et al. , 2004, HIRUNPANICH et al., 2006).

On the other hand, in Mexico, dried calyxes are used in a popular drink traditionally used to treat obesity (ALARCÓN-ALONSO et al., 2012). In addition, vinegar is used in culinary formulations based on beef and fish species such as sea bream, yellow hake, fillet, white hake and tambaqui in the northern regions of Brazil. Based on the knowledge acquired by the researchers in this study, important contributions on the nutritional, chemical and functional potential of this species will be presented in this review.

In this sense, this article will provide the academic community and the population with a more comprehensive view of vinegar, focusing on the characteristics and properties of this raw material of plant origin, which could contribute positively to future studies that use Hibiscus to make new food products and boost future research that helps to improve the health conditions of the population. The aim of this research is to provide an overview of the characteristics of the species Hibiscus sabdariffa L. with its main nutritional contributions, chemical composition and biological properties for application in food products.

2 METHODOLOGY

This study is a systematic review with a qualitative narrative analysis of studies published in journals indexed in the Google Academic, Science Direct, Scielo and PubMed databases. Articles published in the last 23 years were included, used to update or acquire new knowledge, involving the following phases: choice of research topic; definition of keywords; identification in databases; organization in summary tables of the results found; interpretation of the results and comparisons with other research, and it is important to note that, in order to carry out the systematic review, a guiding question was established for the database search: Main benefits for use in food products and derivatives.

The online databases were searched using indexes and sources that allowed for a broader search. A total of 136 results were found, including articles, course completion papers, master's dissertations, doctoral theses and books, from which texts with repetitions and those that did not provide in-depth information on vinegar were excluded. The texts were available free of charge and were only scientific productions, in English and Portuguese, from 2000 to 2023.

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After a detailed reading of the research found, tables were constructed to group together the relevant information found in the studies analyzed, as well as texts that could contribute significantly to increasing the level of information on Hibiscus and that could have a beneficial impact on the health of the population. The results were gathered and distributed throughout this research according to the organization of this review.

3 RESULTS

Table 1 - Characterization of the articles searched in the Google Scholar, Science Direct, Pubmed, Scielo databases for the keywords vinegar, chronic diseases, Hibiscus sabdariffa L., antioxidants and chemical analysis from 2000 to 2023.

AUTHOR / YEAR	DATABASE	DESIGN OF THE STUDY	COUNTRY INVOLVED
ABREU et al., 2019	Google Scholar	Experimental	Brazil
AGUWA et al. 2004	Google Scholar	*in vivo*	Nigeria
AKINDAHUMI, OLAYE, 2003	Google Scholar	*in vivo*	Nigeria
ALARCÓN-ALONSO et al., 2012	Science direct	*in vivo*	Mexico
ALARCÓN-AGUILAR et al., 2007	Google Scholar	*in vivo*	Mexico
AL-ANBAKI et al., 2019	Google Scholar	Clínico multic.	Jordan
ALI et al., 2011	Google Scholar	*in vivo*	China
ALSHAMI, ALHARBI, 2014	Science direct	*in vivo*	Saudi Arabia
AMOS, KHIATAH, 2021	Pubmed	Review	USA
DOS ANJOS et al., 2017	Google Scholar	*in vitro*	Brazil
AROGBODO, FALUYI, IGBE 2021	Google Scholar	*in vitro*	Nigeria
SÁYAGO-AYERDI et al., 2021	Science direct	*in vitro*	Mexico
SÁYAGO-AYERDI. ZAMORA-GASGA, VENENA, 2020	Science direct	*in vitro*	Mexico
BORRÁS-LINARES et al., 2015	Science direct	Experimental	Mexico
CABALLERO-GEORGE et al., 2002	Google Scholar	Experimental	Panama
CARVAJAL-ZARRABAL et al., 2005	Google Scholar	*in vivo*	Mexico
BOTREL et al., 2020	Scielo	Experimental	Brazil
CHEN et al., 2003	Pubmed	*in vivo*	China
CHEN et al., 2004	Pubmed	*in vivo*	China
RIAZ, CHOPRA, 2018	Pubmed	Review	India
FREITAS, SANTOS, MOREIRA 2013	Google Scholar	Experimental	Brazil
ROCHA et al., 2020	Science direct	Review	England
PRIYANKA et al., 2018	Science direct	Review	India
EDO et al., 2023	Science direct	Review	Nigeria
FERREIRA, 2022	Google Scholar	*in vivo, in vitro*	Brazil
FRANK et al., 2012	Pubmed	Experimental	Germany
DA-COSTA-ROCHA ET AL., 2014	Science direct	Review	Germany
DA SILVA, RANOLFI, 2022	Google Scholar	Review	Brazil
MONTALVO-GONZÁLEZ et al., 2022	Pubmed	Review	Mexico
HAMMRITA et al., 2022	Pubmed	*in vivo*	Algeria
HERRERA-ARELANO, 2004	Pubmed	Clínico	Mexico
ARCE-REYNOSO et al., 2023	Pubmed	Clínico	Mexico
DEBELO et al., 2023	Google Scholar	Experimental	USA

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CLIMACO, VARDANEGA, FASOLIN, 2023	Science direct	Experimental	Brazil
FAKEYE, 2008	Google Scholar	*in vitro*	Nigeria
FAROMBI, IGE, 2007	Google Scholar	*in vivo*	Nigeria
GOMES, 2017	Google Scholar	Experimental	Brazil
GURROLA-DIAZ et al., 2009	Science direct	Clínico	Mexico
HIRUNPANICH et al., 2006	Science direct	*in vivo*	Thailand
HONEYWELL, CULBERT, 2019	Google Scholar	Review	USA
HOPKINS et al., 2013	Science direct	Review	USA
ISMAIL, IKRAM, NAZRI, 2008	Google Scholar	Review	Malaysia
MORALES-LUNA et al., 2019	Google Scholar	Experimental	Mexico
JAMROSIZK, BORYMSKA, KACKMARCZYK, 2022	Pubmed	Review	Switzerland
JARONI, RAVISHANKAR, 2012	Google Scholar	Experimental	USA
JULIANI et al., 2009	Google Scholar	Experimental	Senegal
KNUPP, 2007	Google Scholar	Experimental	Brazil
KNUPP, LORENZI, 2014	Google Scholar	Experimental	Brazil
LACAILLE-DUBOIS, FRANCK, WAGNER, 2001	Science direct	Experimental	France
LEE et al., 2009	Pubmed	Experimental	Taiwan
LIN et al., 2007	Science direct	In vivo	Taiwan
KUMAR et al., 2015	Pubmed	Experimental	India
MACIEL et al., 2012	Google Scholar	Experimental	Brazil
MAJDOUB et al., 2021	Pubmed	*in vitro*	Italy
MARÇO, 2009	Google Scholar	Experimental	Brazil
MALACRIDA et al., 2016	Pubmed	Experimental	Italy
MALACRIDA et al., 2022	Science direct	*in vitro*	Italy
MARQUES et al., 2021	Google Scholar	Experimental	Brazil
BARBOSA et al., 2020	Google Scholar	Experimental	Brazil
NORHAIZAN MOHD-ESA, et al., 2010	Science direct	Experimental	Malaysia
OJULARI, LEE, NAM 2019	Pubmed	*In vivo*	South Korea
ZANNOU et al., 2020	Pubmed	Experimental	Turkey
MAHADEVAN et al., 2009	Google Scholar	Review	India
OBOH et al., 2018	Pubmed	*in vivo*	Nigeria
SILVA, 2020	Google Scholar	Experimental	Brazil
OCHANI, D’MELLO, 2009	Pubmed	*in vivo*	India
OLADEJO et al., 2023	Science direct	Experimental	Nigeria
OMS, 2015	Google Scholar	Review	Switzerland
ORISAKWE, HUSAINI, AFONNE, 2004	Pubmed	*in vivo*	Nigeria
PATIL, RAO 2023	Google Scholar	Review	India
PEREDO, GREGORIA et al., 2020	Google Scholar	Experimental	Mexico
PIOVESANA, 2016	Google Scholar	Experimental	Brazil
PIOVESANA, RODRIGUES, NORENA, 2018	Google Scholar	Experimental	Brazil
ALMEIDA, 2017	Google Scholar	Experimental	Brazil
REANMONGKOL, ITHARAT, 2007	Google Scholar	*in vivo*	Thailand
RICHARDSON, ARLOTA, 2021	Google Scholar	Experimental	USA
RODRIGUES et al., 2017	Google Scholar	Experimental	Brazil
ROSA, 2013	Google Scholar	Experimental	Brazil
SALAH, GATHUMBI, VIERLING, 2020	Pubmed	*In vivo*	Germany
SALEM et al., 2021	Google Scholar	Review	South Korea
SALAMI, AFOLAYAN, 2021	Google Scholar	Experimental	South Africa
DA SILVA et al., 2021	Google Scholar	Experimental	Brazil

STEKER, SILVA, SILVA, 2021	Google Scholar	Review	Brazil
SILVA et al., 2019	Google Scholar	Experimental	Brazil
VASCONCELOS, GUIDOTTI, BONFIM, 2018	Google Scholar	Review	Brazil
VILLALPANDO-ARTEAGA et al., 2013	Pubmed	*in vivo*	Mexico
VIZZOTTO, CASTILHO, PEREIRA, 2009	Google Scholar	Experimental	Brazil
YUSMI, MEUTIA, 2020	Google Scholar	*In vivo*	Indonesia
YANG et al., 2010	Pubmed	*in vitro*	China
ZHEN et al., 2016	Pubmed	*in vitro*	USA

Chart 2 - Research into the main therapeutic effects of using Hibiscus sabdariffa L

PROPERTY	**MAIN INFORMATION**	**REFERENCE**
Anti-inflammatory	Ingestion of dried Hibiscus calyx decreased the plasma concentration of monocyte chemoattractant protein 1 (MCP-1), a biomarker in the assessment of inflammatory diseases.	DA COSTA-ROCHA, 2014.
Antihypertensive	Through the inhibition of angiotesin-converting enzyme (ACE), the relaxing effect may be partially endothelium-independent and possibly mediated by the endothelium-derived nitric oxide (EDNO)-dependent action. Anthocyanins, including delphinidin-3-O-sambubioside and cyanidin-3-O-sambubioside, were responsible for ACE inhibition.	HERRERA ARELLANO et al., 2004
Antihyperlidemic	Daily consumption of tea or Hb extracts had a favorable influence on lipid profiles, reduced total cholesterol, LDL-C, triglycerides, and increased HDL-C.	HOPKINS et al., 2013
Source of fiber	Dietary fiber (DF) can be used as a substrate by bacteria that can be fermented in various catabolic pathways. These bacteria have enzymes capable of hydrolyzing glycosyl bonds, and the subsequent fermentation of the released monosaccharides leads to the production of lactate and short-chain fatty acids (SCFAS).	SAYAGO-AYERDI et al., 2020
Antibacterial	The aqueous extract inhibits S. aureus and K. pneumoniae and E.coli.	ROSA, 2013.
Anti-diabetic	The anti-insulin resistance effect occurs by inhibiting the phosphorylation of insulin receptor substrate 1 (IRS-1), which is induced by hyperglycemia, and by acting against the cytotoxicity of high blood glucose.	AMOS, 2021.
Cosmetics	In Malaysia, the oil is used to produce scrubs and soaps.	DA COSTA-ROCHA, 2014.
Nephroprotective effect	The diuretic effect increases urinary volume and quercetin has an effect on the vascular endothelium causing the release of nitric oxide, increasing renal vessel relaxation by increasing its filtration.	ALARCÓN-ALONSO et al., 2012.
Anti-cancer	The extract is characterized by a high content of polyphenols, flavonoids and anthocyanins, which generates anticancer and chemoprotective potential.	MALACRIDA et al., 2022

Studies by Da Costa-Rocha in 2014 evaluated the claims that Hibiscus sabdariffa proved to be effective in relieving pyrexia used in a popular way, and observed the anti-inflammatory potential of the extract of hibiscus calyxes (cHs) studied in vivo; the ethanolic extract obtained better results when compared to the aqueous extracts related to antipyretic effects, reversing yeast-induced fever in rats. The cHs extract may be involved in the inhibition

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of some substances such as cytokines, interleukins (IL), interferons and tumor necrosis factor-a (TNF- α), which may have led to the anti-inflammatory effect (REANMONGKOL, ITHARAT, 2007).

Research on the ethanolic extract of calyxes indicated a pain-reducing effect in an experimental model in rats (ALI, ASHRAF, BISWAS, KARMAKAR and AFROZ, 2011).

Fakeye (2008) in an in vivo study showed that fractions of the crude aqueous-ethanolic extract of dried Chalices exhibited immunostimulatory activity, increasing IL-10 production and decreasing TNF-α production.

Studies carried out by Herrera-Arellano et al. (2004) quantified the total anthocyanin content of H. sabdariffa L. extract at 9.62 mg total anthocyanins/dose, with a reduction in diastolic pressure rates of 12.31%. It was observed that patients treated with H. sabdariffa L. extract had increased urinary sodium excretion, without modifying other urinary electrolytes, including potassium. sabdariffa L. extract increased urinary sodium excretion, with no change in other urinary electrolytes, including potassium, which can be compared to the administration of spironolactone-type diuretics or aldosterone antagonists, which are potassium-sparing.

There is literature by Caballero-George et al. (2002) which suggests that the aqueous extract of plants such as Hibiscus can probably exert its antihypertensive activity through at least three specific mechanisms of action: diuretic, vasodilator and ACE inhibitor; it is also possible to correlate that this effect is due to blocking the binding of the AT 1 receptor to angiotensin II, as anthocyanins have done in other plant species.

Another possibility recognized by Salah, Gathumbi, Vierling (2002) is that the antihypertensive mechanism may occur through the modulation of Ca 2+ channels, stimulated by quercetin and eugenol. In this sense, Lacaille-Dubois, Franck, Wagner (2001) established that oligomeric procyanidins have an ACE inhibitory effect and, additionally, the potassium acetate present in the aqueous extract, from its moderate diuretic effect, contributes an antihypertensive effect.

Sayago-Ayerdi et al., 2020 reported that Hibiscus sabdariffa L. (Hb) calyxes are a source of dietary fiber (DF). This author investigated the changes in the gut microbiota after pre-digested Hb feeding in a dynamic and validated in vitro model of the human colon and established that the production of short-chain fatty acids in Hb feeding may be related to some of its health effects. Dietary fibers have an interesting prebiotic effect by modulating the composition of the intestinal microbiota, which is not only linked to the growth of bacteria of the genus Bifidobacterium and/or Lactobacillus, but appears to be a more complex modulation of several genera.

Studies carried out by Hopkins et al. (2013) indicated that there are positive points and limitations to the evidence considered for the widespread use of teas made with Hb calyces to treat hypertension and hyperlipidemia, and there is still little research to provide guidance for animal and human studies due to the lack of attention to cultivation, preparation and consumption standards. Different potential mechanisms may provide data on the positive impact of Hb extract on cholesterol metabolism. In this case, cholesterol biosynthesis may be reduced by inhibiting HMG-CoA reductase (YANG et al 2010). Decreases in LDL-C may be the

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result of the inhibition of triacylglycerol synthesis by the racemization of hibiscus acid (CARVAJAL-ZARRABAL et al., 2005).

In addition, although not directly related to cholesterol reduction, but beneficial for improving cardiovascular risk factors, Hb may prevent atherosclerosis and improve vasoreactivity by preventing the formation of macrophage-derived foam cells and/or inhibiting LDL-C oxidation due to the antioxidant effects of the extract (FAROMBI, IGE, 2007; OCHANI, D'MELLO, 2009; HIRUNPANICH et al., 2006; CHEN, 2003, CHEN, 2004; LEE et al., 2009).

Hopkins et al. (2013) state that the anthocyanins found in abundance in Hb calyxes are considered to be the phytochemicals responsible for the antihypertensive and hypocholesterolemic effects of Hibiscus. Effective mechanisms have been proposed to explain the hypotensive and anti-cholesterol effects, with the antioxidant effect of anthocyanins inhibiting the oxidation of LDL-C, which prevents atherosclerosis, an important cardiovascular risk factor.

Studies by Rosa (2013), reported that higher plants have secondary metabolic activity, using defense mechanisms from antibiotic substances synthesized against various predators. The aqueous and alcoholic extracts of Hb were found to inhibit infectious hospital bacteria such as S. aureus and K. pneumoniae. On the other hand, the ethanolic extracts of hibiscus calyxes have already been tested in antimicrobial tests for S. aureus, B. stearothermophillus, M. luteus, S. mascences, C. sporogenes, E. coli, K. pneumoniae, B. cereus and P. fluorescence. The antibacterial activity of Hibiscus can be compared to that of streptomycin, which does not inhibit E.coli. Both the aqueous and alcoholic extracts of Hibiscus calyxes were able to inhibit food-borne pathogenic bacteria such as S. typhimurium, E. coli, L. monocytogenes, S. aureus and B. (MACIEL et al. 2012).

Amos, Khiatah (2021) reports that, from a nutritional point of view, Hibiscus contains many bioactive compounds and that many tea lovers consume this beverage made from the leaves and flowers of this raw material of plant origin. These beneficial effects are known to ancient medicinal healers, which may probably be related to the use of this tea. The use of substances such as anthocyanins present in Hibiscus contributes to its antioxidant and anti-inflammatory potential, which probably results in the species' functionality as an antihypertensive, antihyperlipidemic, anti-obesogenic and anti-diabetic.

This species can probably be consumed as part of small and large meals safely, being included as part of a healthy diet, as it has already been tested and in trials with different dosages, and has maintained a safe profile for humans with multiple dosages ranging from 2 g to 30 g daily in the form of tea without harmful side effects (AL-ANBAKI et al., 2019; YUSNI, MEUTIA, 2020).

As for use in extract form, it has been tested in dosages ranging from 100 mg daily to 150 mg twice a day (LIN et al., 2007; GURROLA-DŸAZ et al., 2009). It is important to note that hibiscus has been safely consumed by many generations of different ethnicities, in different cultures and in various age groups.

Vasconcelos, Guidotti and Bonfim (2018) reported that the antioxidant character found in H. sabdariffa L. can help prevent skin aging and has already been used in facial cosmetic

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formulations containing hydroalcoholic extract of this species in cream with physicochemical quality within the legal standards of current legislation, despite the small amount of phytochemical studies in the face of the immense biodiversity that exists, the study reports that the facial cosmetic formulation presented in one of the formulations the lowest toxicity and its antioxidant capacity (SILVA et al., 2019).

Studies carried out by Alarcón-Alonso et al. (2012) reported the natriuretic capacity to be equivalent to that reported by Herrera-Arellano et al. (2004) in clinical studies. Urinary potassium excretion showed a small increase after administration of the aqueous extract of Hibiscus similar to reports with methanolic extract of Hibiscus sabdariffa L. (Aguwa et al., 2004), indicating a potassium-sparing effect, following N+/K+ analysis.

The pharmacological characterization of the diuretic and natriuretic effect of the aqueous extract of H. sabdariffa L. carried out by Alarcón-Alonso et al. (2012), showed results with the ethnometric use of the plant. On the other hand, popular use indicates 10 g of this raw material daily in the form of a decoction of dried calyxes. The results showed that the dose contained 300 mg of extract, indicating that a 60 kg adult could receive a dose of 5 mg of extract/kg. Doses of 25 to 250mg/kg of weight were then analyzed in diuresis trials, and no diuretic effects were observed. Based on this premise, doses of 250 to 500mg/kg of weight were evaluated, resulting in a reproducible diuretic effect, contrasting with the results found by Aguwa et al. (2004), but this author experimented with methanolic extracts, which are more efficient for extracting active compounds, and this is probably why the diuretic effect only occurred at higher doses of the aqueous extract.

Research has evaluated extracts of Hibiscus sabdariffa L. which is not neurotoxic in vitro and indicated that enriched fractions of the plant did not affect the cell viability of non-tumor cells, however, indicated antitumor effects in cell lines of Multiple Myeloma and Oral Squamous Cell Carcinoma (MALACRIDA et al., 2016).

The authors investigated the antitumor action of the enriched fraction of Hibiscus sabdariffa L. on breast cancer cells in vitro in two breast cancer cell lines, MCF-7 and MDAMB-231. The study suggests that the Hb-enriched extract fraction exhibits good antitumor activity in vitro and is effective for both luminal and triple negative breast cancer, and that this fraction could be indicated as a possible therapeutic option in the treatment of breast cancer. It should be noted that further research into the mechanisms of action should be carried out and the possibility of this type of extract fraction being used in combination with an antineoplastic agent should be evaluated for better efficacy (MALACRIDA et al., 2022).

4 CONCLUSION

It can be concluded from the research carried out that Hibiscus sabdariffa L. is strategic for medicinal purposes, with a functional property claim, related to an important aid in the nutritional balance of the diet plan of patients with comorbidities such as obesity, dyslipidemia, hypertension, and some types of cancer, as it has therapeutic properties such as antihypertensive, antioxidant and antimicrobial effects.

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The vinegar tree has the nutritional potential of the PANCs grown in the Brazilian biome. High concentrations of minerals, associated with the hardiness of Hibiscus, suggest that the species is an alternative source of nutrients available to consumers of vegetables. However, there is a need for further studies into the bioavailability of nutrients.

Research carried out in this review article has shown that the characteristics of vinegar can contribute positively to new directions for more specific studies of this raw material of plant origin, especially its nutritional and functional content, which can be used to enrich food products, cosmetics and to extract natural pigments for the production of food colorings.

Finally, the use of the species Hibiscus sabdariffa L., which has been shown in many studies to have so many beneficial characteristics, when included in the human diet, added to culinary preparations or beverages such as teas, could probably result in a food option with a functional property claim for healthy individuals, provided that it can be introduced on a regular basis into a healthy diet in dosages that reduce the risk of chronic non-communicable diseases.

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