

The sensory perception of mangosteen flesh: a bibliometric analysis

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Abstract. Mangosteen is often referred to as the “Queen of Tropical Fruits” because its unique taste combines exotic flavors with a deliciously sweet-and-sour. In Indonesia, several industries produce mangosteen peel extract as a nutraceutical. However, these industries did not process mangosteen pulp optimally, and it was wasted as an unused by-product. This study aimed to map the scientific landscape and research directions linking mangosteen flesh/pulp with sensory perception through bibliometric analysis. The bibliometric analysis methods used were VOSviewer and Biblioshiny to identify patterns most relevant to authors, most relevant authors and affiliations, production over time, globally cited, frequent words, and the collaboration network. A total of 1,120 journal articles were found in Scopus (2015-2025) using the keywords “mangosteen flesh” (21), “mangosteen pulp” (19), and “food sensory perception” (1,080). The results showed that publications on the sensory perception of mangosteen flesh/pulp remain limited, but the annual growth rate was 11.22%. The analysis revealed that Wageningen University & Research was the most relevant affiliation. This study made a preliminary contribution by describing the scientific landscape of sensory perception of mangosteen flesh/pulp and by identifying potential research collaborations. This could be particularly important in developing new mangosteen flesh/pulp-based products with superior sensory qualities.

1 Introduction

Mangosteen is a plant belonging to the *Garcinia* genus and the *Guttiferae* family. Mangosteen is an annual fruit plant native to tropical forests in Asia, including Indonesia, India, Myanmar, Sri Lanka, and Thailand. According to data from BPS-Statistics Indonesia (BPS) 2025, mangosteen production in Indonesia increased from 2021 to 2024, reaching 4.167.526,62 quintal in 2024. Mangosteen is often called the “Queen of Tropical Fruits” because of its distinctive sweet-sour taste and rich bioactive compounds, particularly xanthenes and their derivatives. It is generally consumed fresh. In Indonesia, a number of industries produce mangosteen peel extract for use as a nutraceutical. However, these industries have not optimized the processing of mangosteen flesh, resulting in it being wasted

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as an unutilized by-product. Research and development on products derived from mangosteen flesh include beverages [1]. Although the fruit is well known, the field of study of its flesh's sensory attributes is still developing. However, there seems to be little or no systematic effort to bridge the sensory attributes of mangosteen flesh with those of food products in the global market.

Sensory perceptions play an integral role in how consumers evaluate food products & how well new food products are accepted in the marketplace. There is a gap in the detailed systematic mapping of the sensory food science field and the characteristics of mangosteen flesh [2]. One field that has begun to fill this gap is bibliometric analysis. This is a gap-dividing methodology that not only provides an overview of a dataset but also offers insights into the development of an area of research, leading research centers, and new emerging collaboration networks [3].

As the economic value of the mangosteen flesh/pulp continues to increase, the existing body of research remains fundamentally insufficient. Existing literature research does not systematically map the components of the mangosteen flesh/pulp with the global trends in sensory science. Most available literature has focused on the pericarp's pharmacological properties, leaving the sensory descriptions of the flesh/pulp that influence consumer preferences almost completely ignored.

This study aimed to address the aforementioned gap by conducting the first comprehensive bibliometric analysis of the intellectual structure, dominant themes, and emerging trends in sensory research on mangosteen. This methodology is critical for identifying 'white spaces' in the literature that can drive future product development [3]. By integrating the last decade of literature, the study has offered a guidance framework for researchers and the food industry to improve the economic value of mangosteen flesh/pulp through a sensory-focused approach.

2 Methods

2.1 Source and data collection strategy

The Scopus database was used to establish the objective methodology for the bibliometric analysis, which consists of a systematic collection of relevant academic literature. The search strategy used various combinations of the following keywords: "mangosteen flesh" (21), "mangosteen pulp" (19), and "food sensory perception" (1,080) to provide adequate coverage of the relevant literature and the impact of key publishers, such as Wageningen University & Research, and leading contributors to the descriptive field of bibliometrics.

2.2 Inclusion and exclusion criteria

Particular emphasis was placed on establishing inclusion and exclusion criteria during dataset refinement. To ensure the findings are up to date, only open-access publications from 2015 to 2025 were included in the final dataset. Also, publications that were not in English were removed. The completed dataset of 1,120 publications was appropriate for conducting the bibliometric analysis. The rapid growth of models and technologies, along with the allotted time frame for the published materials, justified ensuring the findings were valuable. In addition, the most recently published research is likely the most accurate representation of the current state of research. Only two types of publications were selected for inclusion as research study contributions and review publications. In this context, review publications were exceptionally valuable because they provide a comprehensive list of the available publications on a topic, articulate the gaps in the research, and offer a strong conceptual

framework to work from. In the literature review and data cleaning, we focused on the terms “mangosteen flesh,” “mangosteen pulp,” “food sensory perception,” and their combinations. The homogenization of author names and journal titles was removed from the trend analysis and network mapping.

This study provides an extensive perspective, but still has some limitations. First, the data collection was limited to Scopus, as only that database contains high-quality, peer-reviewed records. Second, the absence of non-English search parameters may have left out relevant local studies in leading mangosteen-producing countries such as Thailand and Indonesia, which may have been published in the countries' native languages.

2.3 Data analysis

The data analysis used VOSviewer and Biblioshiny in RStudio to identify and visualize patterns of scientific collaboration and to illustrate potential future research pathways and trends in this domain. The bibliometric analysis involved the description of relevant authors, words, affiliations, time period of production, global citations, collaboration networks, and the co-occurrence of keywords to measure the collaboration network of authors and draw potential hypotheses regarding the focus of the research, the location, the involved institutions, and the quantity and variability of published outputs over time.

3 Results and discussion

3.1 Analysis of the most relevant authors

Figure 1 below presents the results of a bibliometric analysis of author productivity most relevant to the research data collected. The bar chart quantifies researchers' contributions by the number of documents indexed in the database. The data indicated the top achievers in the productivity scales. Jianshe Chen and Markus A. Stieger each published 25 documents. The publications showed that the two researchers were highly active in developing the literature. Chen and Stieger are known as the frontrunners in studies on oral food processing, the field that examines the interrelationships among food microstructure, saliva, and mouth movements, and their effects on texture and taste perception [4, 5].

Next was Elke Scholten with 16 documents, then Gastón Ares with 15. In the context of sensory methodology, Gastón Ares's position was notable for his contributions to the development of rapid sensory evaluation and consumer behavior research [6], both of which were of great importance in contemporary food research [7]. A combination of high productivity and citation of the food deconstruction and consumer perception approaches in the sensory field demonstrates their significance.

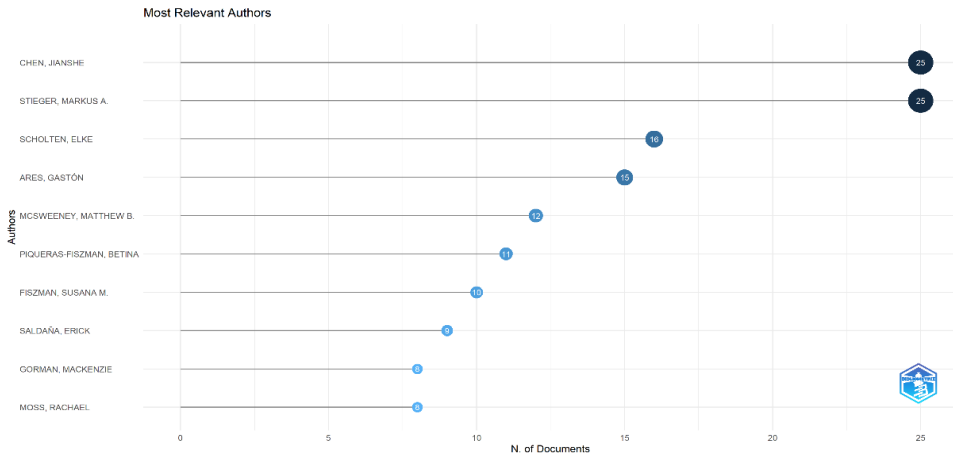


Fig. 1. Most relevant authors

3.2 Analysis of the most relevant affiliations production over time and relevant words

Based on the data (Fig. 2), there was a clear institutional productivity ranking, with Wageningen University and Research (Netherlands) at the top with a total of 128 articles. This was because Wageningen University & Research consistently ranks first in the world (QS World University Ranking) in the fields of Agriculture and Forestry and Food Science and Technology. Such bibliometric dominance indicates that Wageningen is a central node in research topics [3]. Meanwhile, there was a significant difference between the first and second rankings. Ranked 2nd to 5th were Jiangnan University (China) with 75 articles, Universidade de São Paulo (Brazil) with 60 articles, Zhejiang Gongshang University (China) with 57 articles, and Acadia University (Canada) with 56 articles. This group represented active contributors with high research consistency. Jiangnan University is known as the best institution in China for Food Science and Fermentation Engineering. Furthermore, ranks 6 to 10 consist of other institutions, such as Universidad de la República (Uruguay), Bohai University (China), Islamic Azad University (Iran), UNICAMP (Brazil), and Beijing Technology and Business University, each with 32 to 37 articles.

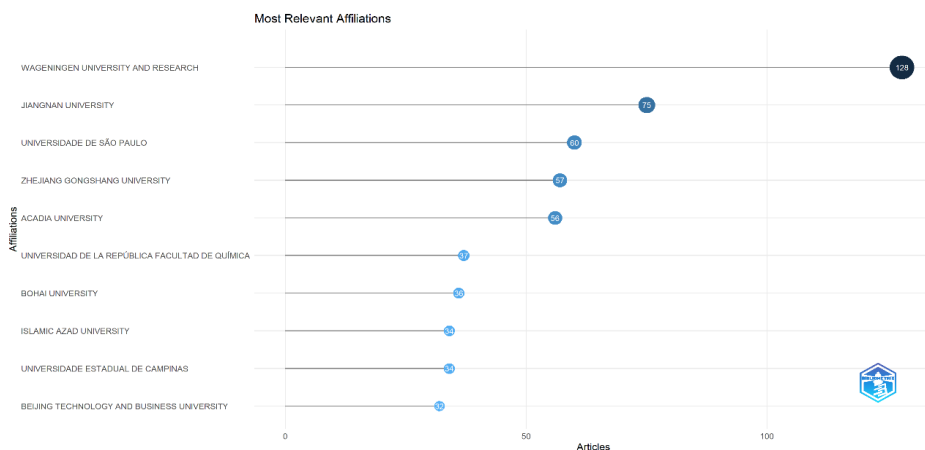


Fig. 2. Most relevant affiliations

The graph in the third image (Fig 3) illustrates when the publications were produced. The X-axis represents the time range (2015 to 2025), while the Y-axis shows the cumulative frequency of articles published. The dominant and consistent institution was Wageningen University and Research (Blue Line), which showed a stable and steep linear growth trend since the beginning of the period (2015). The positive, consistent slope of the graph, without a stagnation phase, indicated that Wageningen's dominance was built over a decade of sustained research productivity, rather than the result of a temporary surge. A new aggressive institution was seen in Acadia University (Red Line). This institution had almost no significant output before 2021 (flat curve). However, there was an exponential surge from 2022 to 2025. Competitive institutions were Jiangnan University (Moss Green) and Zhejiang Gongshang University (Purple), which showed moderate growth patterns at the beginning but experienced significant acceleration towards the end of the period (2023-2025). Jiangnan University, in particular, showed a sharp spike at the end of the curve, projecting the potential to rival Wageningen in the future. Although Wageningen University currently holds hegemony in terms of publication numbers, Jiangnan University and Acadia University have shown higher marginal productivity in recent years.

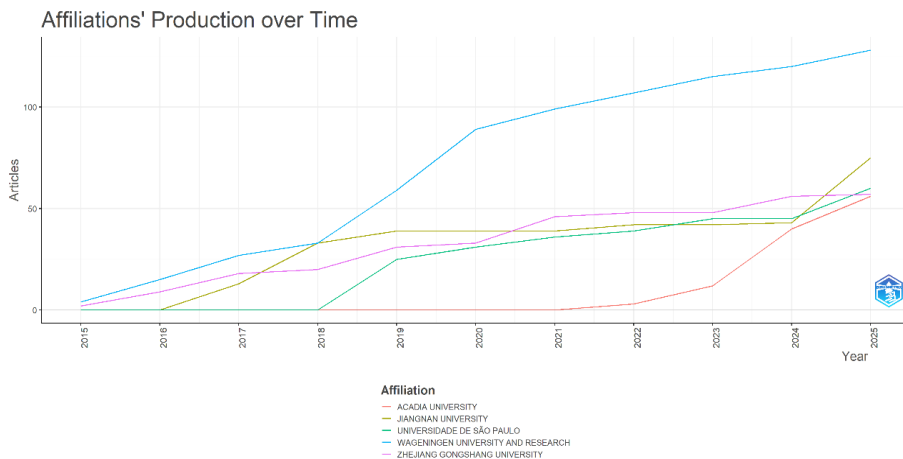


Fig. 3. Affiliations' production over time

The graph in Fig 4 showed the keywords that describe the landscape of research activities in the area of Food Science. The most relevant keyword was "sensory perception," which was mentioned 1076 times, followed by "sensory analysis" (406) and "taste" (246). This suggests that research on the flesh/pulp of mangosteen fruit was not confined solely to its chemical composition but also examines the relationship between fruit characteristics and consumers' psychological and physiological responses. The keywords "chemistry," "textures," and "food storage" provided evidence of an attempt to understand the relationship between mangosteen pulp storage conditions and its texture and taste, and how this, in turn, impacts consumer perception. The keywords "human" and "humans" indicate that research activities involve real panels to conduct objective and subjective sensory evaluations. Contrary to previous studies that focused solely on the nutritional composition of mangosteen pulp, this study expanded its scope to include the eating experience. The combination of chemical evaluation and analysis of institutional-level parameters suggests that the field of

study is maturing, with the sensory attributes of mangosteen products serving as key drivers of innovation in food products [2].

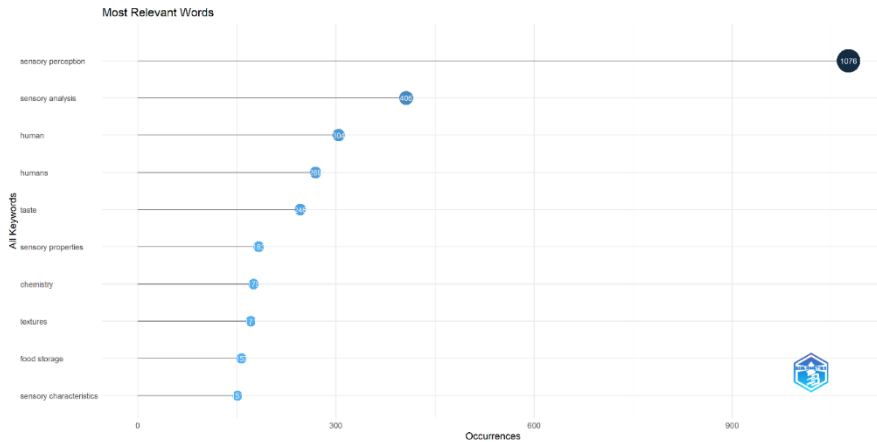


Fig. 4. Most relevant words

3.3 Analysis of the most globally cited and the collaboration network

Figure 5 was a visualization of the collaboration network or collaboration density map. In bibliometric analysis, this map shows the strength of collaborative relationships between researchers and the concentration of expertise in specific domains. Researchers Stieger, Markus A. & Scholten, Elke, from the same institution, Wageningen University and Research, were among the densest clusters on the right side. Markus Stieger was a key figure who explained why this institution topped the previous article production chart. Their research generally focuses on food structure, texture, and sensory perception [8]. Researcher Ares Gastón occupied the area with the highest red density, indicating a very high frequency of collaboration. Ares (from the Universidad de la República) was a leading reference in sensory analysis methodology. Researcher Chen Jianshe represents the cluster from Zhejiang Gongshang University, highlighting the significant contributions of Chinese researchers to the physicochemical aspects of food. Researcher Matthew B. and McSweeney were at the top of the map, corresponding to the surge in publications from Acadia University in the graph in Fig. 3.

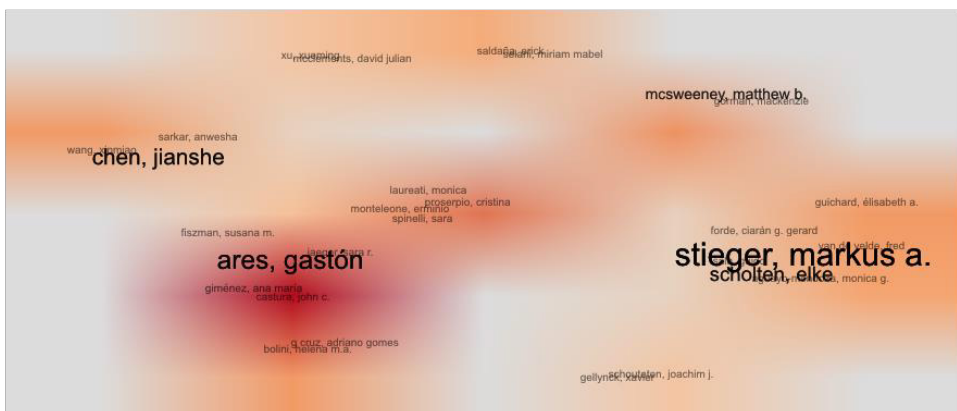


Fig. 5. Collaboration network

Table 1 presents the 10 most globally cited papers with the greatest influence in the bibliometric data repository. The parameters used include Total Citations (TC), TC per Year, and Normalized TC. The study by Kyriacou (2018) ranks first, having been published in the journal *Scientia Horticulturae* and receiving 309 citations. This study explains that the quality of fruits and vegetables constitutes a dynamic composite of their physicochemical properties and consumer perception. Preharvest factors include: the optimized application of controlled stress conditions that increase primary and secondary metabolites and improve organoleptic and functional aspects of quality [9]. Next, Heiniö's (2016) article in *Trends in Food Science & Technology* had 255 citations. The TC per Year results showed that Kyriacou (2018) had the highest total citations, but Ciesarová (2020) showed a very impressive performance with 38.67 citations per year. The Normalized Total Citations value is used to compare the impact of an article with other articles published in the same year [10]. Kyriacou's (2018) research had the highest score (8.02), indicating that its impact was 8 times greater than the average of other articles in the same field that year. Heiniö's (2016) research, with a score of 6.56, strengthens its position in the literature on the development of food sensory research [11].

Table 1. The most globally cited

Paper	DOI	Total Citations	TC per Year	Normalized TC
Kyriacou, 2018, <i>Sci Hort</i>	10.1016/j.scienta.2017.09.046	309	38.63	8.02
Heiniö, 2016, <i>Trends Food Sci Technol</i>	10.1016/j.tifs.2015.11.002	255	25.50	6.56
Custodio, 2019, <i>Trends Food Sci Technol</i>	10.1016/j.tifs.2019.07.039	243	34.71	5.28
Wang, 2016, <i>Crit Rev Food Sci Nutr</i>	10.1080/10408398.2012.745479	233	23.30	5.99
Ciesarová, 2020, <i>Food Res Int</i>	10.1016/j.foodres.2020.109170	232	38.67	6.09
Yu, 2018, <i>Food Chem</i>	10.1016/j.foodchem.2017.09.037	230	28.75	5.97
Liu, 2015, <i>Lwt</i>	10.1016/j.lwt.2015.05.061	218	19.82	5.14
Xu, 2019, <i>J Texture Stud</i>	10.1111/jtxs.12356	215	30.71	4.68
Ovalle-Magallanes, 2017, <i>Food Chem Toxicol</i>	10.1016/j.fct.2017.08.021	206	22.89	5.29
Xu, 2016, <i>Food Chem</i>	10.1016/j.foodchem.2016.04.105	201	20.10	5.17

3.4 Analysis of keyword co-occurrence

Overlay Visualization map (Fig 6) that illustrates the network of interrelationships between keywords (co-occurrence network). This visualization analyzed the research's intellectual structure by grouping technical terms into color-coded clusters that represent specific sub-topics [12]. The Purple & Red clusters with the keyword “sensory perception” were the largest nodes among all descriptors, overlapping with “human,” “sensory properties,” and “rheology.” This confirmed the data in Most Relevant Words (Fig 4) that the main focus of the literature was human perception of the texture and physical properties of mangosteen.

Furthermore, in the Green color cluster, there was a strong relationship between “food storage,” “ascorbic acid,” and “meat” (related to mangosteen meat/flesh). This showed that the research also explores how storage conditions affect the nutritional content and organoleptic quality of the fruit flesh. Furthermore, the Blue cluster was dominated by the

terms “volatile organic compounds,” “*garcinia mangostana*,” “fermentation,” and “metabolomics.” This explained the scientific basis for the keywords “taste” and “chemistry” that appeared in the previous analysis, which volatile compounds determine the aroma and distinctive taste of mangosteen.

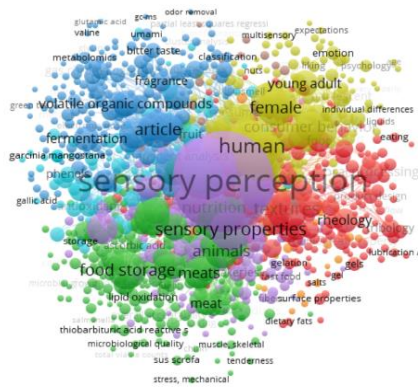


Fig. 6. Overlay visualization

Density visualization (Fig. 7) using VOSviewer software. Unlike the collaboration network (Fig. 5), the density map provides an overview of research concentration based on keyword intensity and the strength of their connections.

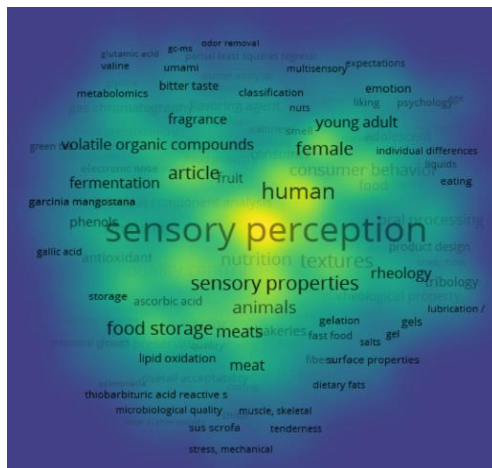


Fig. 7. Density visualization

The analysis results showed a high intensity with a very dense yellow color in sensory perception and humans, confirming that the existing literature was very dense in discussing the interaction between the physical quality of mangosteen and human responses. Furthermore, correlations in the green-yellow transition area around the epicenter include the terms “textures,” “sensory properties,” and “consumer behavior.” This indicated that sensory research on mangosteen has diversified towards psychophysics and consumer economic behavior [2]. Furthermore, the green-to-blue area shows lower density but played an important role in supporting basic research. Clusters containing “volatile organic compounds,” “antioxidant,” and “metabolomics” indicated strong but more specific research on molecular identification of mangosteen aroma and flavor.

4 Conclusion

Mangosteen (*Garcinia mangostana* L.) flesh has high potential for processing into food products, such as instant powdered drinks. Research on mangosteen flesh over the past decade has seen a significant shift from mere chemical analysis to a human-centered sensory perception approach, with Wageningen University and Research as the leading institution in terms of productivity. The keyword “sensory perception” was the dominant keyword, appearing 1,076 times, indicating that mangosteen quality was assessed through the integration of rheology, volatile compounds, and consumer behavior. Research on mangosteen flesh/pulp and its sensory perception is still relatively rare, and this topic remains very broad and necessary for further study.

This research was funded by the Indonesian Ministry of Education, Culture, Research, and Technology within the Dissertation Study Program scheme, with grant number 006/C3/DT.05.00/PL/2025.

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