A bibliometric study about unconventional food plants

Um estudo bibliométrico sobre plantas alimentícias não convencionais

Un estudio bibliométrico sobre plantas alimentarias no convencionales

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Abstract
Data on unconventional food plants (UFP's) are still scarce in the literature, however the aim of this study is to identify the papers published on unconventional food plants, which topics have been studied over the years, and which countries stand out for research, through the bibliometric analysis tools. A search was conducted in the Web of Science Core Collection (WoS) database, the dataset of 25 retrieved articles published between 2008, and March 16, 2022 was analyzed using VOSviewer and the Bibliometrix R package. Brazil was the country with the highest number of publications and the ten most cited articles worldwide are all by Brazilians. The co-occurrence map with the keywords generated six main clusters. Despite the benefits studied, there are few papers on UFP's. Bibliographic mapping offers the possibility of obtaining a large amount of bibliographic information, making it more manageable, objective and practical to serve scientific policy makers, institutions and research managers.
Keywords: Scientometrics; Bibliometrics; Non-conventional food plant species; Keyword analysis.

Resumo
Plantas que possuem uma ou mais partes comestíveis, de crescimento espontâneo, sem a utilização de aditivos químicos, nativas de uma região ou exóticas, que não fazem parte da alimentação diária são denominadas de plantas alimentícias não convencionais (PANC's). Dados sobre estas espécies vegetais ainda são escassos na literatura, diante disto, este artigo aplica as ferramentas de análises bibliométricas para identificar os trabalhos publicados sobre plantas alimentícias não convencionais, quais temas já foram estudados ao longo dos anos e quais países se destacam pela pesquisa. Foi realizada uma pesquisa no banco de dados Web of Science Core Collection (WoS) e analisado o conjunto de dados de 25 artigos recuperados, publicados entre 2008 e 16 de março de 2022, usando o VOSviewer e o pacote Bibliometrix R. O Brasil foi o país com maior número de publicações e o dez trabalhos mais citados mundialmente, são todos de brasileiros. O mapa de co-ocorrência com as palavras-chave geraram 6 clusters principais. Apesar dos benefícios estudados, existem poucos trabalhos sobres PANC's. Os resultados desta pesquisa orientará os estudiosos a identificar quais temas são necessários para a execução de pesquisas futuras.
Palavras-chave: Cientometria; Bibliometria; Espécies vegetais alimentícias não convencionais; Análise de palavras-chave.

Resumen

Los datos sobre plantas alimentarias no convencionales (PFN) son aún escasos en la literatura, sin embargo el objetivo de este estudio es identificar los trabajos publicados sobre plantas alimentarias no convencionales, qué temas se han estudiado a lo largo de los años y qué países destacan para la investigación, a través de las herramientas de análisis bibliométrico. Se realizó una búsqueda en la base de datos Web of Science Core Collection (WoS) y se analizó el conjunto de datos de 25 artículos recuperados publicados entre 2008 y el 16 de marzo de 2022 utilizando VOSviewer y el paquete Bibliometrix R. Brasil fue el país con el mayor número de publicaciones y los diez artículos más citados en todo el mundo son todos de brasileños. El mapa de co-ocurrencia con las palabras clave generó seis clusters principales. A pesar de los beneficios estudiados, hay pocos artículos sobre las UFP. El mapeo bibliográfico ofrece la posibilidad de obtener una gran cantidad de información bibliográfica, haciéndola más manejable, objetiva y práctica para servir a los responsables de la política científica, a las instituciones y a los gestores de la investigación.

Palabras clave: Cienciometría; Bibliometría; Especies vegetales alimentarias no convencionales; Análisis de palabras clave.

1. Introduction

Scientometrics or bibliometric analysis is a scientific statistical and quantitative evaluation of publications within a defined topic, based on citation index data. It can be used to identify articles of interest, detect research foci, locate the most relevant journals in the area under study, and analyze interrelationships between authors from different institutions and countries (Feng et al., 2021). This method organizes the existing literature, showing its trajectory of publications, as well as traditional and emerging fields of research (Sharifi et al., 2021). Bibliometric studies are necessary for assessing the current state of research, as well as the contributions of researchers and countries in knowledge areas (Giraldo et al., 2019).

Plants that have one or more edible parts, spontaneous growth and without the use of chemical additives, native or exotic, that are not part of everyday food, are called unconventional food plants (UFP's) (Kinupp & Lorenzi, 2014). This definition encompasses most wild and regional food plant species, whose knowledge and consumption is largely in small rural communities, far from large urban centers. Despite their use in small communities as food and medicinal application for several years (Leal et al., 2018), few studies on UFP's are found in the scientific literature.

To date, there are no bibliometric studies on UFP's available. Given the above, the objective of this research is to identify the works published on unconventional food plants, which topics have already been studied over the years and in different countries. Research trends were identified by bibliometrics and quantitative methods that analyze scientific publications were used as an information process. This study can provide strategic directions and justification for the execution of future research.

2. Methodology

2.1 Data collection

A literature search was performed in the Web of Science Core Collection (WoS) online database updated through March 16, 2022, the search strategy was using the term "unconventional food plants". The search was performed on studies that mentioned the term in any searchable field (default option in WoS). No language or date restrictions were applied. The documents were exported in "full records and cited references" tab format. WoS was used instead of Scopus because of the quality of the data for a bibliometric search due to the standardization of cited references, for example (Zammarchi & Conversano, 2021).

2.2 Data analysis and visualization

From the data exported from the Web of Science Core Collection and with the help of the Bibliometrix package version 3.1 in R version 4.1.3 the countries with the highest number of published papers and/or citations were identified (based on the affiliation of the corresponding authors as well as other authors) and the collaboration network of the countries was

plotted. The most cited papers, the types of papers, and the categories in which they have been published were also described.

To create the bibliometric maps, the complete citation records were exported from WoS to be treated by the software VOSviewer version 1.6.18. In the co-occurrence map, the assignment of terms to the same cluster depends on their co-occurrence in the title or abstract of the publications. A cluster formed by terms with the same colors represents a research theme in which one or more research topics can be identified. In the annual terms map, the color of a term indicates the average publication year of all publications in which the term occurs (Cecchini et al., 2020). The VOSviewer also provides the option to exclude data by omitting terms deemed not relevant to the analysis. When using this feature of the software, the terms "l." and "diversity" that could be used redundantly (an example: variety) were omitted.

3. Results and Discussion

3.1 Numerical data of publications on unconventional food plants

A total of 25 documents (21 journal articles, one early access article, two review articles and one early access review article) published from 2008 to March 16, 2022, were identified. Analysis of the search categories performed with the WoS analytical tool showed that the most represented area was "food science technology" (48%), followed by "agronomy" (20%) and "plant sciences" (20%). The annual growth in scientific production was 10.41% and 2021 was the year with the highest number of published papers, with a total of 12 papers (Figure 1).

Figure 1 - Growth of annual scientific production of articles identified by WoS.
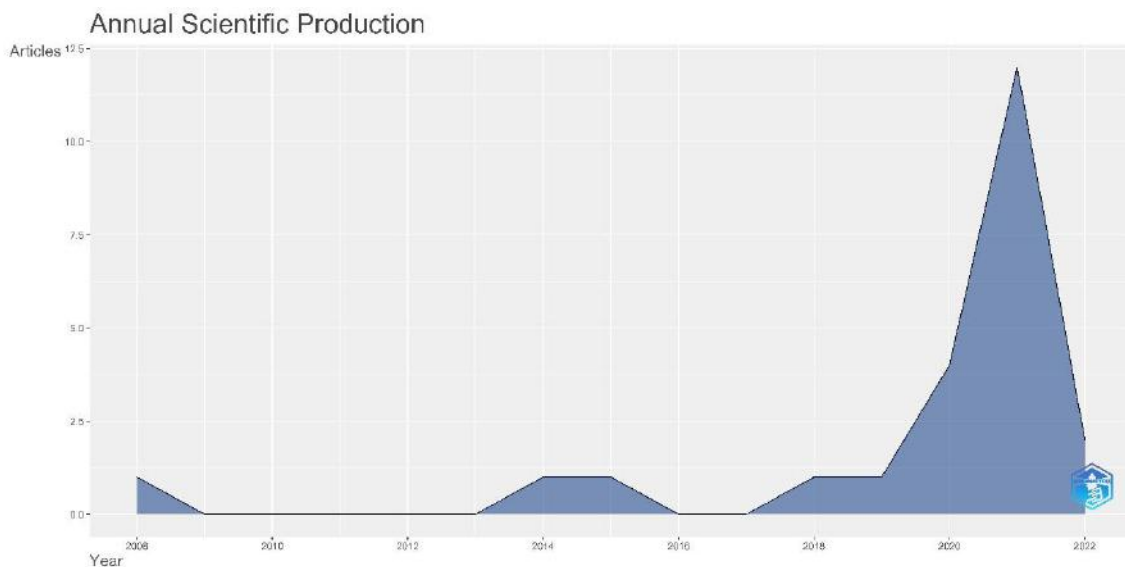
Source: Bibilometrix (2022).

The ten most cited papers worldwide, are all Brazilian authors (Table 1). Kinupp and De Barros (2008) evaluated and identified 69 UFP's species native to the metropolitan region of Porto Alegre, located in the state of Rio Grande do Sul, Brazil. The authors concluded that several UFP's species showed high values of protein and minerals, but the vast majority of these species remain unknown or underutilized. It is worth mentioning the work done by Dr. Valdely Ferreira Kinupp, who, in addition to having one of the most cited papers, has been working on the identification of UFP's for over ten years and is the author of the book entitled "Plantas Alimentícias Não Convencionais (PANC) no Brasil" coauthored with Professor Harri Lorenzi, published in 2014 by Plantarum, where dozens of unconventional food species were identified, with information on morphological aspects, botanical identification, and general and culinary use of each species. The information provided in this book serves as a guide and reference for future research.

Table 1 - List of the ten most cited identified papers on UFP's.

Article Title	Authors	Total citations	Average citation per year
Protein and mineral contents of native species, potential vegetables, and fruits	(KINUPP; DE BARROS, 2008)	53	3,53
Knowledge, use, and disuse of unconventional food plants	(LEAL; ALVES; HANAZAKI; 2018)	18	3,6
Exploring consumers' knowledge and perceptions of unconventional food plants: case study of addition of *Pereskia aculeata Miller* to ice cream	(MAZON; MENIN; CELLA; LISE et al. 2020)	6	2
Are Famine Food Plants Also Ethnomedicinal Plants? An Ethnomedicinal Appraisal of Famine Food Plants of Two Districts of Bangladesh	(AZAM; BISWAS; MANNAN; AFSANA et al. 2014)	6	0,67
Nutritional potential and bioactive compounds of xique-xique juice: An unconventional food plant from Semiarid Brazilian	(CARVALHO; GUERRA; BORGES; BEZERRIL et al. 2021)	5	2,5
Emulsified cooked sausages enriched with flour from ora-pro-nobis leaves (*Pereskia aculeata Miller*)	(SOBRINHO; COSTA; GONCALVES e CAMPAGNOL, 2015)	5	0,63
Chemical Characterization, Antioxidant Activity and Cytotoxicity of the Unconventional Food Plants: Sweet Potato (*Ipomoea batatas(L.) Lam.*) Leaf, Major Gomes (*Talinum paniculatum(Jacq.) Gaertn.*) and Caruru (*Amaranthus deflexus L.*)	(MOURA; SANTANA; LOURENÇO; SOUZA et al. 2021)	3	1
Physicochemical characteristics and bioactive compounds of the Xique-xique (*Pilosocereus gounellei*) cactus from Caatinga Brazilian: are they nutritive and functional?	(BEZERRIL; DE SOUZA; LIMA; PACHECO et al. 2021)	2	1
Biomass production of the aquatic macrophyte *Ceratopteris pteridoides* (Hook.) Hieron (Pteridaceae) in nutrient addition treatments	(FERREIRA; PIEDADE; PIEDADE; LOPES, 2021)	2	1
Health-Promoting Properties of Brazilian Unconventional Food Plants	(PEISINO; ZOUAIN; DE CHRISTO SCHERER; SCHMITT et al. 2020)	2	0,67

Source: Authors (2022).

The works conducted by Leal et al. (2018), Mazon et al. (2020) are research studies on the knowledge and consumption of UFP's in municipalities in Brazil, while the study performed by Azam; Biswas; Mannan; Afsana et al. (2014) was conducted in villages located in Bangladesh. Both studies concluded that in addition to culinary aspects, many of these plants have medicinal potential and use, but their knowledge and consumption is restricted to small rural communities and/or far from large urban centers.

The research conducted by Sobrinho et al. (2015) had the proposal to evaluate the addition of flour from the leaves of ora-pro-nobis (*Pereskia aculeata Miller*) in sausage formulations. The researchers concluded that the flour of ora-pro-nobis leaves, in the concentration of up to 2%, can be considered as an excellent source for nutritional improvement, due to the high content of fiber and protein.

Carvalho et al. (2021) and Bezerril et al. (2021) both studied the xique-xique cactus (*Pilosocereus gounellei*). The first group of researchers prepared a juice with cladodes of the plant and characterized its nutritional composition, determined the bioaccessibility of phenolic compounds and antioxidant activity. As a result, the authors describe the xique-xique juice as a new source of intake of minerals, fibers and phenolic compounds. The second group of researchers, on the other hand, evaluated the centesimal composition, bioactive compounds, bioaccessibility and antioxidant activity of the stem and vascular cylinder of the plant. The authors concluded that the xique-xique cactus can be considered as a food alternative with nutritional potential, rich in bioactive compounds and can be used in various food products.

In an ethnobotanical survey of UFP's consumed in Ilha de Mem de Sá, located in Sergipe, Brazil, and in order to characterize the three most used food plant species, Moura et al. (2021) identified 31 species of UFP's and that knowledge about the plants was concentrated in older individuals. The three species most consumed by the local population were *Talinum paniculatum (Jacq.) Gaertn*. leaves, *Ipomoea batatas (L.) Lam.* leaves (purple and white pulp varieties) and *Amaranthus deflexus L*. leaves. Both species have been shown to be nutritional alternatives for diversification in the diet of modern society.

Ferreira et al. (2021) evaluated the biomass production and nutrient levels in fronds of Ceratopteris pteridoides (*Pteridaceae*), submitted to different treatments. The authors concluded that the daily intake of C. pteridoides could contribute to mineral supplementation, besides diversifying existing crops and cooperating to sustainable agriculture.

In order to investigate the phytochemical profiles and the in vitro anti-inflammatory and antioxidant activities of the species *Hypochaeris chillensis*, *Emilia fosbergii* and *Emilia sonchifolia*. Peisino et al. (2020) found that all species studied, exhibited promising bioactive compounds capable of neutralizing free radicals, controlling oxidative stress and modulating the inflammatory process.

Figure 2 - Cross-country collaboration network of the papers identified by WoS.
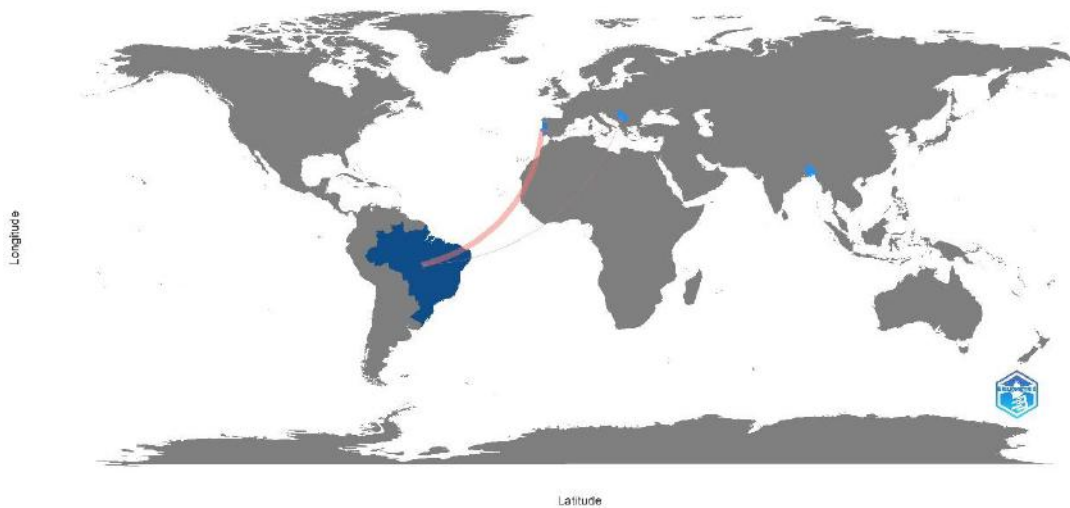

Source: Bibilometrix (2022).

Figure 2 represents the collaboration network between the countries. Brazil stands out as the country with the largest number of publications with 24 papers, two in collaboration with Portugal and one paper in collaboration with Serbia. Portugal also published one paper in collaboration with Serbia. Brazil is a country of vast territorial extension and that has a rich diversity of plant species, which has increasingly attracted the interest of researchers, which corroborates with the high number of publications and citations.

3.2 Co-occurrence map

The frames represent the terms, the size of the frame is proportional to the number of articles in which the term was retrieved, the thickness of the lines between the frames represents the strength of correlation between two terms. The strongly correlated terms are close to each other and are automatically assigned to the same cluster. A total of 22 terms and six main clusters of strongly related terms were identified by VOSviewer (Figure 3).

Figure 3 - co-occurrence map of the studies identified by WoS.
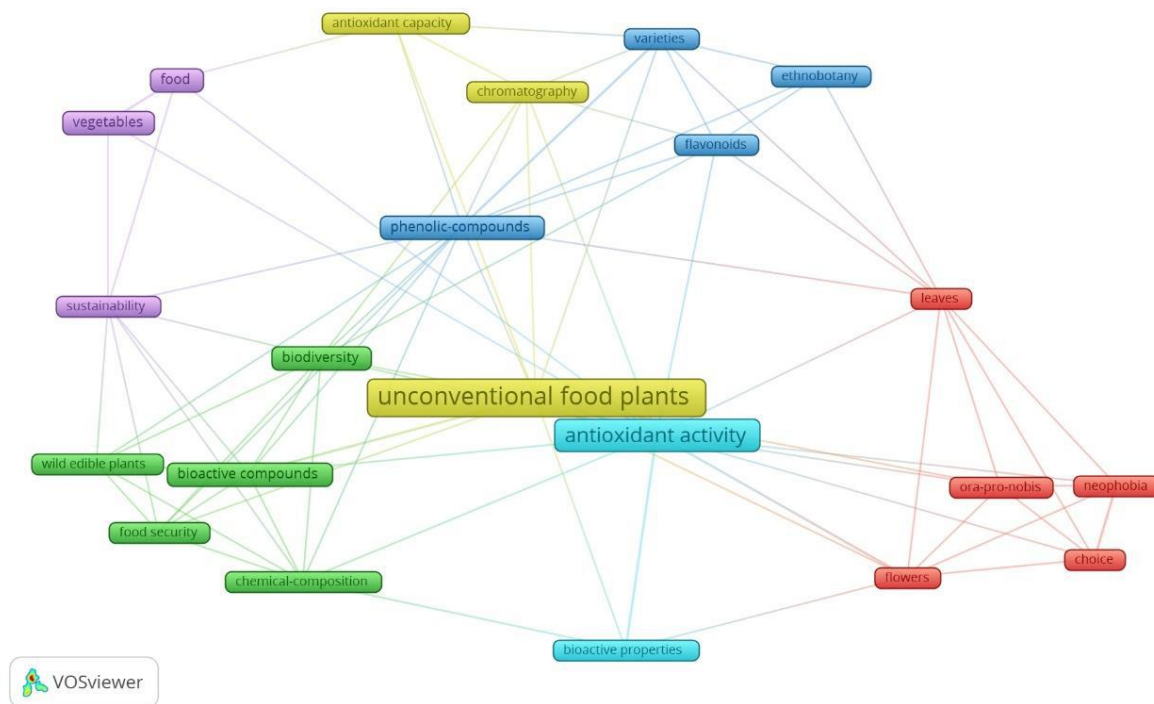
Source: Authors (2022).

The yellow cluster contains the main search keyword "unconventional food plants" and is related to the analyses that have been most performed on UFP's chromatographic analyses and techniques employed to evaluate antioxidant capacity. Chromatographic techniques have a high sensitivity and precision in the identification of compounds, especially phenolic compounds, which may exert antioxidant functions. In vitro tests, such as DPPH (2,2-diphenyl-1- picrylhydrazyl) radical scavenging, is one of the most widely used methodologies to evaluate antioxidant capacity or activity. It is observed that the term "antioxidant activity" (cyan blue cluster) is very close to the term "unconventional food plants" and has a strong link with the term "bioactive properties". Bioactive properties is the definition for non-nutritive substances present in foods, which possess chemical and biological properties whose effects provide benefits to human health (Braicu et al., 2022). From the articles identified, the authors concluded that the UFP's studied have high antioxidant capacity and that the consumption of these vegetables can lead to improvements in the health status of consumers, which justified the proximity of such terms on the map.

The dark blue cluster refers to ethnobotanical studies identified in the search, about the research work on the variety of UFP's present in a given region and how they are used by the population, coupled with the identification studies of phenolic compounds classified as flavonoids. Flavonoids are a group of hydroxylated phenolic compounds recognized as important free radical scavengers (Braicu et al., 2022).

The green cluster is related to the existing biodiversity of UFP's the wide variety of plant species and which, depending on the region are known as "wild edible plants". Chemical composition analyses again identified the presence of bioactive compounds. The consumption of UFP's appears as an alternative to maintain food security, since they are plant species that grow spontaneously, i.e., available to the population without the need for implementation of large planting systems and at high cost; native to the region rescuing and respecting traditional and cultural habits; besides being rich in nutrients that promote the improvement and/or maintenance of the individual's nutritional status.

The purple cluster is represented by the terms "food", "vegetables" and "sustainabillity". Research shows that UFP's can be used for the development of new and healthy food products, as well as promoting a more sustainable food production chain.

The term "neophobia" together with the term "ora-pro-nobis", both present in the red cluster, is justified by the work conducted by Mazon et al. (2020). The authors reported the participants' rejection of the new product made, an ice cream using mucilage from ora-pro-nobis leaves.

Despite the benefits studied, consumption and knowledge about UFP's is still restricted to small rural communities, far from large urban centers. The consumption of leaves and/or flowers of plant species that are not present in our eating routine causes a certain repulsion for these foods. This behavior in rejecting or refusing to eat/experiment new foods is defined as neophobia (Mattavelli & Rizzoli, 2022).

4. Final Considerations

Through the bibliometric analysis it is possible to state that the scientific interest in unconventional food plants began in 2008, a relatively new area of research, with a large contribution from Brazilian researchers and studies. In addition to species identification, characterization and studies to determine bioactive compounds and antioxidant capacity are the main research topics. Despite the benefits studied, UFP's are still underutilized and poorly disseminated, especially in large urban centers.

In view of the above, there is a need for further studies on such plant species. Topics on nutritional characterization; the medicinal potential use of the plants; whether there is toxicity or any risk in consuming such plant species; what are the best strategies to popularize the consumption of UFP's in large urban centers; the use of UFP's in the formulation of new products. All these questions serve as directions for future research.

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