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REVIEW ARTICLE

Salicornia as a salt substitute in obesity-induced hypertension: an integrative review

Salicornia como sustituto de la sal en la hipertensión inducida por obesidad: una revisión integradora

Salicornia como um substituto ao sal na hipertensão induzida por obesidade: uma revisão integrativa

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Abstract

The aim was to map the existing evidence in the literature on the role of Salicornia sp. as a complementary therapy in the treatment of Obesity-Induced Hypertension. This is an integrative review carried out between January 2019 and December 2021, in the MEDLINE, LILACS and SciELO databases, reaching a total of 70 publications. After applying the inclusion and exclusion criteria, a corpus of 10 articles was obtained. The studies analyzed were carried out in seven countries. Nine studies revealed positive effects of Salicornia supplementation in improving hypertension in animal models. Two of them included direct effects and seven indirect effects. One study revealed an adverse effect of supplementation. It is concluded that plants of the genus Salicornia have beneficial effects as a substitute for common salt in the control of arterial hypertension in animal models. The need for Randomized Clinical Trials to analyze the benefit in humans is highlighted.

Descriptors: Chenopodiaceae; Chronic Disease; Health Promotion; Cardiovascular Diseases; Therapeutic Adherence.

Resumén

El objetivo fue mapear la evidencia existente en la literatura sobre el papel de Salicornia sp. como terapia complementaria en el tratamiento de la Hipertensión Inducida por la Obesidad. Esta es una revisión integradora realizada entre enero de 2019 y diciembre de 2021, en las bases de datos MEDLINE, LILACS y SciELO, alcanzando un total de 70 publicaciones. Tras aplicar los criterios de inclusión y exclusión se obtuvo un corpus de 10 artículos. Los estudios analizados se realizaron en siete países. Nueve estudios revelaron efectos positivos de la suplementación con Salicornia en la mejora de la hipertensión en modelos animales. Dos de ellos incluyeron efectos directos y siete efectos indirectos. Un estudio reveló un efecto adverso de la suplementación. Se concluye que las plantas del género Salicornia tienen efectos benéficos como sustituto de la sal común en el control de la hipertensión arterial en modelos animales. Se destaca la necesidad de Ensayos Clínicos Aleatorizados para analizar el beneficio en humanos.

Descriptores: Chenopodiaceae; Enfermedad Crónica; Promoción de la Salud; Enfermedades Cardiovasculares; Adhesión al Tratamiento.

Resumo

Objetivou-se mapear as evidências existentes na literatura sobre o papel da Salicornia sp. como terapia complementar no tratamento da Hipertensão Induzida por Obesidade. Trata-se de uma revisão integrativa realizada entre janeiro de 2019 a dezembro de 2021, nas bases de dados MEDLINE, LILACS e SciELO, atingindo um total de 70 publicações. Após a aplicação dos critérios de inclusão e exclusão, obteve-se um corpus de 10 artigos. Os estudos analisados foram realizados em sete países. Nove estudos revelaram efeitos positivos da suplementação de Salicornia na melhora da hipertensão em modelos animais. Dois deles incluíram efeitos diretos e sete efeitos indiretos. Um estudo revelou um efeito adverso da suplementação. Conclui-se que plantas do gênero Salicornia apresentam efeitos benéficos como substituto do sal comum no controle da hipertensão arterial em modelos animais. Destaca-se a necessidade de Ensaios Clínicos Randomizados para analisar o benefício em humanos.

Descritores: Chenopodiaceae; Doença Crônica; Promoção da Saúde; Doenças Cardiovasculares; Adesão Terapêutica.

Introduction

Cardiovascular diseases (CVD) are the leading causes of death in the world, accounting for more than 17 million deaths in 2008, with estimates around 23.6 million in 2030. However, these conditions could be avoided with control of risk factors, of which arterial hypertension and unhealthy diet are considered the main responsible for the global burden of preventable CVD[1-3].

Systemic Arterial Hypertension (SAH) is a chronic disease, with multifactorial causes associated with functional, structural and metabolic changes. Even though the epidemiology of hypertension varies between regions and countries, the proportion of Brazilian adults with SAH in 2013 was 32.3%. Most cases of hypertension are primary, with no obvious identifiable causes, although there are recognizable risk factors associated with the condition, which can be categorized into modifiable and non-modifiable[3-5].

Genetic composition, sex, race, age and family history are considered non-modifiable risk factors, as they are individual characteristics that cannot be changed or adjusted, and little can be done to control them. However, environmental factors that are determined by behavior, such as physical activity, consumption of salt and fats, alcoholism and smoking, can be adjusted to prevent the development of the disease[5,6].

Among these factors, excessive salt consumption is a public health challenge. Data from a previous study showed that, in the national territory, severe CVDs represented a potential impact of R$ 30.8 billion, corresponding to 1.74% of the Gross Domestic Product in 2004. The World Health Organization (WHO) recommends that the consumption of salt for the adult population is less than 5 g/day, however, in Brazil, according to the 2008 Family Budget Survey, the average consumption is 12 g/day, exceeding by more than twice the proposed limit[7-9].

Ellison and Welling[10] emphasized that there is much interest in establishing the mechanisms by which salt intake raises blood pressure. Among all the hypotheses proposed to explain this correlation, the most developed are those that suggest primary dysfunction of blood vessels and the Sympathetic Nervous System, in addition to the activation of the immune system.

On the other hand, Dong et al.[11,12] demonstrated that another important risk factor for Systemic Arterial Hypertension is obesity. In agreement, according to the Howe et al.[13], small size at birth followed by rapid adiposity gain in childhood is associated with higher blood pressure in young adulthood.

To elucidate the pathophysiology related to Obesity-Induced Hypertension, Kotchen[14] explains that the putative physiological mechanisms are complex, interdependent and redundant, although an understanding can have important therapeutic implications. Body mass gain is related to an increase in plasma insulin, which in turn has an anti-natriuretic effect, increasing extracellular volume and, consequently, raising systemic blood pressure[14,15].

In this context, Gomes Alves et al.[16] emphasize that adherence to the pharmacological treatment of SAH is an essential step for the success of antihypertensive therapy. Non-adherence, in turn, results in aggravation of the pathological process, increasing morbidity and hospital admissions. Therefore, non-pharmacological measures that encourage a change in lifestyle, such as reducing sodium intake and, consequently, lowering blood pressure, encouraging the patient to adhere to drug treatment, are essential.

Therefore, a halophyte plant native to the coastal region of Portugal, called Salicornia europaea (SE), popularly known as sea asparagus, was discovered and some preliminary studies suggested properties related to blood pressure reduction. The plant's bioactivity is due to its excellent nutritional value, levels of minerals, vitamins, antioxidants and diuretic effect. In addition, the vegetable has a characteristic salty taste, and may be a possible substitute for common salt. The use of SE in Mediterranean cuisine is a common practice, having been consumed as a spiced vegetable and herb in coastal areas of Europe and Korea[17-19].

Given the above, considering the high rates of morbidity and mortality from cardiovascular diseases, in Brazil and in the world, and the prevalence of hypertension related to obesity and unhealthy diet, associated with the promising and safe bioactive qualities of Salicornia, the present study is justified by the lack of information about its effects and mechanisms in the context of obesity-induced arterial hypertension. Therefore, this article sought to identify the direct and indirect consequences of the vegetable on SAH, in addition to possible adverse events through an integrative literature review. Thus, the central line of investigation for this article was: Can the replacement of common salt by an extract derived from the plant of the genus Salicornia alter the development of Obesity-induced Systemic Hypertension?

Methodology

This study involved an integrative literature review, using the concepts and methods proposed by Soares et al[20], which establish that, in the field of health, the integrative review aims to establish a summary of scientific information to identify and understand problems related to the population, requiring authors to draw up hypotheses and conclusions in order to contribute to evidence-based practices. In addition, an integrative review allows the analysis of different types of sources and studies, providing a holistic understanding of a health phenomenon[21,22].

The research process followed the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[23]. It is noteworthy that this type of study does not require the approval of the Research Ethics Committee. Only studies in the public domain were used and all ethical criteria regarding the preservation of authorship and citation of sources were respected.

The selection of works took place between January 2019 and December 2021. To search for articles, the following databases were consulted: National Library of Medicine (MEDLINE via PubMed), Latin American and Caribbean Center for Health Sciences (LILACS) and Scientific

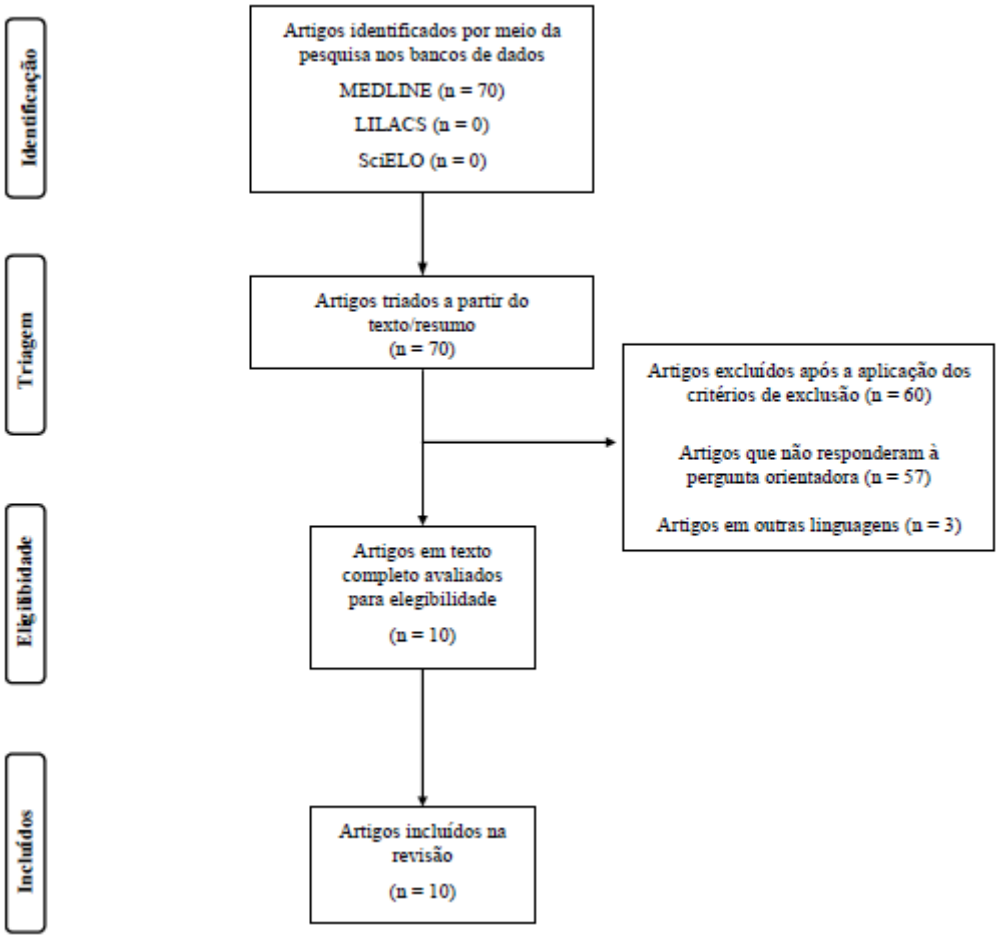
Electronic Library Online (SciELO). The following official descriptors (DeCS) were used: "Hypertension", "Obesity" and "Salicornia".

Cross-checking was performed using the advanced search tool and the Boolean AND operator. The search was performed using the descriptors in Portuguese and their respective equivalents in English: "hypertension AND obesity AND salicornia; hypertension AND salicornia; obesity AND salicornia". Articles in Portuguese, English and Spanish published between January 2008 and December 2021 were used as filters.

The following were included in this study: research with human beings; basic research (animals, cell culture and chemical analysis of food); complete articles available electronically, involving the topic Salicornia, Hypertension and Obesity. The exclusion criteria related to the texts found were: articles that did not answer the guiding question; articles in languages other than English, Portuguese or Spanish.

The selection of articles was performed by searching the MEDLINE (n=70), LILACS (n=0) and SciELO (n=0) databases, resulting in a total of 70 articles that were screened for applicability based on in the title and abstract. After applying the exclusion criteria, 10 original studies were identified. Each full text was then independently analyzed to determine if they met the inclusion criteria. At that moment, a critical reading of the documents was carried out, resulting in a total of 10 publications, all located in the MEDLINE database. This result was discussed and a consensus was reached, so that decisions did not involve disagreements. The flowchart in Figure 1 represents the corpus structure of this review.

Figure 1. Flowchart of the PRISMA selection process for the consulted articles. Maringá, PR, Brazil, 2021



For data extraction, a standardized form was created in Microsoft Excel, containing the criteria: authors, date and place of publication; type of study and level of evidence; goals; evaluated parameters; interventions; results and conclusions.

Regarding the levels of evidence, the studies were classified as: I - Systematic review of randomized trials; II - Randomized trial or observational study with dramatic effect; III - Non-randomized controlled cohort/follow-up study; IV - case series studies, case-control studies or historically controlled studies; V - Mechanistic reasoning[24].

The articles listed for this review were then organized into three categories, considering their characteristics: Direct effects of Salicornia consumption in the prevention of SAH; Indirect effects of Salicornia in the prevention of SAH; Adverse events of Salicornia consumption as a therapeutic resource.

Results

The study summarized information published in 7 countries, 3 from Great Britain [25-27], 1 from Switzerland [17], 1 from France[28], 1 from South Korea [29], 2 from the United

States[30,31], 1 from the Netherlands[32] and 1 from Nigeria[33]. For the level of evidence, the following distribution was observed: 9 level V[17,25,26,28–33] and 1 level IV [27]. By year of publication were: 1 of 2009[30], 2 of 2014[27,33], 3 of 2015[25,29,31], 1 of 2016[17], 1 of 2017[28], 1 of 2018[26] and 1 of 2019[32].

Regarding methodologies, 7 pre-clinical studies were included[17,25,26,28,29,31,33] and 2 literature reviews of preclinical studies[30,32]. A total of 9 studies evaluated the effects of Salicornia as a salt substitute in improving hypertension[17,25,26,28–33].

Two of them evaluated the direct effects of Salicornia in improving hypertension, with both studies reporting positive results in rats[17,25]. Evidence suggests that the decrease in blood pressure observed in the context of preclinical research may be associated with the replacement of common salt with Salicornia and its vascular protective effect. In agreement, data from seven studies evaluated the indirect effects of Salicornia in the control of SAH[26,28–33]. The cited effects were: the ability to promote a decrease in body weight[26,31,32], antioxidant and anti-inflammatory effects[30,33], the improvement of the lipid profile of rats[26], a preventive potential of vascular remodeling[28] and the ability to improve food quality characteristics[29].

However, a case report described an adverse effect of the use of Salicornia in the treatment of SAH[27]. It has been reported that consumption of Salicornia herbacea (SH) may be related to the development of Thyrotoxic Hypokalemic Periodic Paralysis (PPHT). Despite this, the study does not clarify the mechanisms related to the consumption of the vegetable with the triggering of the reported paralysis, which opens space for further studies on the subject.

The studies showed a multitude of mechanisms associated with the substitution of common salt for Salicornia and consisted mainly of laboratory studies in animals. It is a fact that systematic reviews of high-quality randomized trials often count as the best evidence[34]. Nonetheless, according to Howick et al.[35], Well-conducted randomized trials are sometimes not available, and other forms of evidence must be considered, at least for hypothesis generation. Furthermore, Faggion[36] highlighted that animals are fundamental to the development of human therapies, providing mechanistic information as well as information on efficacy and safety. The studies included in the synthesis of this review are presented in Chart 1.

Chart 1. Synthesis of selected articles on the effects of Salicornia in the prevention and control of obesity-induced hypertension. Maringá, PR, Brazil, 2021

Authors, date and place of publication	Type of study/Level of Evidence	Objectives	Evaluated parameters	Interventions	Results and conclusions
Zhang et al.[25], 2015, Great Britain	Experimental study / Level V	Investigate the effects of Salicornia bigevolli Torr (SPS) on the blood pressure of rats.	a) Blood pressure; b) Serum components: Nitric Oxide, Angiotensin-II and Endothelin-1.	Feed the mice SPS.	Ingestion of common salt for long periods can lead to hypertension, while the use of SPS as a substitute can increase the body's antioxidant properties, preventing kidney and liver damage caused by excess salt, preventing the occurrence of hypertension.
Panth et al.[17], 2016, Switzerland	Experimental study / Level V	Investigate the effect of Salicornia europaea (SE) on vascular function and blood pressure in rats.	a) Blood pressure; b) Body weight.	Feed the mice with SE.	The intake of SE had little effect on increasing blood pressure, compared to consumption of NaCl, and may improve the hypertensive state. In addition, SE consumption did not induce vascular dysfunction, with the transferuric acid component being one of the main responsible for the vascular protective effect.
Rhee et al.[30], 2009, United States	Literature review/ Level V	Analyze botanical, chemical and pharmacological information of Salicornia herbacea (SH).	a) Database analysis.	Not applicable.	Studies have demonstrated curative and HS modulating properties in diabetes, obesity and hyperlipidemia. The main activity appears to be its antioxidant, anti-inflammatory and immunomodulatory effects. The results suggest that HS can be used as a nutraceutical potential in inflammatory diseases.
Kwon et al.[33], 2014, Nigeria	Experimental study / Level V	Investigate the effects of Salicornia herbacea supplementation on lipid peroxidation in rats.	a) Serum components: Glucose, Triglycerides (TG), Total Cholesterol (TC) and High Density	Feed the mice with SH.	SH intake decreased triglyceride and MDA levels. In addition, the expression of antioxidant proteins in skeletal muscle was increased.

			b) Lipoprotein; Malondialdehyde (MDA) levels in skeletal muscle; c) Expression of antioxidant proteins in skeletal muscle.		
Lim et al.[29], 2015, South Korea	Experimental study / Level V	Evaluate the effects of the addition of SH on the physicochemical characteristics of Frankfurter sausages.	a) Frankfurter composition analysis: fat, protein and salt content; b) Water holding capacity; c) Cooking loss.	Add SH in the preparation of sausages.	The addition improved cooking loss, water holding capacity, emulsion stability, hardness and viscosity. SH also improved texture-related sensory attributes such as tenderness and juiciness.
Pichiah et al.[31], 2015, United States	Experimental study / Level V	Evaluate the anti-obesity effect of SH ingestion in rats.	a) Body and liver weight; b) Serum components: leptin and insulin; c) Lipid profile.	Feed the mice with SH.	SH intake significantly decreased body and liver weight, triglycerides, and serum leptin and insulin levels.
Won et al.[28], 2017, France	Experimental study / Level V	Analyze the effects of Salicornia europaea (SE) on atherosclerotic responses (especially migration and proliferation) in vascular smooth muscle and formation of vascular neointima.	a) Cell viability assays, proliferation and migration of vascular smooth muscle cells (VSMCs).	CMLVs from rat aortas were treated with SE.	The results suggest that SE can inhibit the migration and proliferation of CMLVs and reduce hyperplasia during vascular remodeling. Therefore, SE may be a potential ingredient for supplemental or nutraceutical diets in preventing vascular remodeling-related diseases.
Rahman et al.[26], 2018, Great Britain	Experimental study / Level V	Investigate the anti-obesity effects and mechanisms of action of SE.	a) Abdominal fat (visceral and subcutaneous); b) Serum components: TG, CT, HDL and low-density lipoprotein (LDL); c) Atherogenic index: CT/HDL.	Feed the mice with SE.	Body weight and abdominal fat were reduced, in addition to an improvement in the lipid profile. In addition, transferuric acid was identified as the main component responsible for suppressing adipocyte differentiation and intracellular lipid accumulation.
Na et al.[32], 2019, Netherlands	Literature review/ Level V	Classify natural components that have important effects on obesity control based on experimental techniques.	a) Database analysis.	Not applicable.	Among other components, HS was cited for having beneficial effects on weight reduction and fat gain and on improving the lipid profile.
Yun et al.[27], 2014, Great Britain	Case report/ Level IV	Investigate the influence of Salicornia herbacea consumption as a treatment resource for diabetes and hypertension on serum potassium and Thyrotoxic Hypokalemic Periodic Paralysis (PPHT).	a) Serum components: Thyro-stimulating hormone (TSH), T3, T4 and potassium.	Discontinue SH supplementation.	Eight months after discontinuation of HS, without other treatments, the patient's thyroid function tests and serum potassium level were normalized.

The discussion of the analyzed articles is presented below, grouped by similarities for better understanding. Effectively, the findings of this review revealed that analyzing a possible change in the development of hypertension requires a look that considers multiple aspects of this condition.

Discussion

Improvement of hypertension through the direct effects of Salicornia

Beneficial results in preventing the hypertensive state due to consumption of Salicornia europaea were observed by Panth et al.[17] by means of high pressure liquid chromatography. The components of SE were identified, of which the main ones are sodium chloride (55.6%), 5-hydroxymethylfurfural, P-coumaric acid and transfeluric acid. The authors established that moderate salt intake is certainly essential for maintaining the homeostatic properties of extracellular volume, blood pressure, and vascular function. However, when this consumption is excessive, it can worsen hypertension and generate vascular dysfunction by endothelial stiffening by reducing the release of nitric oxide (NO). Therefore, it was observed that the replacement of sodium chloride by the plant can prevent such vascular changes, mainly through the action of transfeluric acid.

Although the exact mechanism of this protection needs further investigation, the results suggest that transfeluric acid increases the bioavailability of NO, an important vasodilator. Furthermore, when using hypertensive rats, it became clear that a high salt diet, compared to SE intake, promoted higher blood pressure indices, suggesting that a high pure NaCl intake has a significant effect on the blood pressure marker. However, the use of SE instead of NaCl had a protective effect and less impact on blood pressure in rats[17]. These results demonstrate that the vegetable can prevent the occurrence of SAH, in addition to improving the evolution of the disease.

There is also evidence on the benefits of replacing common salt with an extract derived from Salicornia bigelovii Torr (SB), for the prevention of hypertension. Zhang et al.[25] emphasized that, in Sprague-Dawley rats, consumption of the vegetable compared to NaCl did not significantly alter the serum levels of NO, Angiotensin-II and Endothelin-1. However, a possible antioxidant effect was observed, since a group of hypertensive rats treated with the vegetable obtained an increase in superoxide dismutase and sodium-potassium pump activity, and a decrease in malondialdehyde (MDA) levels. MDA is considered a plasma biomarker to determine oxidative damage[37], therefore, its reduction in plasma has an indicative value of antioxidant protection. Therefore, the authors found that, as Panth et al.[17], although Salicornia bigelovii Torr has NaCl in its composition (22.1%), its consumption may be beneficial compared to common salt, having a lower impact on blood pressure due to the presence of other active components that can repair oxidative damage[25]. In order to investigate the antioxidant properties of Salicornia, Rhee et al.[30] reported that, using the Rancimat and Thiobarbituric Acid methods, the likely compounds responsible for such activity would be two flavonoids: quercetin-3'-O-β-D-glucopyranoside and isorhamnetin-3'-O-β-D-glucopyranoside.

Improvement of hypertension through the indirect effects of Salicornia

Previous studies had already associated the consumption of Salicornia with effects that possibly have repercussions on hypertension. Through a review of literature published in South Korea[32], the potential in vitro and in vivo anti-obesity and anti-inflammatory effects of 13 naturally derived ingredients were investigated based on the enzymatic activity of lipid metabolism. Among the selected natural raw materials, Salicornia herbacea was cited as a plant capable of suppressing body mass gain and promoting hypoglycemic effects, reducing plasma cholesterol levels, animal models.

To further investigate this hypothesis, Rahman et al.[26] performed a laboratory study to explore the anti-obesity activity and mechanism of action of Salicornia europaea through an experiment with Sprague-Dawley rats. For this, 50 rats were divided into five groups, followed for 12 weeks: a normal control group, a control group that was induced to obesity by a hypercaloric diet, a group supplemented with 250 mg/kg/day of desalinated SE, a group supplemented with with 500 mg/kg/day of desalted SE and one group supplemented with 200 mg/kg of Garcinia cambogia. As a result, it was possible to observe that Salicornia europaea promoted a reduction in the body mass and abdominal fat of the animals, in addition to providing an improvement in the lipid profile. In agreement with previous studies by Panth et al.[17], the authors of this experiment found that transfeluric acid is the main component responsible for suppressing the differentiation of adipocytes, the accumulation of intracellular lipids and for modulating the negative regulation of genes responsible for adipogenesis.

Kwon's Study et al.[33] also carried out laboratory research with rats. The experiments were carried out with the implantation of a diet supplemented with Salicornia herbacea. Thus, the authors randomly and equally divided 16 Sprague-Dawley males into two groups, followed for 8 weeks: a control group with a high-fat diet and an experimental group with a vegetable-supplemented diet. After this interval, it was observed that, although the body weights of both groups were not significantly different, the triglycerides and MDA levels of the group that received Salicornia were significantly lower than the control group, reinforcing Zhang's antioxidant and hyperlipidemic thesis et al.[25].

In addition, recent evidence suggests that foods rich in fat and/or sodium chloride promote obesity by increasing adipose tissue mass and adipocyte size, while dietary fiber intake prevents weight gain[39]. Due to the fact that Salicornia herbacea has both dietary fiber and sodium chloride in its composition, Pichiah and Cha[31] decided to investigate whether replacing common salt with SH in a high-fat diet could prevent the development of obesity, through

a more targeted experiment than the previous study by Kwon et al.[33]. To elucidate this hypothesis, the authors randomly divided 50 male mice into 5 groups with different types of diet, followed for 15 weeks: a control group receiving a normal diet, a group receiving a high-fat diet alone, a group receiving a high-fat diet associated with 1% sodium chloride 10 g/kg, a group receiving a high fat diet associated with 3% cellulose 30 g/kg and a group receiving a high fat diet supplemented with Salicornia herbacea 50 g/kg. After comparing the data, it was found that the vegetable has significant effects in decreasing body weight gain and decreasing the hepatic accumulation of triglycerides.

Rhee's et al.[30] and Won et al.[28] studies demonstrated that both Salicornia herbacea and Salicornia europaea have several pharmacological components with antioxidant, anti-inflammatory and immunomodulatory activities. There is evidence that SE has an effect on vascular hyperplasia by inhibiting platelet-derived growth factor-BB, reducing cell proliferation in the tunica intima of animals with balloon catheter[28]. These results reinforce the thesis that the use of Salicornia may have a beneficial effect for post-angioplasty patients, as well as becoming a treatment option in cases of cardiovascular diseases. Won et al.[28] also state that the main phenolic compounds identified in Salicornia europaea were: protocatechuic acid, chlorogenic acid, caffeic acid, p-coumaric acid, ferulic acid and four flavonoids, including isorhamnetin-3-β-d-glycoside, isorhamnetin, quercetin-3- β-d-glycoside and quercetin. However, evidence indicates that ferulic, chlorogenic, protocatechuic and caffeic acids are the most relevant for the antihyperplasia effect[28]. In this sense, the research obtained promising results on the possible use of Salicornia europaea as a nutraceutical in the prevention of diseases related to vascular remodeling.

It is notable that the food industry's interest in reducing salt and fat is proportional to the consumer's interest in enjoying increasingly healthier foods. Excessive intake of sodium contained in processed foods, especially in meat products, is the main cause of increased blood pressure and cardiovascular disease[38]. However, salt and fat, despite being harmful to health, have several functions in the texture and softness of products. With that in mind, the physicochemical properties of Salicornia herbacea were evaluated in an experimental study in South Korea, where the plant was added as an ingredient to low-salt and low-fat pork sausages[29]. The aim of the study was to investigate the effect of the plant on the textural and sensory characteristics of the food. The research revealed that the addition of Salicornia herbacea reduced 10% of the total fat of the food tested and, in addition to increasing the physicochemical characteristics of the sausage, such as improved texture, softness and juiciness, there was also a gain in palatability, presentation and impact on the health of those who consume it.

Adverse events of Salicornia as a treatment resource

Finally, only one study selected for this integrative review described an adverse event from the consumption of Salicornia herbacea. Yun et al.[27] reported the case of a 56-year-old Korean man who used HS during the treatment of diabetes and hypertension and presented with Thyrotoxic Hypokalemic Periodic Paralysis. The patient was using seven pills a day for a period of 6 months. However, data are inconsistent to attribute a relationship between HS use and disease development, as the epidemiology of PPHT shows that Asian ethnicity and males are commonly affected by this endocrine disorder.

Previous studies have suggested that excess thyroid hormones, β2-adrenergic stimulation and hyperinsulinemia may be related to the sudden onset of PPHT by increased Na+–K+ ATPase activity, resulting in transport of potassium to the intracellular compartment, with consequent hypokalemia and changes in muscle strength[40, 41]. Therefore, as there are no other scientific reports on side effects or complications after ingestion of salicornia-derived nutraceuticals, more clinical data are needed to evaluate the use of Salicornia as a therapeutic or prophylactic resource in order to increase antihypertensive therapeutic adherence, defined as the correct execution of the pharmacological prescription[42].

Conclusion

This integrative review explored scientific publications that discussed the direct and indirect antihypertensive pharmacological effects of different species of the genus Salicornia. The research aimed to elucidate non-pharmacological therapeutic tools to prevent and/or treat Systemic Arterial Hypertension. In the surveys reviewed here, it was highlighted that the halophyte plant has promising properties against Obesity-Induced Hypertension, mainly due to its antioxidant and anti-obesity characteristics, in addition to its role in the management of atherosclerosis.

Together, the high rates of morbidity and mortality from cardiovascular diseases, in Brazil and in the world, and the high prevalence of obesity-related hypertension, the study suggests an indication that associating the bioactive and promising qualities of Salicornia with the current protocol of therapy for SAH would be beneficial, since, in addition to having great nutritional value, this genus of vegetable stands out for its characteristic salty taste, with the potential to replace common salt and favor adherence to treatments. However, one of the limitations of this review is the fact that there are no randomized controlled trials evaluating the effects of Salicornia in humans, since most of the studies analyzed were experiments on animals.

Although one study reported an adverse event from Salicornia consumption, evidence with the correct methodology for this purpose is lacking. Therefore, the research made it possible to answer the guiding question about the replacement of common salt by Salicornia in the development of Obesity-Induced Hypertension: the results in experimental research were promising and significant; however, the absence of clinical trials makes it difficult to recommend the problem raised in humans. With this statement, we believe that new evidence based on clinical research on this content is sorely needed for further consideration.

The contribution resulting from the present study consisted of gathering and organizing the existing data on the subject in question, making visible the points that will need to be examined more carefully.

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