

Novelty of Sacha Inchi (*Plukenetia volubilis* L.) Seed Research and Its Applications : A Bibliometric and Study Analysis

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ABSTRACT

VOS viewer software was utilized to visually observe the metadata of the reference articles. This research employs bibliometric analysis to examine the existing literature on Sacha Inchi seeds and its applications. The visualization primarily focuses on research and review articles that have been filtered using specific keywords and top authors. Data was gathered from the Science Direct. In total, 84 articles published between 2009 and 2023 were selected for analysis. A notable observation is that the majority of research articles were published in 2021, while the review articles were most commonly published in 2022. Interestingly, no review article publications on SI seeds and their applications were found between 2009 and 2012. Furthermore, the application of SI seeds is widely utilized in various fields, including food, medicine, cosmetics, and other industries..

Keywords : Application, Bibiliometric, *Plukenetia volubilis*, Sacha Inchi, Visualization

INTRODUCTION

Sacha inchi (*Plukenetia volubilis* L.) is a type of oilseed that originated from the Amazon Rainforest in Peru. Traditionally, it has been cultivated in San Martín and six other Peruvian departments, but it is also now being grown in various South American countries. The oil extracted from sacha inchi seeds has a high content of polyunsaturated fatty acids (PUFA), particularly α -linolenic acid (53.8%) and linoleic acid (33.4%), as well as a notable concentration of tocopherols (2540.1 mg/kg), with a major presence of γ -tocopherol (64.7%) and δ -tocopherol (35.3%). Sacha inchi (*Plukenetia volubilis* L.), also commonly known as Inca peanut, is a native plant found in the Amazon forest and belongs to the Euphorbiaceae family.

Bibliometric analysis is an essential contemporary approach that cannot be overlooked, as it allows for the examination and assessment of research evolution, perspectives, challenges, and future prospects. This quantitative study of bibliographic material offers an overview of a specific research domain, classifying it based on articles, authors, and journals. The popularity of bibliometric analysis can be attributed to the availability and advancements of bibliometric software like Gephi, Leximancer, VOSviewer, along with renowned scientific databases like Scopus, Web of Science (WoS), and Google Scholar. Furthermore, cross-disciplinary bibliometric methodologies have made it accessible from information science to business research. In this study, we will focus on the field of food technology concerning the development of Sacha inchi.

This observation will be used as the data support for the development of Sacha Inchi Seed (SI seed) which follow the global trend. The aims of this study was to highlight the research global, to find the research gap and to know the position of recent research for expanding research on SI eed compound and its potential applications. Additionally, this research aims to consolidate all the relevant data concerning the development of SI seed, especially in the fields of food and health.

METHOD

The source of reference was taking from Science Direct. The references focused in review and research articles. All documents were imported for its metadata using RIS file. The range of references are started from 2009 until 2023 (research and review articles). The metadata for each article was precisely completed by checking manually using Mendeley Reference Manager software. This study focuses on analyzing the title, the abstract's fields content, and keywords. Further bibliometric analysis was conducted using VOSviewer 1.6.18 for windows software. The minimum number of occurrences of a term was set at 1 and the number of terms to be selected was set on maximal of the threshold. In this report, due to the lack of knowledge, similar keywords which understandably having identic meaning were not merged, however in our further publication this issue will be solved

VOSviewer is used to visualize and analyze trends in the form of bibliometric maps. VOSviewer can make publication maps, country maps, or journal maps based on networks (co-citation) or build keyword maps based on shared networks. The frequency of keywords can be adjusted as desired and less relevant keywords can be removed. VOSviewer software can also be used to do data mining, mapping, and grouping articles that were taken from a database source

After the visualization results are obtained, a review of all articles will be conducted, and they will be summarized in the form of a table based on the content of each article. The table's content will be sorted by the latest to the oldest articles. Each row in the table will contain relevant information from each article to facilitate better understanding and further analysis.

RESULTS AND DISCUSSION

We collected the data through Science Direct, accessed on June 5th, 2023. Based on the data retrieval date, it is known that the latest publication was published in May 20th, 2023. Here we had collected 84 references which closely related with sachu inchi seed and its application.

Bar Chart of Period Publishing

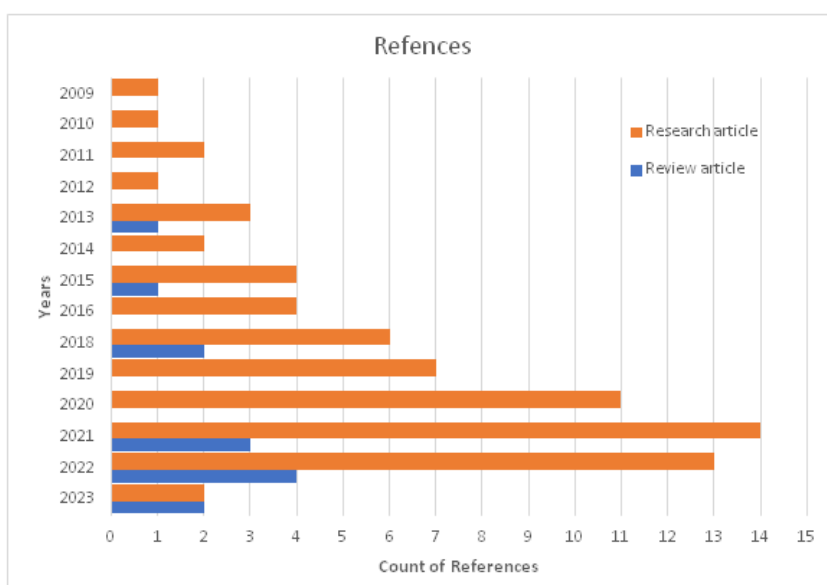


Figure 1. Bar Chart of Period Publishing

As shown in Fig. 1, in 2009 and 2010, there was one research article publish each year. Then in 2011, it increased to two articles. The number of research article publication fluctuated from 2012 until 2014, and

then consistently increased from 2015 until 2021. The publication of review articles began in 2013. The highest number of research articles was published in 2021, with a total of 14 articles. The review articles were most commonly published in 2022, with a total of 4 articles. The results of the bibliographical analysis are presented in Fig. 2 of this article. We present two visualizations filtered by keywords from the references: network visualization and overlay visualization.

Network Visualization Using VOSviewer

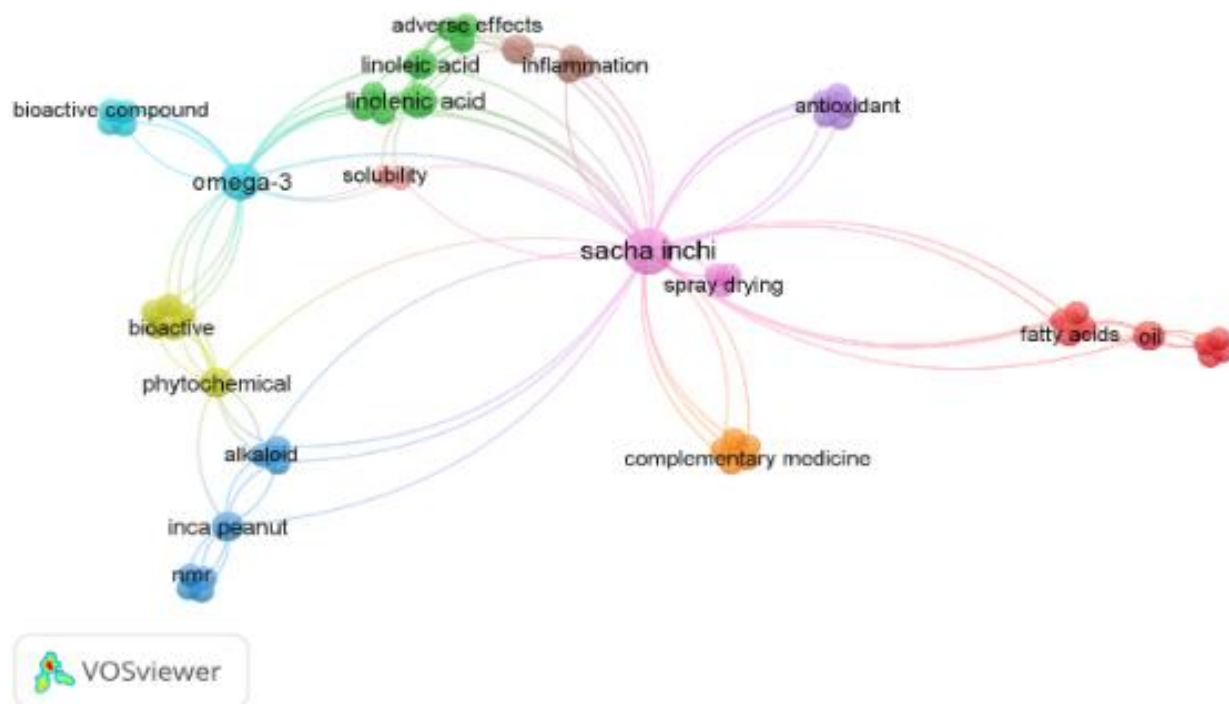


Fig 2. Network Visualization Using VOSviewer

Figure 2. presents the network visualization of the references, comprising 56 items, 10 clusters, 169 links, and a total link strength of 173. The size of the circles and the distance between them reflect the number of citations and the level of similarity, respectively. Co-citation network analysis resulted in 10 distinct clusters depicted in 11 different colors: red, brown, green, yellow, purple, pink, orange, pink, light blue, dark blue, where each color represents a research topic.

The largest cluster is *sacha inchi* (pink). Based on the visualization results obtained using VOSviewer, this visualization is divided into 10 clusters. The first cluster consists Cluster 1 (9 items) consists emulsion, physical stabil, fatty acids, FTIR, gamma-irradiation, nanoemulsion, oil, required hlb, tocopherols, ultra high-pressure . Cluster 2 (8 items) consists adverse effects, clinical trial, extraction, inca nut, linoleic acid, linolenic acid, supercritical carbon dio, toxicity. Then, Cluster 3 (8 items) consists alkaloid, inca peanut, nmr, oil content, omega-3 fatty acid seed, safety, soxhlet extraction.

Cluster 4 (6 items) consists bioactive, edible oil, human nutrition, phytochemical, underutilised species, unsaturated fatty acid . Cluster 5 (5 items) consists antioxidant, nutrient, oilseed, pressed cake, tea seed. Cluster 6 (5 items) consists bioactive compound, biopolymers, efficiency and encapsulation, gastric simulation, omega-3. Cluster 7 (5 items) consists complementary medicine, ethnopharmacology. Cluster 7 (5 items) consists complementary medicine, ethnopharmacology, functional food, nutrition, precision. Cluster 8 (4 items) consists inflammation lipid profile, obesity, oxidative stress. Cluster 9 (4 items) consists

oil release, omega 3, sachinchi, spray drying. Cluster 10 (2 items) consists solubility, supercritical extraction

Overlay Visualization Using VOSviewer

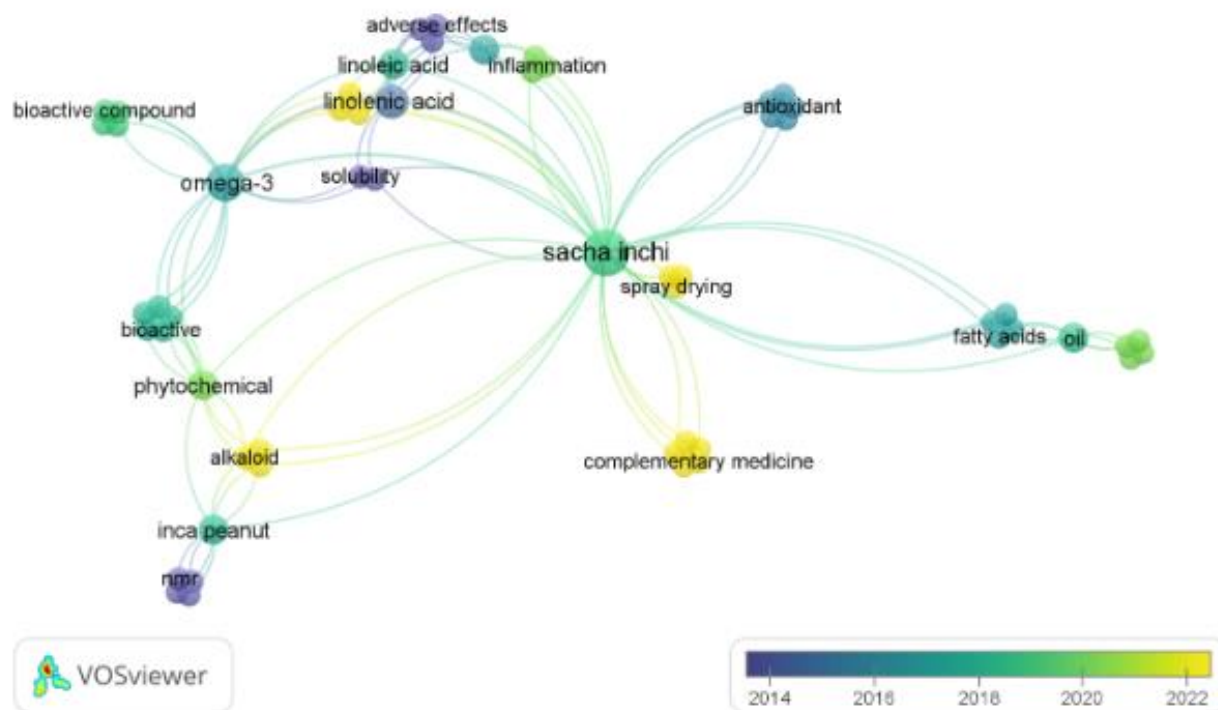


Fig. 3 Overlay Visualization Using VOSviewer

In Figure 3, the novelty of the articles is visually depicted, with brighter nodes indicating more recent publications. The yellow-colored nodes represent research and review articles published between 2022 and 2023, covering topics such as alkaloid, component analysis, spray drying, and extraction. These recent articles reflect the latest advancements and investigations in the field of Sacha inchi.

On the other hand, the purple-colored nodes indicate articles published in older years, specifically from 2014 and earlier. These older publications might lay the foundation for the research on Sacha inchi but could be considered less current in terms of their relevance to the current state of knowledge. The green-colored nodes represent articles published in the intermediate period, around 2018 to 2020. These articles likely contributed to bridging the gap between earlier research and more recent findings.

From a close examination of Figure 3, we can infer that the majority of the research related to SI seed primarily focuses on understanding its various components and their functional roles. This suggests that researchers have been interested in exploring the biochemical constituents and potential applications of these components.

Furthermore, the visual representation in Figure 3 reveals that some of these components have undergone significant development and processing, leading to the creation of diverse products. This indicates that the research on Sacha inchi has progressed beyond basic understanding and has entered the realm of practical applications and innovations.

Table 1. Topic of the article about SI seed compound and some treatments

Formed	Topic	Reference
SI seed extract with different solvent extract	Phenolic total, Antioxidant activity, Anti-glucosidase activity	(Thummajitsakul et al., 2023)
Meal	– High total crude protein content (Ultrasound assisted deep eutectic solvent-based) – Protein content (major n minor protein)	Mancera-Rodriguez et al., 2022)
SI seed oil (SIO)	Omega 3	(Jitpinit et al., 2022)
SI seed roasted	Metabolite and flavour compound (using GC)	(Keawkim & Na Jom, 2022)
Raw SI seed and SIO	Nutrition, fitonutrition, toxicity, safety	(Goyal et al., 2022)
SIO	Phenolic and volatile compound	(Ramos-Escudero et al., 2021)
SIO	Aqueous enzymatic extraction of PUFAs	(Nguyen et al., 2020)(Gao et al., 2019)
SIO	Fatty acid composition	(Abreu-Naranjo et al., 2020), (Dierge et al., 2020)
SI seed	Structure, antioxidant and immunomodulatory activity of a polysaccharide extracted	(Tian et al., 2020)
SIO	Identification of polyunsaturated triacylglycerols (PUTAGs)	(Li et al., 2020)
Seed	Determination of oil contents in SI seeds at different developmental stages by two methods: Soxhlet extraction and time-domain nuclear magnetic resonance	(Atanasov et al., 2018)
Extraction protein of SI	Characterization of SI protein hydrolysates produced by crude papain and Calotropis proteases	(Rawdkuen et al., 2018)
SIO	Tocotrienol and plastoquinone-8 (PQ-8) content	(Trela & Szymańska, 2019)
SIO	Physicochemical properties, PY, EE of powder	(Geranpour et al., 2020)
Seed, seed shell, leaf and SIO	Nutritional composition and biological activity	(Wang et al., 2018)
Seed	Effect of xanthan gum or pectin addition on SI oil-in-water emulsions stabilized by ovalbumin or tween 80: Droplet size distribution, rheological behavior and stability	(Vicente et al., 2018)

Table 2. Potential of SI seed and its application

Application	Reference
Replacing fish oil as PUFAs source	(Goyal et al., 2022), (Nascimento et al., 2021)
Fortification SI oil in white chacama pate production to provide a healthier product	(Mancera-Rodriguez et al., 2022)
Adding SI oil in chicken sausage to improving the nutritional value	(Wongpattananukul et al., 2022)

Using SI oil as fatty acid-based alkyd resin	(Obregón et al., 2023), (El Ghazzaqui Barbosa et al., 2022), (Hadzich et al., 2020)(Hadzich et al., 2020)06:10 AM
Deep-frying French fries by using SI oil	(Rodríguez et al., 2021)
Potential application of glutelin fraction hydrolysates of SI seed as natural antioxidant supplements to prevent Non-communicable disease (NCDs)	(Zhan et al., 2021)
SIO as catalyst for the synthesis of gold nanoparticles (AuNPs)	(Qiao & Qi, 2021) (Dabhane et al., 2021) (Kratošová et al., 2019)
SI flour as biofabrication of silver nanoparticles	(Kumar et al., 2021)
Replacing Fish oil with SIO in terms of growth rate, physical parameters, FA profile, and the energetic substrates and enzymatic pathways involved in LC-PUFA biosynthesis in fish using the rainbow trout (<i>Oncorhynchus mykiss</i>)	(Lima et al., 2019)
Synthesis gold nanoparticle (AuNPs) by using SI	(Bordiwala, 2023)
Replacing <i>cocoa butter</i> for making <i>dark chocolate</i>	(Aranguren & Marcovich, 2023)
SIO as microcapsule	(Castro-Alayo et al., 2023)
SIO as emulsifier	(Rostamabadi et al., 2023)
Microencapsulated SI oil has been fortified in yogurt production to increase PUFAs content and the health benefit, Combining with fish oil for making skimmed milk, acacia gum and grape juice and further supplemented in chocolate panned products	(Goyal et al., 2022) (Suwannasang et al., 2022) Barbosa et al. (2021)(Fadini et al., 2018) (Silva et al., 2019)
SI seed powder for making cheese, chocolate, brownies, yogurt, and hamburger	(Goyal et al., 2022)
Functional food for patient with hypercholesterolemia	(Fidalgo Rodríguez et al., 2020)
Potential as cancer diet for cancer patient	(Dierge et al., 2020)
Application SI in food uses (SIO in food formulation, edible oil) and non-food uses (nanoparticle, biodiesel, cosmetic and pharmaceutical products)	(Wang et al., 2018)
The Amino acid fertilizer from SIO	(Ma et al., 2018)
SI seed flour/powder (SISF) as a low-cost biomaterial for the fabrication of AgNps	Mancera-Rodriguez et al., 2022)
SI meal as alternative protein sources for finfish diets	(Khieokhajonkhet et al., 2021)
resin alkyd –based Sacha Inchi	(Obregón et al., 2023)
The polysaccharides from Sacha inchi seeds exhibited immune-enhancing action by inducing the proliferation of RAW264.7 cells and increased the expression of cytokines such as IL-6, TNF- α and IL-1 β	(Tian, et al, 2020).
Cosmetic function from SIO	Bravo et al, 2020

CONCLUSION

By employing bibliometric and study analysis and utilizing the VOSviewer software, we conducted a comprehensive examination of the global trend of SI seed and its applications. During this analysis, we identified several terms that appeared multiple times and found that they held the same meaning. A total of 84 articles published between 2009 and 2023 were carefully selected for this investigation.

Notably, the year 2021 witnessed a significant increase in the publication of research articles related to SI seed indicating a growing interest and focus on this subject. Additionally, the year 2022 saw a surge in the publication of review articles, further contributing to the understanding and dissemination of knowledge in this area. Interestingly, we observed a gap in the literature between 2009 until 2012, with no review article publications on SI seed and its application during that period. It is worth mentioning that the application of SI seeds is widely prevalent in diverse fields, such as food, medicine, cosmetics, and others. Based on table 2, SI has been widely developed in various processed forms, especially in the form of Sacha inchi oil (SIO).

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