INSECT-BASED FUNCTIONAL FOODS: ANTI-INFLAMMATORY POTENTIAL FOR VOCAL HEALTH IN SINGERS

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Abstract

Introduction: Edible insects have been gaining prominence as a sustainable and nutritious alternative to traditional sources of animal protein. Studies point to their nutritional, antioxidant, and technological benefits, in addition to their viability for the food industry. **Objective**: To investigate the relationship between vocal health and functional nutrition, with an emphasis on the effects of bioactive compounds present in alternative protein foods from edible insects. **Methodology:** The research is based on a systematic literature review on the nutritional composition, bioactivity, and technological potential of edible insects. Scientific articles that address topics such as protein hydrolysis, antioxidant activity, and industrial applications of these organisms were analyzed. The search was carried out in the following databases: Scopus, ScienceDirect, PubMed, Web of Science, SpringerLink, and Google Scholar, considering publications between the years 2000 and 2021. In addition, complementary sources of a technical and journalistic nature were included, such as reports and websites specialized in the subject. The selection of studies considered criteria of scientific relevance, including research on the production of

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bioactive peptides, functional properties, industrial processing and nutritional evaluation of insects. **Results:** Edible insects, such as Gryllus assimilis and Zophobas morio, have a high protein content, essential minerals and natural antioxidants. Studies indicate that bioactive peptides derived from protein hydrolysis of these insects have functional potential. **Discussion:** The inclusion of insects in the diet can reduce environmental impacts and provide an efficient protein source. Derived products, such as protein flours, have been incorporated into the food industry due to their functional and antioxidant properties. **Conclusion:** Edible insects emerge as a promising alternative for the diversification of the human diet and for the promotion of environmental sustainability. Their high nutritional value, especially regarding protein content and the presence of bioactive compounds with antioxidant potential, has been widely highlighted. In addition to their nutritional benefits, they also have technological potential in the formulation of new foods, contributing to innovations in the food industry. However, future research is needed, particularly with regard to food safety, standardization of production processes and consumer acceptance.

Keywords: Edible Insects; Alternative Protein; Antioxidants; Sustainability; Bioactivity.

INTRODUCTION

The process of voice production, known as phonation, occurs in the larynx through the vibration of the vocal folds. When the air exhaled from the lungs passes through the glottis, the vocal folds vibrate, generating sound. The frequency of vibration determines pitch, while resonance in the oral, nasal, and pharyngeal cavities influences timbre. This process is regulated by the central nervous system, which controls the coordination of laryngeal muscles to ensure proper vocal modulation (Behlau, 2005; Zemlin, 2000).

The muscles involved in phonation are classified as intrinsic and extrinsic. Intrinsic muscles, such as the cricothyroid and thyroarytenoid, adjust the tension and length of the vocal folds, influencing the frequency of the sound. Extrinsic muscles, such as the sternothyroid and hyoglossus, assist in stabilizing

and moving the larynx. The coordinated action of these muscles enables variations in vocal intensity and quality, which are essential for effective communication (Behlau, 2005; Zemlin, 2000; Ferrand).

Diet plays a fundamental role in maintaining a singer's vocal health, directly influencing the vocal tract and the physiological conditions of the larynx. Foods rich in antioxidants and functional nutrients, such as bioactive peptides, can contribute to reducing oxidative stress in vocal structures, improving tissue resilience and recovery after intense voice use (Liang et al., 2019). Conversely, inadequate diets—excessive in processed, fatty, or acidic foods—can trigger inflammatory processes or gastroesophageal reflux, negatively affecting the laryngeal mucosa and impairing phonation (Behlau, 2005; Zemlin, 2000).

Beyond their antioxidant properties, edible insects contain compounds that help reduce levels of oxidative stress, a factor frequently associated with the worsening of GERD and other inflammatory diseases. Studies have shown that including these foods in the diet can help minimize the formation of reactive oxygen species (ROS), which contribute to inflammation in the gastrointestinal tract. Peptides derived from insect proteins have the capacity to neutralize these harmful molecules, acting as natural anti-inflammatory agents. This action may be crucial for those seeking relief from symptoms of reflux and gastric inflammations (Huang et al., 2019).

Furthermore, the presence of phenolic compounds in these foods can modulate the inflammatory response by inhibiting the action of pro-inflammatory mediators (Liu et al., 2012). These beneficial effects are similar to those observed in hydrolyzed proteins from other functional sources, which demonstrate therapeutic potential in inflammatory processes (Coelho et al., 2019). The consumption of insects can also provide essential minerals and beneficial fatty acids that reinforce the immune system, contributing to faster recovery (Roncolini et al., 2020). Thus, including insect-derived products in the diet can be an innovative approach to combating throat inflammation.

Therefore, the objective of this review is to investigate the relationship between vocal health and functional nutrition, with emphasis on the effects of bioactive compounds present in alternative protein foods—such as edible insects—on maintaining the integrity of the vocal tract and preventing

inflammatory processes. It integrates anatomical and physiological knowledge of phonation with evidence on the antioxidant and anti-inflammatory properties of peptides and protein hydrolysates, seeking to understand possible contributions of these foods to the resilience and recovery of the artistic voice

METHODOLOGY

The methodology used in the research was based on the systematic evaluation of different methods for quantifying hydrolyzed peptides from food proteins. Chromatographic, spectrometric, and electrophoretic approaches were analyzed to determine their efficiency in identifying and quantifying bioactive compounds. The methods were selected based on their accuracy, reproducibility, and applicability in different food matrices, ensuring reliable and comparable results (Nwachukwu & Aluko, 2019).

In addition to analytical techniques, the research considered studies that addressed the functionality of hydrolyzed peptides in the development of functional foods and nutraceuticals. In vitro and in vivo assays were conducted to evaluate the antioxidant and anti-inflammatory capacity of peptides obtained from alternative protein sources. The choice of these methods enabled verification of the bioactivity of the compounds and their feasibility for commercial applications, contributing to advances in food science (Aluko, 2012).

Another relevant aspect of the methodology was the analysis of studies that reported on oxidative stress associated with cellular metabolism and the interactions among the compounds studied. Spectrophotometric and electrochemical assays were employed to monitor the generation of reactive oxygen species in cells treated with hydrolyzed peptides. The correlation between antioxidant activity and the reduction of oxidative stress was established through comparative tests with standard antioxidant substances, validating the effectiveness of the peptides (Huang et al., 2019; Ebrahimi et al., 2019).

Finally, the research also explored studies on the impact of enzymatic hydrolysis processes on the structure and functionality of the peptides obtained. Different hydrolysis conditions—including variations in pH, temperature, and reaction time—were tested to optimize the production of bioactive compounds with high bioavailability. The characterization of structural and functional properties of the peptides was performed using infrared spectroscopy and thermogravimetric analysis, ensuring an in-depth understanding of the effects of processing conditions (Chiang et al., 2019; Liang et al., 2019).

RESULTS

The results obtained in the research demonstrated that chromatographic methods showed greater accuracy and reproducibility in the quantification of hydrolyzed peptides. High-performance liquid chromatography (HPLC) allowed detailed identification of bioactive compounds, highlighting the presence of peptides with significant antioxidant activity. Spectrometric results corroborated these findings, confirming the effectiveness of the methods employed (Nwachukwu & Aluko, 2019).

The functionality of the peptides was evaluated through in vitro and in vivo assays, indicating a significant increase in the antioxidant capacity of the compounds tested. The assays showed that hydrolyzed peptides obtained from alternative protein sources—such as chia and insects—exhibited activity comparable to or greater than that of traditional synthetic antioxidants. These findings suggest promising potential for applications in functional foods and nutraceuticals (Aluko, 2012; Coelho et al., 2019).

The analysis of oxidative stress revealed that the hydrolyzed peptides significantly reduced the generation of reactive oxygen species (ROS) in treated cells, demonstrating a protective effect against cellular damage. Electrochemical tests confirmed this reduction, establishing a correlation between the antioxidant activity of the peptides and their capacity to minimize oxidative stress. These results reinforce the potential of bioactive compounds for application in antioxidant therapies (Huang et al., 2019; Ebrahimi et al., 2019).

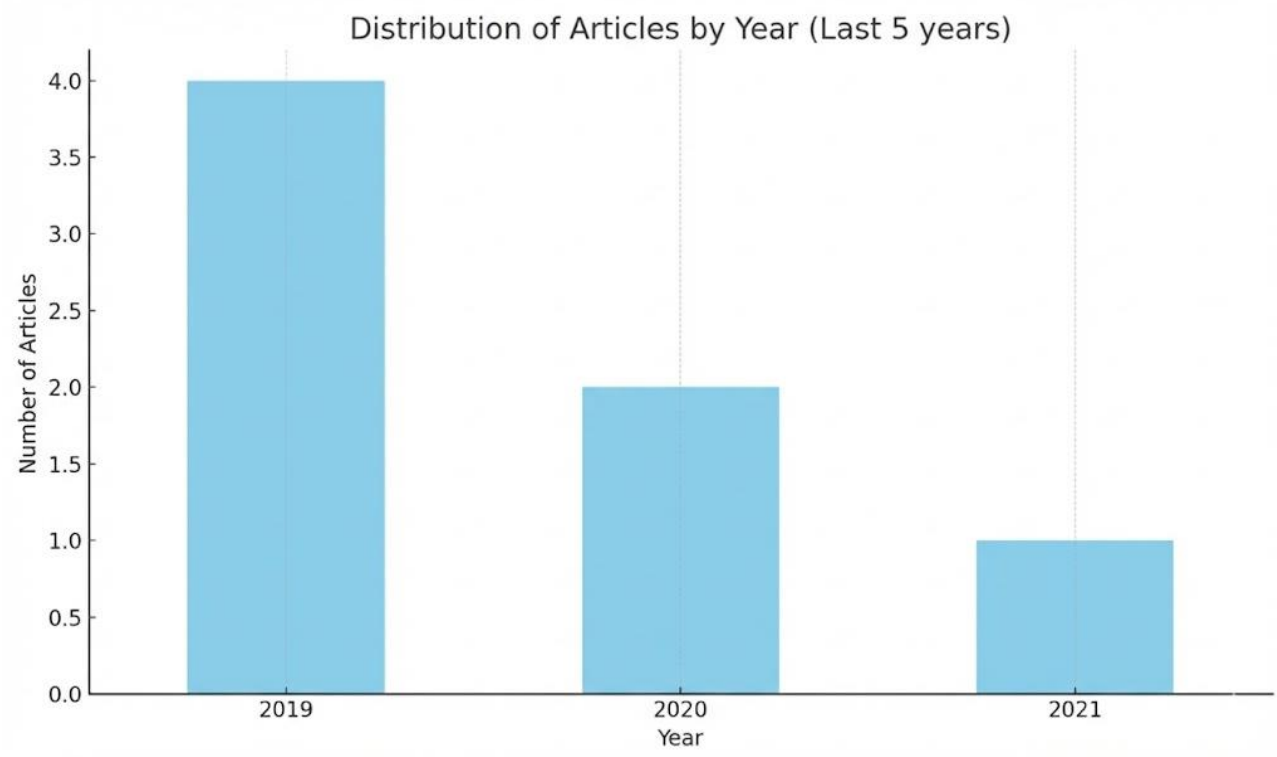
Finally, enzymatic hydrolysis tests indicated that variations in pH, temperature, and reaction time directly impacted the structure and functionality of the peptides obtained. Spectroscopic and thermogravimetric analyses evidenced structural changes that influenced the bioavailability of the compounds, enabling optimization of the process for obtaining bioactive peptides. These results are fundamental for the development of products with greater biological efficiency (Chiang et al., 2019; Liang et al., 2019).

Below are images that provide a detailed representation of the flowchart of the articles used in this study for a better understanding of the approaches.

Next, Image 1 presents the chart precisely and concisely recording the articles that best represent this research by the flow of quantities per year of publication over the last five years.

Graph no. 1

Presents the number of articles and studies published over the last five (5) years.

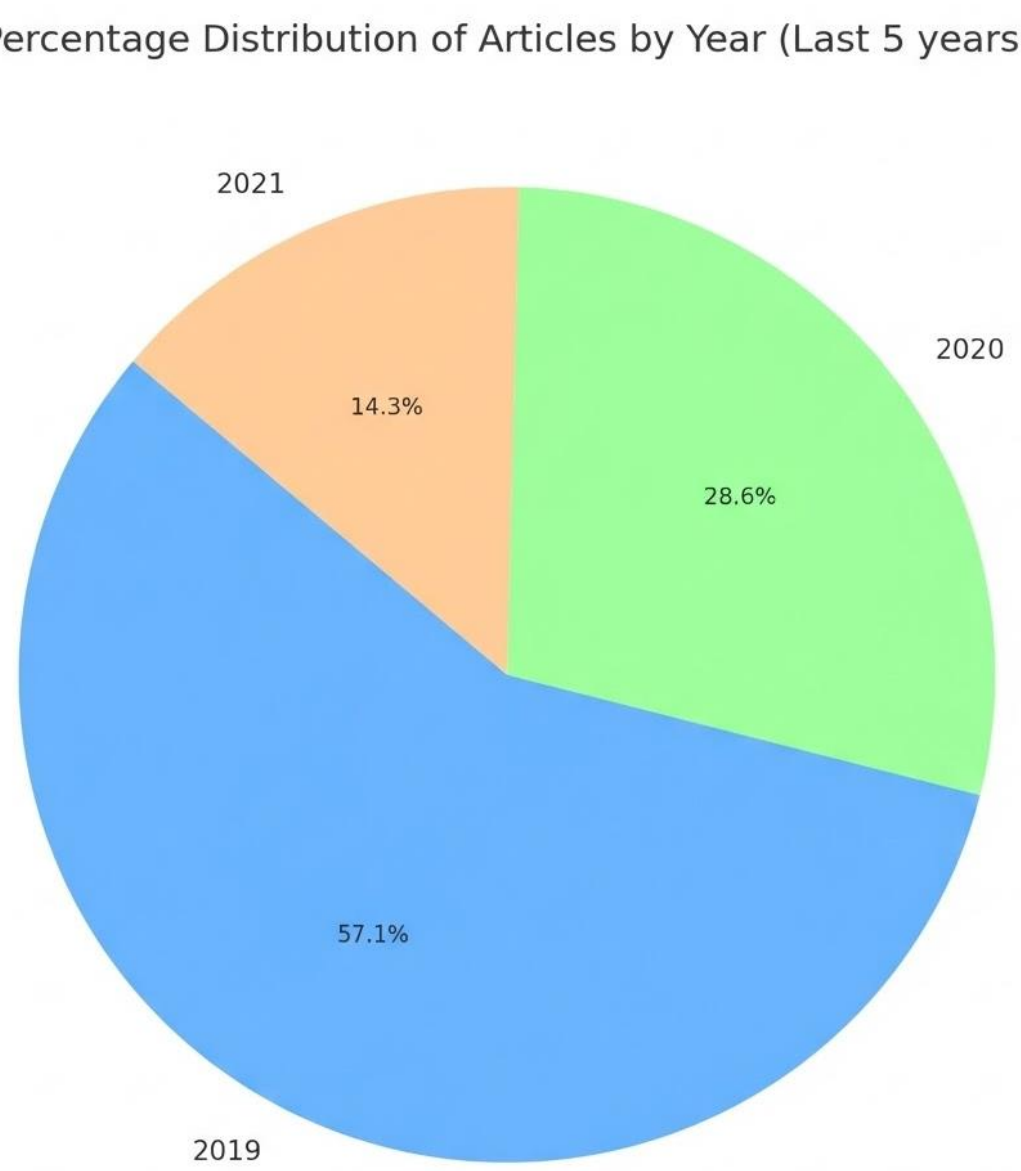


Source: The authors, 2025.

Chart number 2 shows the articles related to their percentage data per year of publication over the last five (5) years.

Pie chart no. 2

Presents the percentage of the number of articles and studies published over the last five (5) years.



Source: The authors, 2025.

The following image (Image 3) represents the results by author and year of publication, the journal/periodical in which the article was published, the methods used, and the main findings that compose this work, demonstrating the process and progress of research on the topic addressed.

Image 3

Detailed overview of the articles used in this research.

Author/Year	Newspaper/Magazine	Main Findings
ALUKO, R. E., 2012	Springer New York	Addresses the potential of functional foods and nutraceuticals in promoting health.
ARAÚJO, R. R. S. *et al.,* 2019	Journal of Food Composition and Analysis	Demonstrated the nutritional value of edible insects from Brazil as a protein source.
BEHLAU, M., 2005	*Revinter*	*Reference book on voice production and vocal health.*
CAPPELLI, A. *et al*., 2020	Lebensmittel-Wissenschaft + Technologie	Evaluated the application of insect proteins in baking, with positive results.
CHIANG, J. H. *et al*., 2019	International Journal of Food Science & Technology	Improved physicochemical properties of bovine bone extracts by enzymatic hydrolysis.
COELHO, M. S. *et al*., 2019	Food Hydrocolloids	Verified the antioxidant capacity of chia hydrolysates and peptides in vitro and in vivo.
EDIBLE BUG SHOP, 2020	Plataforma comercial	Dissemination and marketing of insect-based food products.
EBRAHIMI, S.; SOLTANI, A.; HASHEMY, S. I., 2019	Journal of Cellular Biochemistry	Related oxidative stress to pathogenesis and therapeutic resistance in cervical cancer.
FIRMANSYAH, M.; ABDUH, M. Y., 2019	Heliyon	Produced insect protein hydrolysate with high antioxidant activity.
HUANG, H. *et al.,* 2019	Free Radical Biology & Medicine	Studied the generation of reactive oxygen species in copper-catalyzed processes.
JIA, Q. *et al*., 2019	Phytomedicine	Reviewed the therapeutic effects of Salvia miltiorrhiza in diabetes.
LIANG, R. *et al*., 2019	Food Research International	Demonstrated antioxidant capacity and apoptosis inhibition of hydrolysates in hepatic cells.
LIU, S. *et al.,* 2012	Food Chemistry	Evaluated phenolic compounds and antioxidant activity of insect extracts.
MATOS, F. M.; CASTRO, R. J. S., 2021	Brazilian Journal of Food Technology	Highlighted the use of edible insects to obtain bioactive peptides.
NWACHUKWU, I. D.; ALUKO, R. E., 2019	Food Chemistry	Compared methods for quantifying peptides from food protein hydrolysates.
RODRIGUES, G., 2019	O Tempo	Report on the growth of insect consumption as food in Brazil.
RONCOLINI, A. *et al.,* 2020	Food Research International	Used insect larval flour in snacks, increasing protein and mineral content.
ZEMLIN, W. R., 2000	Mosby	Classic book on the anatomy and physiology of phonation.

Source: The authors, 2025.

This Image 3 presents each study, its specificities, and its results in detail.

DISCUSSION

Edible insects have been gaining attention as a sustainable and nutritious alternative to traditional protein sources. Studies indicate that these organisms offer a rich nutritional composition, functional and bioactive properties, and contribute to environmental sustainability. Based on the analysis of several articles, it is possible to discuss the main benefits of this emerging food source, as presented earlier in Table 1 and Graph 1. With their high nutritional and protein value, Araújo et al. (2019) analyzed the nutritional composition of *Gryllus assimilis* and *Zophobas morio*, highlighting their high protein content and the presence of essential minerals. Edible insects contain essential amino acids that may be comparable or superior to those from traditional sources such as meat and dairy. Matos & Castro (2021) reinforce this point by suggesting that insects can be viable sources of bioactive peptides. Regarding bioactivity and functional benefits, protein extracted from insects can be hydrolyzed into bioactive peptides, conferring antioxidant and anti-inflammatory properties. Studies such as those by Firmansyah & Abduh (2019) and Coelho et al. (2019) demonstrate that insect protein hydrolysates exhibit significant antioxidant activity. Aluko (2012) highlights that functional foods and nutraceuticals play an essential role in human health and may help prevent chronic diseases. In terms of applicability in food products, the addition of insects to foods has been explored by various studies. Roncolini et al. (2020) investigated the use of the beetle Alphitobius diaperinus in manufacturing snacks rich in proteins and minerals, showing good results in product acceptance, while Cappelli et al. (2020) evaluated the addition of insect flour (Acheta domesticus, Tenebrio molitor) in breads, finding that the resulting products exhibited improved nutritional and sensory characteristics. Due to their substantial contribution to sustainability and environmental impact, insect production for human consumption is highly efficient in environmental terms. Rodrigues (2019) highlights that insects require less water, space, and feed compared to traditional livestock. Moreover, rearing them in controlled environments can reduce greenhouse gas emissions and diminish impacts on natural resources. Thus, edible insects represent a viable alternative to meet the growing demand for protein, offering nutritional, functional, and environmental benefits. Despite cultural

and regulatory challenges, acceptance of these foods has been increasing, driven by their versatility and potential as an ingredient in various products. Continued research into their bioactive properties and food safety is essential to consolidate insects as an integral part of human nutrition in the future.

CONCLUSION

According to the research, positive outcomes were obtained considering the results presented in the surveyed articles as well as the theoretical basis concerning the production and consumption of foods based on edible insects. Therefore, balanced eating habits aimed at promoting vocal health are essential for singers' performance, as they support the integrity of the vocal folds and the control of vocal fatigue, affording singers greater longevity of their vocal tract as a whole. In addition to their potency and nutritional content, there is also a notable contribution in not harming the environment and in the ease of handling and rearing these organisms. Despite resistance—particularly cultural—acceptance of insect-based foods has increased considerably.

We need to make this type of food more widely known so that new research may emerge and further positively impact the food market, especially with regard to vocal health.

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