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Global research trends on avocado oil and its fatty acid composition: A bibliometric review

Global research trends on avocado oil and its fatty acid composition: A bibliometric review

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Abstract

The high content of unsaturated fatty acids in avocado oil (*Persea americana*) has prompted in-depth exploration across research subjects. This study uses bibliometric analysis to assess global research trends on avocado oil and its fatty acid composition from 2004 to 2024. The search string retrieved 255 articles from the Scopus database and then analyzed using R BibliometriX and VOSviewer software. These tools analyze descriptive structures and collaborative patterns and create network data maps. For comparison, we separated the data into two research periods, namely 2004−2013 and 2014−2024. There was a significant increase in the number of publications, with research focuses expanding from fundamental analysis of the chemical composition of avocado oil to practical applications such as adulteration detection and therapeutic use. An increase was also seen in the number of international collaborations, authors, countries, sources, affiliations, and diversification of research topics with Latin American and European countries as the main contributors. However, there are gaps related to the variability of fatty acid composition across cultivars and long-term health effects. This study provides in-depth insights into the evolution of avocado oil research to improve the quality of life of the global population.

Keywords: Bibliometric analysis, BibliometriX, Fatty acids, *Persea americana*, VOSviewer

1. Introduction

Avocado oil (*Persea americana*) has long been known for its various health benefits, including its high monounsaturated fatty acid contents (76.89 g/100 g−84.7 g/100 g) [1,2]. The main fatty acids composed avocado oil (Av-O) is oleic acid (41.28−57.93%), followed by palmitic acid (19.90−29.45%) and linoleic acid (8.44−14.95%) [3]. This fatty acid content not only provides high nutritional values but also offers various health benefits, including reducing the risk of kidney disease, liver disease [4], cholesterol, cardiovascular disease [5], and caring for hair [6] and skin [7,8].

The publication related to the application of Av-O in food and supplement having benefits to human health has increased in recent years [9]. Over the past two decades, the scientific and industrial communities have paid more attention to Av-O. The main reasons to use Av-O are global awareness of the importance of a healthy diet and the need for better oil sources [10]. As a consequence, the research trend of this era does not only discuss the benefits of Av-O but also post-harvest avocado technology [11−13], processing technology [14−16], the proper analysis techniques [17−19] of Av-O to ensure that Av-O based products consumed is of the quality according to its claims [20,21].

The increasing trend of Av-O publications either in the form of original article or review articles has encouraged researchers to perform some researches related with Avocado and Av-O including physical and chemical compositions (fatty acid compositions, triacylglycerol's and some minor components such as phenolics, carotenes, vitamins, and phytosterols), pharmacological activities having the beneficial

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effects to human health, Av-O applications in food and pharmaceutical products as well as quality control and its authentication analysis [22–25]. In the process of literature searching for Av-O studies, there is often unintentional duplication of research objectives. Therefore, bibliometric analysis is needed at the beginning to understand the dynamics of research development, identify the most researched topics, and evaluate the collaboration network between researchers and institutions [9]. For example, the temporal trend of publications can show a significant increase in recent years, reflecting the urgency and relevance of the topic. In addition, collaboration between countries and institutions shows that the research being developed is multidisciplinary and requires a cross-sectoral approach [26]. Faced with the need to collect data and analyze research trends on avocado oil and its fatty acids over the past two decades, this review aims to find novelties and research gaps. Thus, this research not only contributes to scientific knowledge but also opens up new opportunities for innovation and product development that can improve society's quality of life and welfare globally [1].

Some bibliometrics studies related to Avocado (*Persea americana* Mill.) and Av-O existed in some publications. Zakaria et al. has carried out the bibliometric study on Avocado including the use of underutilized parts such as peel and seeds, from the perspective of green agro-industry [9]. The bibliometric analysis on the use of the underutilized by-products of Av-O in biorefinery leading to the significant beneficial effects toward environment has also carried out by Aguilar-Vasquez [27]. Fernando et al. conducted the bibliometrics analysis on Av-O focusing on scientific contributions toward gap analyses in Av-O researches in the last ten years [28]. However, the bibliometrics study focusing on the global research trends on Av-O and its fatty acid composition has not been reported yet. The objective of this study was to use bibliometric analysis for assessing the global research trends on Av-O and its fatty acid composition during last ten years from 2004 to 2024.

2. Materials and methods

2.1. Search strategy

An in-depth literature search was conducted using the Scopus database, one of the global most critical and comprehensive scientific material collections. Our search of the used references was based on the PRISMA guidelines [29], as shown in Fig. 1. The search keywords used to find relevant articles were (“Avocado Oil” OR “Persea americana”) AND (“Fatty Acid”). All searches and document retrievals were conducted during July 2024. The obtained documents were filtered to exclude some documents based on our search criteria, which included publication years between 2004 and 2024 and articles published in journals in English only (Fig. 1). We only included original articles, which are primary sources and did not include other types of documents, such as review articles, books, or book chapters, which are usually secondary sources.

Studies on avocado oil (Av-O) and its fatty acids in various avocado fruit parts were further analyzed by adding them to the search string [9]. The additional searches were performed separately using additional

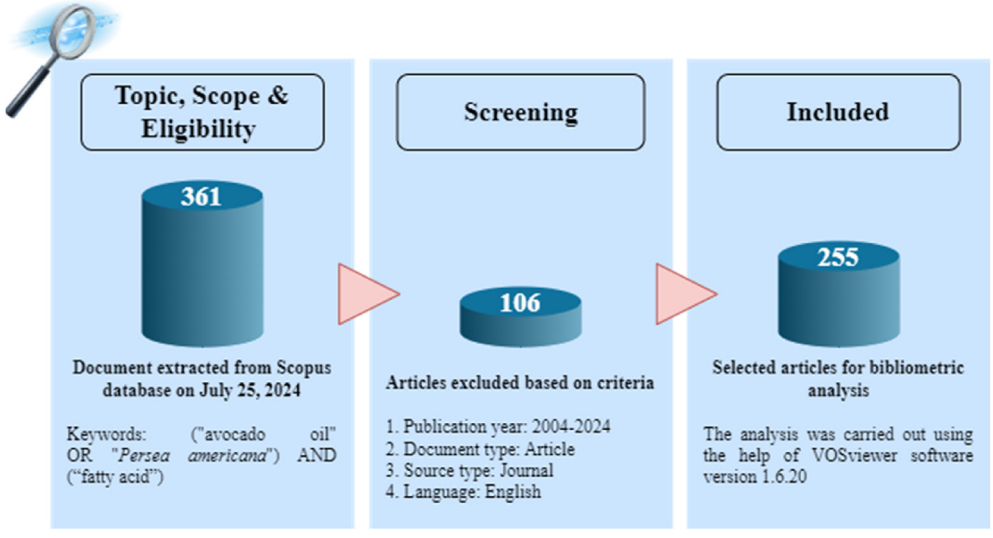

Fig. 1. Search strategy based on PRISMA flow diagram.

Boolean characters for each avocado fruit part (pulp OR mesocarp OR flesh*, peel OR skin*, seed*). This search was also performed to look at the research slices for each avocado fruit part (pulp OR mesocarp OR flesh AND peel OR skin*, pulp OR mesocarp OR flesh AND seed*, peel OR skin AND seed*, pulp OR mesocarp OR flesh AND peel OR skin AND seed*).

2.2. Data analysis

Two hundred fifty-five articles from 2004 to 2024 obtained from Scopus searches were downloaded in RIS, CSV, and BibTeX formats. The data were divided into two categories (research periods) based on publication distribution: 2004 to 2013 and 2014 to 2024. The aim was to see the evolution of trends. All documents were subjected to bibliometric analysis using Biblioshiny [30] and included in the R package BibliometriX and VOSviewer version 1.6.20 [9] to analyze, create, and visualize bibliometric networks. All software is free to download and use and effectively performs bibliometric analysis [31].

3. Result

3.1. Annual publication trends

Fig. 2 presents the publication pattern of avocado oil (Av-O) and fatty acid research in the last two decades. The number of publications from 2004 to 2024 increased significantly to reach 250 articles. In the last decade, the number of publications has increased rapidly to 195 articles from 60 articles in the previous decade. This number has increased clearly from only single digits each year from 2004 to 2012 to double digits each year from 2013 to 2024.

3.2. Main information of the collection article

The main information of the collected articles is presented in Table 1. The database of Scopus produced 255 articles published from 2004 to 2024. In the last decade, more articles were published than in the previous decade. Other data, such as the number of sources, plus keywords, and author keywords, were also higher in 2014–2024 than in 2004–2013. This indicates that the topic coverage is getting wider, and research is getting more specific in exploring various aspects of avocado oil and its fatty acids. The number of authors, authors of multi-authored articles, co-authors per article, and collaboration index were higher in 2014–2024 than

Table 1. Main bibliometric information on avocado oil and its fatty acids in the last two decades.

Description	Publication Period	
	2004–2013	2014–2024
Documents	60	195
Sources (Journals)	49	134
Annual Growth Rate (%)	13.8	1.34
Document Average Age	13.9	4.25
Average citations per doc	52.7	18.26
Keywords Plus	822	1895
Author's Keywords	215	632
Authors	220	923
Authors of single-authored docs	3	3
Authors of multi-authored docs	217	920
Single-authored docs	3	3
Co-Authors per Document	4.17	5.68
International co-authorships (%)	20	22.56

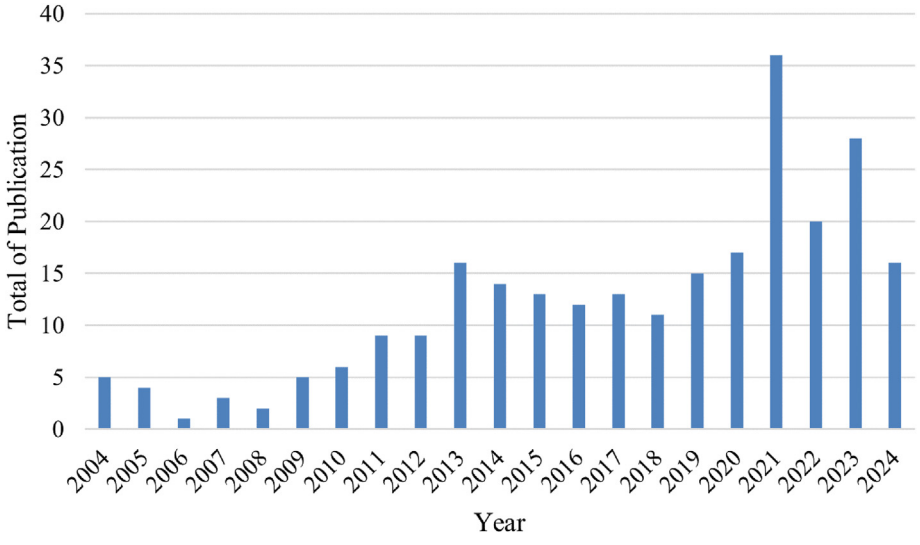

Fig. 2. Temporal evolution of scientific publications on avocado oil and its fatty acids research from 2004 to 2024.

in 2004–2013, indicating more collaboration. The average number of citations per document in 2014–2024 was lower than in 2004–2013. This decrease may be due to the period causing more citations to papers published earlier [9].

3.3. Most productive authors, co-authorship, and collaboration patterns

The number of productive authors has increased from 220 authors during 2004–2013 to 923 authors during 2014–2024. The top 10 productive authors in the last two decades are presented in Table 2. Initially, the results of the R BibliometriX analysis placed the top ten positions based on the number of publications and the alphabet of the author's name. These results are not objective because several authors have the same number of publications. Therefore, a re-analysis was carried out by considering the fractionalized article data and the order of authorship in the article for authors with the same publication as supporting data.

The results of the reanalysis period 2004–2013 showed that Meyer M.D. and Terry L.A. [32,33] from the Laboratory of Plant Science, Cranfield University, Bedfordshire, UK, published on the analysis of chemical composition in avocados. While the period 2014–2024, Green H.S. and Wang S.C. [20,21,34] from the Department of Food Science and Technology, University of California Davis, Davis, CA, USA, published a lot of articles related to Av-O authentication to evaluate its quality and purity. The analytical methods based on spectroscopy chromatography in combination with chemometrics were employed for the authentication analysis of Av-O [25]. The re-analysis results also show that several authors with the same number of publications and country of origin have the same the fractionalized article value. Since these authors often publish together. However, this result also shows the lack of international collaboration between authors. This condition is more clearly analyzed through the visualization of co-authorship.

Co-authorship relationships among authors were mapped to investigate the relationships between each author of a publication they collaborated with. The mapping is presented through color visualization and link lines [26,31]. Fig. 3A shows the co-authorship relationships between authors who published at least one document between 2004 and 2013. A total of 229 authors met the requirements, 12 of them had extensive relationships, resulting in 2 different color clusters. Fig. 3B shows the co-authorship relationships between authors who published at least one document between 2014 and 2024. Nine hundred fifty-seven (957) authors met the requirements, 44 of them had extensive relationships, resulting in 5 different color clusters. The node size is proportional to the number of articles published. The thicker the node size, the more articles there are.

Clusters formed during the publication year of 2014–2024 were found to be more numerous than those during year 2004–2013. The increased numbers indicated a significant evolution in terms of cooperation and complexity from the year period 2004–2013 to year period 2014–2024. Herber D. and Lu Q.Y., in the period 2004–2013, became authors with a relatively large number of publications and co-authorship. Furthermore in 2014–2024, Pedreschi R. is taken into account as one of the authors with many publications and extensive co-authorship.

3.4. Most productive countries and collaboration patterns

Table 3 presented top ten (10) productive countries in the last two decades. As a result from R BibliometriX analysis, based on the number of publications and the alphabetical order of the

Table 2. Most prolific author of research publications on avocado oil and its fatty acids in the last two decades.

Rank.	Publication Period					
	2004–2013			2014–2024		
	Authors (Country)	NP	AF	Authors (Country)	NP	AF
1	Meyer M.D. (United Kingdom)	3	1.33	Green H.S. (USA)	8	3.45
2	Terry L.A. (United Kingdom)	3	1.33	Wang S.C. (USA)	8	3.45
3	Yanty N.A.M. (Malaysia)	3	1.00	Pedreschi R. (Chile)	8	1.03
4	Marikkar J.M.N. (Malaysia)	3	1.00	Defilippi B.G. (Chile)	7	0.83
5	Hernández-Brenes C. (Mexico)	3	0.54	Sivakumar D. (South Africa)	5	1.35
6	Wang X. (Israel)	3	0.53	Ariza-Ortega J.A. (Mexico)	4	0.81
7	Kobiler I. (Israel)	3	0.53	Machado M. (Portugal)	4	0.79
8	Lichter A. (Israel)	3	0.53	Pintado M. (Portugal)	4	0.79
9	Leikin-Frenkel A. (Israel)	3	0.53	Mendonça C.R.B. (Brazil)	4	0.79
10	Prusky D. (Israel)	3	0.53	Yahia E.M. (Mexico)	4	0.72

NP: Number of Publications.
AF: Articles Fractionalized.

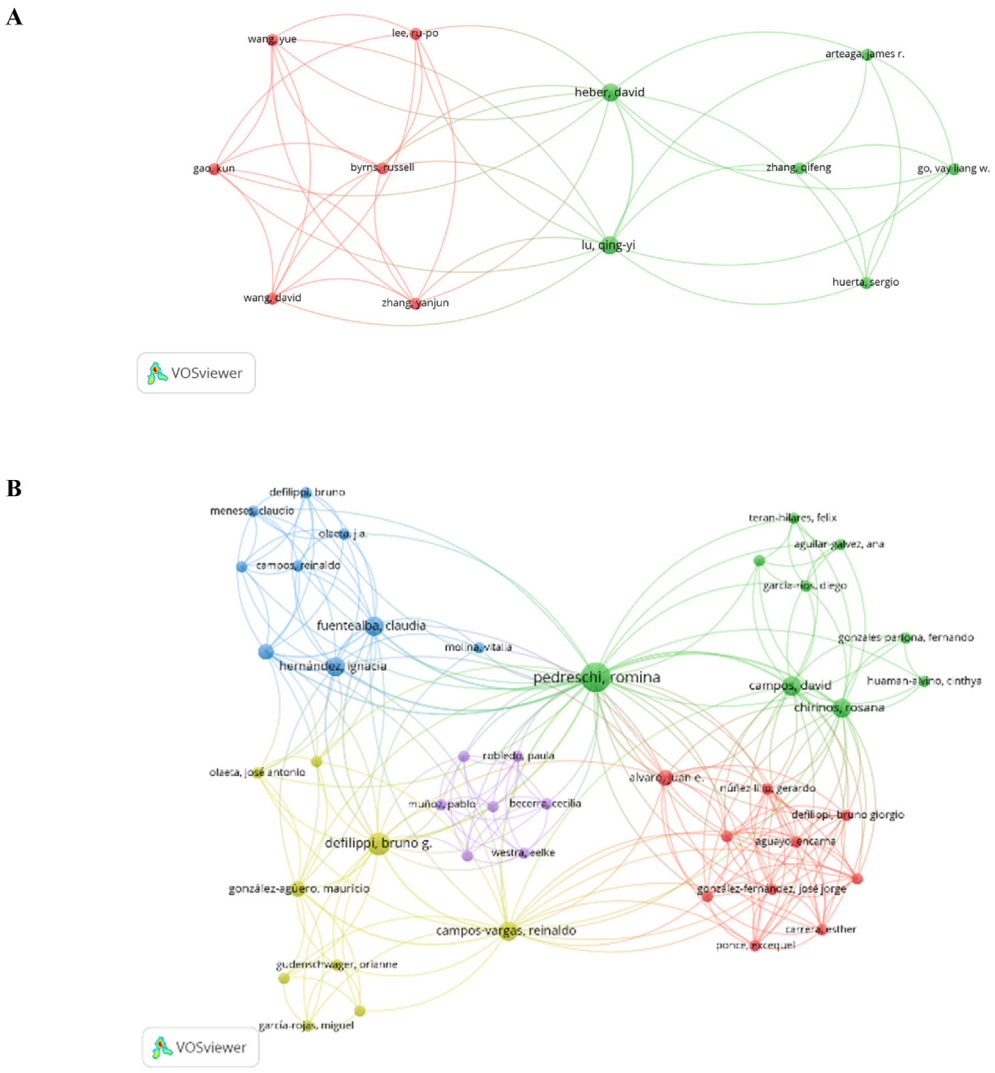

Fig. 3. Distribution of collaborative relations between authors in avocado oil and fatty acid research. A: 2004-2013, B: 2014-2024.

Table 3. The most productive country in publishing research on avocado oil and its fatty acids in the last two decades.

Rank.	Publication Period					
	2004–2013			2014–2024		
	Country	NP	TC	Country	NP	TC
1	Mexico	41	505	Mexico	225	401
2	Spain	35	298	Brazil	160	495
3	Brazil	27	122	USA	101	264
4	USA	26	762	Chile	79	285
5	Israel	15	48	China	69	39
6	South Africa	13	121	Spain	51	49
7	UK	9	291	South Korea	38	32
8	Malaysia	9	101	Portugal	37	25
9	New Zealand	6	64	South Africa	34	110
10	France	6	ND	Egypt	31	88

TC: Total Citation.
ND: Not Detected.

country names. Because several countries have the same number of publications, the data on the number of article citations from each country is added as a consideration. Interestingly, some countries with a large number of publications have fewer citations. From 2004 to 2013, Israel, New Zealand, and France were in the top 10 countries with the most publications but outside the top 10 countries with the highest number of citations. The same happened to China, Spain, South Korea, Portugal, and Egypt from 2014 to 2024. Publication of Av-O and its fatty acid compositions for the past two decades has been dominated by the countries of the American continent. Mexico is one of the countries that has maintained its existence for the past two decades. In 2004–2013, Mexico was in the

top position out of 30 countries that had ever published. In the following decade, there was an increase in the number of productive countries to 40, with Mexico still being the most productive country.

Co-authorship relations between countries were mapped to investigate the relationships between each country researchers collaborated with. The mapping is presented through color visualization and link lines [26,31]. Fig. 4A showed the co-authorship links between countries that published at least one document between 2004 and 2013. A total of 30 countries met the requirements, 6 of which had extensive relations, resulting in 3 different color clusters. Fig. 3B showed the co-authorship links between countries that published at least one document between 2014 and 2024. A total of 43 countries met the requirements, 28 of which had extensive relations, resulting in 8 different color clusters.

3.5. Distribution and impact of research journals on avocado oil and its fatty acid compositions

Table 4 listed the ten most relevant sources over two decades, which are sorted by the number of publications followed by the number of citations. In 2004–2013, 49 relevant sources were found, and in 2014–2024, 134 were found. The top 10 sources from the two periods focused heavily on the development of avocado oil as a food ingredient [35–37]. Journal of Agricultural and Food Chemistry, as the most relevant source from 2004 to 2013, experienced an increase in the number of publications in 2009 to four from only one document. However, this increase only occurred every year in the next period. Unlike Food Chemistry source, although 2004–2013 it was in second place, the growth in the number of publications continued to increase by one document every three, two, or even once a year. This explained why Food Chemistry become the most relevant source in the period 2014–2024.

Another factor that influences this relevance is the h-index score of the local impact source. This score shows how often each article from the source is cited in the collection of articles analyzed. Of course, this score is used to see the impact obtained by the source from each related article published [9,31]. Several sources from 2004 to 2013 showed the number of publications in line with their impact, for

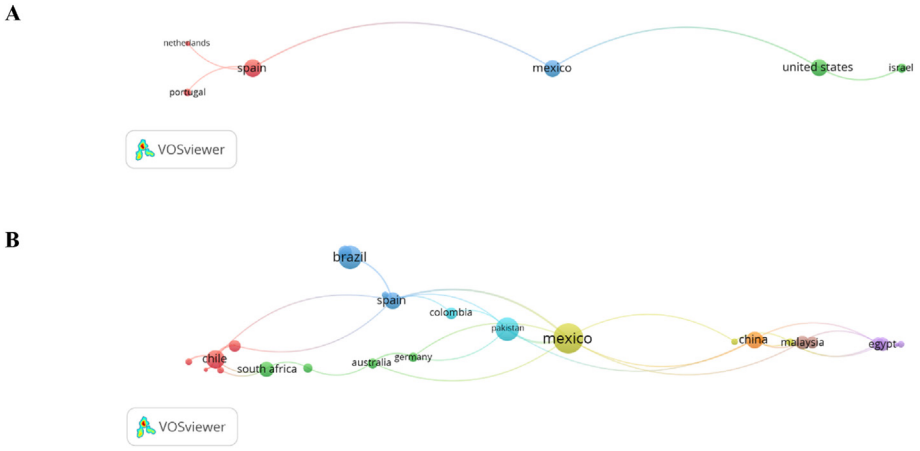

Fig. 4. Distribution of collaborative relations between countries in avocado oil and fatty acid research. A: 2004–2013, B: 2014–2024.

Table 4. Relevant sources for research on avocado oil and its fatty acids in the last two decades.

Rank.	Publication Period					
	2004–2013			2014–2024		
	Source	NP	TC	Source	NP	TC
1	Journal of Agricultural and Food Chemistry	5	360	Food Chemistry	6	188
2	Food Chemistry	4	543	Scientia Horticulturae	6	92
3	Food Research International	2	219	Foods	5	11
4	Journal of Bioenergetics and Biomembranes	2	62	Journal of Food Composition and Analysis	4	93
5	Physiological and Molecular Plant Pathology	2	14	Molecules	4	67
6	Asian Journal of Chemistry	2	ND	Food Chemistry Advances	4	14
7	Critical Reviews in Food Science and Nutrition	1	372	Horticulturae	4	5
8	Journal of Nutritional Biochemistry	1	173	JAOCS, Journal of The American Oil Chemists' Society	3	254
9	Meat Science	1	132	Postharvest Biology and Technology	3	107
10	Veterinary Journal	1	102	European Journal of Lipid Science and Technology	3	100

example, the Journal of Agricultural and Food Chemistry (5 publications, h-index 5). Likewise, for 2014–2024, for example, Food Chemistry with 6 publications and h-index of 5. However, the high number of publications is not always in line with its impact; for instance, in 2014–2024, Horticulturae having 4 publications with h-index of 1.

3.6. Co-occurrence analysis of author keywords

The larger nodes and words generally indicate the greater keyword weight. The shorter distances indicate stronger relationships between 2 nodes. Thicker lines indicate more frequent occurrences of the two keywords. In Fig. 5, we can see a visualization of the research focus. In 2004–2013, avocado oil research focused on testing its sterols, vitamin E, and carotenoid content (sage green cluster) [38,39]. Avocado oil is also closely related to its fatty acid composition, which in this period focused on testing fatty acid composition based on variety, ripeness, and harvest time (brown cluster) [40,41].

The expansion of research focus occurred during the period 2014–2024. In which the research has focused on the application steps, including quality control of Av-O by detecting Av-O adulterations using the chemometric methods [21] (blue cluster). Likewise, the focus of research on Av-O and fatty acid compositions focused on antioxidant activity [42–44], mainly oleic acid [45] (gray cluster). Furthermore, the focus of research on fatty acids of Av-O is to study the metabolomics aspects [46] and

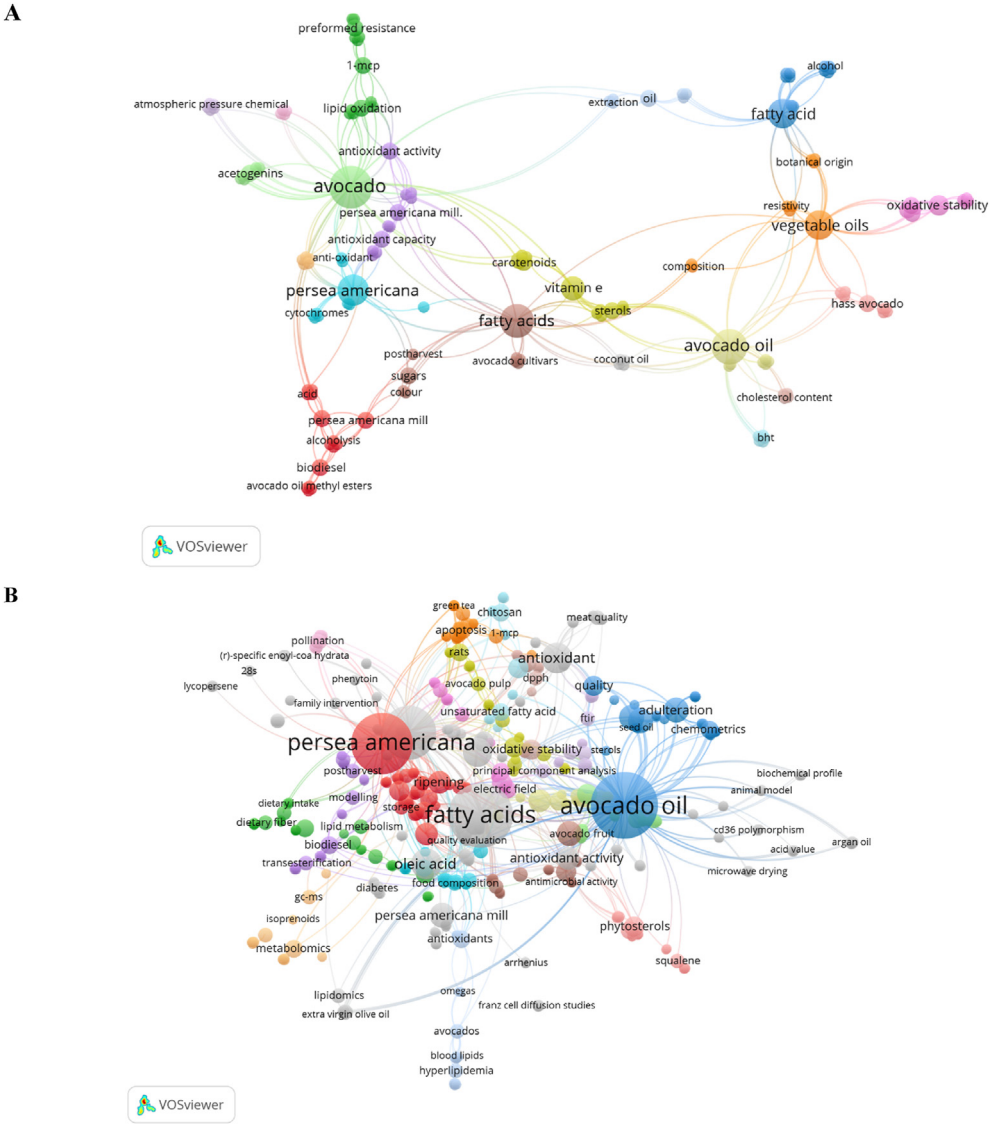

Fig. 5. Distribution of co-occurrence relations of author keywords in avocado oil and fatty acid research. A: 2004–2013, B: 2014–2024.

the use of unsaturated fatty acids in modulating apoptosis in cancer cells [47,48].

3.7. Distribution of publications with the most productive affiliates

Table 5 listed the ten most relevant affiliates over the two decades. These affiliates are ranked by the number of publications followed by the level of affiliate production over time as a consideration. The level of affiliate production is assessed based on the year of first publication in that period, the number of publications when first published, and the continuity of the affiliate in publishing each year. As recorded during 2004–2013, 78 institutions have published research on Av-O and its fatty acids, including the Federal University of Pernambuco. This university is one of the institutions that originated in Brazil. During 2004–2013, this institution only started publishing in 2013 with 11 articles. In contrast to Cranfield University in the UK, this institution started publishing in 2008 with two articles. It continued to increase in the following years until seven publications at the end of 2013. Pontificia Universidad Católica de Valparaíso from Chile is the most productive institution out of 296 other institutions published in 2014–2024. During that period, Pontificia Universidad Católica de Valparaíso published its article again in 2016 as many as 1 article and continued to increase until 2024.

3.8. Articles with the most popular cited

Of the total 60 articles from 2004 to 2013, only 58 articles have been cited. Referring to Table 6, the article "Hass Avocado Composition and Potential Health Effects" has the highest citation. This article broadly discusses the nutritional and phytochemical composition of avocados. This composition includes proximate analysis, minerals, vitamins, and lipids. This content is then linked to its role in cardiovascular health [49]. In 2014–2024, out of a total of 195 articles, only 176 were cited. In this period, the article entitled "The Influence of Fatty Acids on Tribological and Thermal Properties of Natural Oils as Sustainable Biolubricants" became the article with the highest citation. This article discusses using natural oils, such as avocados and other oils, as sustainable lubricants. These oils were analyzed for thermogravimetry and viscosity. It also discusses the influence of fatty acid composition on tribological performance [50].

Other articles in the top 10 highest citations during the period of 2004–2013 and 2014–2024 discuss many factors which influence the profile and composition of fatty acid composition of Av-O. Some influencing factors are harvest and post-harvest periods [51], level of ripeness and growing area [52] and extraction methods [53,54]. The number of citations of articles in the period 2004–2013 is known to be higher than in the period 2014–2024. The longer an article is published, the more time it has to be cited by other researchers. In addition, research published in the early period may likely have covered new and highly relevant topics. Contributing to attracting more attention and citations [9].

3.9. A bibliographic search of avocado oil and its fatty acids based on fruit part

The development of Av-O research trends encourages more comprehensive exploration. Avocado oil, sourced from pulp, is now expanding to other parts of the fruit, such as seeds [48] and skin [55]. Fig. 6A showed the number of publications on

Table 5. The most productive affiliation publishing research on avocado oil and its fatty acids in the last two decades.

Rank.	Publication Period			
	2004–2013		2014–2024	
	Affiliation	NP	Affiliation	NP
1	Federal University of Pernambuco	11	Pontificia Universidad Católica de Valparaíso	22
2	Cranfield University	7	Universidad Michoacana de San Nicolás De Hidalgo	21
3	University of California	7	Universidade Católica Portuguesa	19
4	University of Kwazulu-Natal	6	Instituto Politécnico Nacional	17
5	Universidad Politècnica de València	6	Tshwane University of Technology	16
6	Inst. Nac. Cardiol. Ignacio Chavez	5	Chinese Academy of Tropical Agricultural Sciences	15
7	Institute of Technology and Storage of Agriculture Products	5	Universidade de Franca	13
8	Charles Sturt University	5	Universidad Nacional Agraria La Molina	13
9	Ciudad Universitaria	5	Griffith University	13
10	The New Zealand Institute for Plant and Food Research Limited	5	University of California Davis	13

Table 6. The most cited article on avocado oil and its fatty acids in the last two decades.

Rank.	Publication Period							
	2004–2013				2014–2024			
	Article	DOI	TC	TC per year	Article	DOI	TC	TC per year
1	Dreher M.L., 2013, Critical Reviews in Food Science and Nutrition	10.1080/10408398.2011.556759	372	31.00	Reeves C.J., 2015, Tribology International	10.1016/j.triboint.2015.04.021	187	18.70
2	Villa-Rodríguez J.A., 2011, Food Research International	10.1016/j.foodres.2010.11.012	189	13.50	Prescha A., 2014, JAOCS Journal of the American Oil Chemists' Society	10.1007/s11746-014-2479-1	152	13.82
3	Ozdemir F., 2004, Food Chemistry	10.1016/j.foodchem.2003.08.012	189	9.00	Duarte P.F., 2016, Ciência Rural	10.1590/0103-8478cr20141516	102	11.33
4	Lu Q.Y., 2005, The Journal of Nutritional Biochemistry	10.1016/j.jnutbio.2004.08.003	173	8.65	Alkhalaf M.I., 2019, Journal of King Saud University - Science	10.1016/j.jksus.2018.10.010	88	14.67
5	Haiyan Z., 2007, Food Chemistry	10.1016/j.foodchem.2005.12.039	157	8.72	Krumreich F.D., 2018, Food Chemistry	10.1016/j.foodchem.2018.03.048	84	12.00
6	Rodríguez-Carpena J.G., 2012, Meat Science	10.1016/j.meatsci.2011.06.007	132	10.15	Kilaru A., 2015, BMC Plant Biology	10.1186/s12870-015-0586-2	77	7.70
7	Berasategi I., 2012, Food Chemistry	10.1016/j.foodchem.2011.11.018	121	9.31	Donetti M., 2014, Journal of Food Composition and Analysis	10.1016/j.jfca.2013.11.011	71	6.45
8	Lu Q.Y., 2009, Journal of Agricultural and Food Chemistry	10.1021/jf901839h	115	7.19	Dávila J.A., 2017, Bioresource Technology	10.1016/j.biortech.2017.06.063	68	8.50
9	Henrotin Y., 2005, The Veterinary Journal	10.1016/j.tvjl.2004.08.014	102	5.10	Pedreschi R., 2014, Postharvest Biology and Technology	10.1016/j.postharvbio.2014.01.024	66	6.00
10	Meyer M.D., 2008, Journal of Agricultural and Food Chemistry	10.1021/jf8011322	86	5.06	Dos Santos M.A.Z., 2014, JAOCS Journal of the American Oil Chemists' Society	10.1007/s11746-013-2289-x	65	5.91

TC: Total Citation.

Av-O and its fatty acids, focusing on each part of the avocado fruit. Several publication slices, such as seeds and skins, are considered waste [56]. These publications discuss chemical content [57], activity [58], and their utilization [59]. Other slices are between publications on pulp, skin, and seeds [3]. These publications discuss a lot about the comparison of chemical composition profiles [3,60] to metabolomic analysis [43,61] and oil authentication [56,62] from the three parts of the avocado fruit.

Fig. 6B showed the subject areas of publications for each part of the avocado fruit. Pulp, seed, and skin are the most frequently used titles and keywords in agriculture, chemistry, biology, and pharmacy publications [9]. Publications in agricultural and biological sciences discuss post-harvest technology to obtain the maximum chemical content of avocado oil [63]. The fields of chemistry, pharmacology, toxicology, and pharmaceutics discuss the chemical composition analysis [64] and activity of avocado oil [65]. Engineering and physics fields discuss equipment's effectiveness [66] in obtaining avocado oil and its use as renewable energy [67].

3.10. Fatty acid composition of avocado oil

Table 7 showed the fatty acid composition of Av-O. The search was controlled on Hass avocado variants extracted using the Soxhlet method and analyzed using Gas Chromatography-Flame Ionization Detector (GC-FID). The analysis of the fatty acid composition focused on differences in growing location and avocado fruit parts. The study was carried out on major fatty acid components only, although the current trend in analysis has reached minor fatty acid components [15].

Avocado contains fruit oil with a low saturated fatty acid (SFA) composition (<30%) and most of the unsaturated fatty acids, such as monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) [68]. Oleic acid is one of the MUFA components, with the highest composition reaching

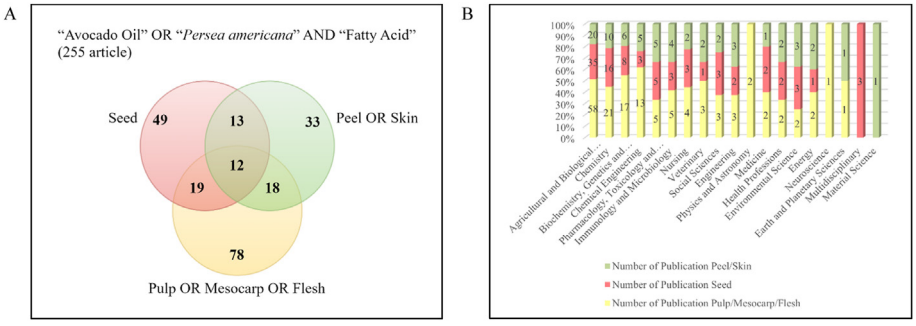

Fig. 6. A bibliographic of avocado oil and its fatty acids based on fruit part. A: Number of publications, B: Publication subject area.

Table 7. Fatty acid composition of avocado oil.

Country of Origin	Part	Palmitic C16:0	Palmitoleic C16:1	Stearic C18:0	Oleic C18:1	Linoleic C18:2	Linolenic C18:3	Ref
Mexico	Pulp	22.59 ± 0.23	11.63 ± 0.13	0.24 ± 0.02	49.19 ± 0.57	14.72 ± 0.06	1.63 ± 0.16	[68]
Uruapan, Mexico	Pulp	20.9 ± 0.3	9.08 ± 0.1	0.644 ± 0.01	61.2 ± 1.4	13.0 ± 0.3	1.52 ± 0.1	[64]
Zapotl'an, Mexico	Pulp	21.83	9.073	0.366	52.51	15.05	1.170	[56]
USA	Pulp	22.24 ± 0.05	13.14 ± 0.01	0.93 ± 0.08	47.69 ± 0.03	14.47 ± 0.01	1.54 ± 0.00	[68]
Lima, Peru	Pulp	27.50 ± 1.29	13.13 ± 1.46	NR	39.44 ± 2.27	18.95 ± 1.61	0.97 ± 0.12	[11]
São Paulo, Brazil	Pulp	27.96 ± 0.03	16.25 ± 0.03	0.60 ± 0.03	36.57 ± 0.01	16.33 ± 0.01	0.81 ± 0.00	[65]
Rabat-Sale-Kenitra, Morocco	Pulp	20.91 ± 0.03	9.82 ± 0.02	0.49 ± 0.07	54.53 ± 0.05	12.93 ± 0.03	0.90 ± 0.03	[45]
Rabat-Sale-Kenitra, Morocco	Pulp	20.94 ± 0.05	9.83 ± 0.04	0.44 ± 0.08	54.51 ± 0.12	12.96 ± 0.04	0.88 ± 0.04	[1]
Tenerife, Spain	Pulp	19.5 ± 1.58	10.3 ± 1.39	0.525 ± 0.02	57.1 ± 4.10	11.6 ± 2.17	0.655 ± 0.13	[69]
Donja Bistra, Croatia	Pulp	20.34 ± 0.22	8.58 ± 0.14	0.45 ± 0.03	57.93 ± 0.52	8.44 ± 0.22	0.000	[3]
New Zealand	Pulp	20.61 ± 0.16	10.31 ± 0.03	0.30 ± 0.01	50.97 ± 0.30	16.10 ± 0.11	1.72 ± 0.02	[68]
Australia	Pulp	25.63 ± 0.11	7.29 ± 0.05	0.45 ± 0.16	42.59 ± 0.16	20.87 ± 0.10	3.19 ± 0.06	[68]
Zapotl'an, Mexico	Seed	22.75	6.430	2.607	37.47	22.90	0.505	[56]
Donja Bistra, Croatia	Seed	29.45 ± 0.60	8.72 ± 0.33	0.000	41.28 ± 0.67	14.95 ± 0.40	0.000	[3]
Zapotl'an, Mexico	Peel	23.66	7.920	0.912	56.54	10.97	0.000	[56]
Donja Bistra, Croatia	Peel	19.90 ± 0.44	7.60 ± 0.11	0.55 ± 0.02	56.79 ± 0.50	11.62 ± 0.34	1.33 ± 0.01	[3]

NR: Not Reported.

37.47–64.87% [56]. This is followed by palmitic acid as SFA with a composition of 19.90–29.45% and linoleic acid as PUFA with a composition of 8.44–14.95% or even higher [3]. The proportional distribution of SFA, MUFA, and PUFA in avocado oil is influenced by many factors, including geographical origin [68,69]. Other parts of the avocado fruit, such as the skin and seeds that are also explored for their oil content, show an interesting fatty acid composition to discuss. Proportionally, the fatty acid content in the seeds is lower than the pulp. However, the skin shows almost the same proportion [3,56]. Some current research trends also investigate the authenticity of avocado oil, claiming that it is extracted from its pulp [21,70].

4. Discussion

Bibliometric analysis of Av-O and its fatty acid composition over the past two decades reveals several important insights related to identifying the research trends and collaborations, evaluating scientific impact, and productivity levels [31]. The main elements considered in this analysis are publication indicators, citation indicators, and network analysis [9]. Data from each component is linked to each other to rank the analysis results. The productivity of Av-O publications and its fatty acid composition in 2004–2024 did not indicate an exponential yearly increase. During the research period, fluctuations were caused by various factors. Several factors suspected of influencing are funding, research interest, technological advances, the scarcity of avocados, and collaboration between researchers [9].

Collaboration between researchers is one of the most influential factors [9,31]. Although the results of the analysis of authors of multi-authored docs in both periods were much higher than authors of single-authored docs, international co-authorships only reached 20%. This result was verified through the composition of fractionalized articles, which showed the same value for many researchers with joint publications and the same country of origin. The results of the VOSviewer co-authorship analysis strengthen this suspicion where grouping generally occurs only between authors from Latin American countries or Europe, especially the UK and USA.

This country condition is one of the focuses of attention, considering that countries with the highest avocado production are different from countries that generally have superior and sophisticated analysis instruments. Latin American countries such as Mexico, Colombia, Brazil, Chile, and Peru are productive avocado countries [71]. Meanwhile, sophisticated analysis technology is generally located in mainland Europe, such as the UK, Spain, Netherlands, France, Germany, and several other countries, such as Australia and the USA [20,21]. Several articles with the highest citations appear from the ten most productive authors, countries, affiliations, and sources. However, the UK, the USA, and several other European countries have dominated the most productive publication sources over the past two decades.

The bibliometric analysis also identified several recurring keywords in the literature, including the nutritional composition of Av-O [60,64], its health benefits [72], as well as its potential applications in food [73], cosmetics, and nutraceuticals [74]. Recent research has focused on the antioxidant properties of avocado oil [43,66] and its role in cardiovascular health [75–77], emphasizing its high content of monounsaturated fats [1,69] and other bioactive compounds [14,66]. The growing interest in sustainable and environmentally friendly extraction methods [66,78] is also a growing research hotspot reflecting broader environmental concerns in the food industry.

This review highlights some of the most cited publications and influential authors that have shaped the current understanding of avocado oil's chemical profile and health benefits. The exploration extends through the identification of the chemical profile of avocado oil from different growing regions [68], varieties [64], post-harvest treatments [63], extraction methods [79], analytical methods [80], and even unused fruit parts such as skin and seeds [57,58]. These contributions provide basic knowledge about avocado oil's chemical composition, including the carotenoid, phenolic, and lipid profiles, triacylglycerols, tocopherols, and fatty acids [64].

Analysis of fatty acid composition in oil is important for health, quality, and stability considerations. Monounsaturated fatty acids (MUFA) are good for heart health because they can lower LDL (Low-Density Lipoprotein) cholesterol levels and increase HDL (High-Density Lipoprotein) cholesterol [65]. Meanwhile, polyunsaturated fatty acids (PUFA) can reduce inflammation, lower blood pressure, and support heart health. High unsaturated fatty acids in oil composition indicate better quality. Fatty acid composition is also recognized as a parameter of the oil stability [81]. Although high unsaturated fatty acid content indicates better quality, it also shows that the oil is susceptible to oxidation reaction. As a consequence, the oil produced tends to be more easily damaged when

exposed to heat, air, or light, affecting the oil's shelf life, taste, and aroma [82].

5. Conclusion

This bibliometric study reveals significant trends in avocado oil and fatty acid composition research from 2004 to 2024. In the last two decades, there has been an increase in the number of publications, international collaborations, authors, countries, sources, affiliations, and diversification of research topics. Key findings indicate that Latin American and European countries are the main contributors to this research, with the focus shifting from fundamental analysis of the chemical composition of avocado oil to practical applications such as adulteration detection and therapeutic use. However, several gaps need to be bridged, including studies on the variability of fatty acid composition across cultivars and the long-term health effects of avocado oil consumption. Further in-depth research and well-designed clinical trials are needed to validate the health benefits of avocado oil and further explore its potential applications. This study enriches the scientific literature and opens up new opportunities for product innovation that can improve the global population's quality of life and well-being.

Conflict of interest

The authors declare that they have no conflicts of interest to this work.

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References

[1] Nasri C, Halabi Y, Hajib A, Choukri H, Harhar H, Lee LH, et al. Proximate composition, lipid and elemental profiling of eight varieties of avocado (Persea americana). Sci Rep 2023; 13. https://doi.org/10.1038/s41598-023-50119-y.

[2] Thompson SV, Bailey MA, Taylor AM, Kaczmarek JL, Mysonhimer AR, Edwards CG, et al. Avocado consumption alters gastrointestinal bacteria abundance and microbial metabolite concentrations among adults with overweight or obesity: a randomized controlled trial. J Nutr 2021;151: 753–62. https://doi.org/10.1093/jn/nxaa219.

[3] Marović R, Badanjak Sabolović M, Brnčić M, Ninčević Grassino A, Kljak K, Voća S, et al. The nutritional potential of avocado by-products: a focus on fatty acid content and drying processes. Foods 2024;13. https://doi.org/10.3390/foods13132003.

[4] Silva VAP, Boaventura GT, Abboud RS, Ribas JAS, Chagas MA. Consumption of avocado oil (Persea americana) improves the biochemical profile of rats submitted to long-term androgenic stimulation. Nutr Hosp 2020;37: 1033–8. https://doi.org/10.20960/nh.03155.

[5] Duarte PF, Chaves MA, Borges CD, Mendonça CRB. Abacate: Características, benefícios à saúde e aplicações. Ciência Rural 2016;46:747–54. https://doi.org/10.1590/0103-8478cr20141516.

[6] Lourenço CB, Gasparin RM, Thomaz FM, da Silva GC, Martin AA, Paiva-Santos AC, et al. Impact of hair damage on the penetration profile of coconut, avocado, and argan oils into caucasian hair fibers. Cosmetics 2024;11:64. https://doi.org/10.3390/cosmetics11020064.

[7] Rydlewski AA, Pizzo JS, Manin LP, Galuch MB, Santos PDS, Zapiello C, et al. Evaluation of possible fraud in avocado oil-based products from the composition of fatty acids by GC-FID and lipid profile by ESI-MS. Chem Pap 2020;74: 2799–812. https://doi.org/10.1007/s11696-020-01119-z.

[8] De Oliveira AP, Franco EDS, Rodrigues Barreto R, Cordeiro DP, De Melo RG, De Aquino CMF, et al. Effect of semisolid formulation of persea americana mill (Avocado) oil on wound healing in rats. Evid base Compl Alternative Med 2013:472382. https://doi.org/10.1155/2013/472382.

[9] Zakaria R, Vit P, Wijaya A, Ahmad AH, Othman Z, Mezzetti B. A bibliometric review of Persea americana Mill. (Lauraceae): a green gold in agroindustry. AIMS Agri Food 2022;7:831–54. https://doi.org/10.3934/agrfood.2022051.

[10] Claudia Cecilia PT, Iván Antonio GM. Consumption of vegetable oils of Persea americana L., and Vitis vinifera L., as part of nutritional support in non-communicable diseases in the population of the state of oaxaca, Mexico: pretest-postest intervention study without control. J Nutr Sci Vitaminol (Tokyo) 2021;67:135–8. https://doi.org/10.3177/jnsv.67.135.

[11] Campos D, Teran-Hilares F, Chirinos R, Aguilar-Galvez A, García-Ríos D, Pacheco-Avalos A, et al. Bioactive compounds and antioxidant activity from harvest to edible ripeness of avocado cv. Hass (Persea americana) throughout the harvest seasons. Int J Food Sci Technol 2020;55:2208–18. https://doi.org/10.1111/ijfs.14474.

[12] García-Rojas M, Morgan A, Gudenschwager O, Zamudio S, Campos-Vargas R, González-Agüero M, et al. Biosynthesis of fatty acids-derived volatiles in "Hass" avocado is modulated by ethylene and storage conditions during ripening. Sci Hortic 2016;202:91–8. https://doi.org/10.1016/j.scienta.2016.02.024.

[13] Mpai S, Sivakumar D. Influence of growing seasons on metabolic composition, and fruit quality of avocado cultivars at 'ready-to-eat stage'. Sci Hortic 2020;265:109159. https://doi.org/10.1016/j.scienta.2019.109159.

[14] Krumreich FD, Mendonça CRB, Borges CD, Crizel-Cardozo MM, dos Santos MAZ, Otero DM, et al. Margarida avocado oil: effect of processing on quality, bioactive compounds and fatty acid profile. Food Chem Advan 2024;4: 100617. https://doi.org/10.1016/j.focha.2024.100617.

[15] Dávila JA, Rosenberg M, Castro E, Cardona CA. A model biorefinery for avocado (Persea americana mill.) processing. Bioresour Technol 2017;243:17–29. https://doi.org/10.1016/j.biortech.2017.06.063.

[16] Tan CX, Chong GH, Hamzah H, Ghazali HM. Comparison of subcritical CO2 and ultrasound-assisted aqueous methods with the conventional solvent method in the extraction of avocado oil. J Supercrit Fluids 2018;135:45–51. https://doi.org/10.1016/j.supflu.2017.12.036.

[17] Cervantes-Paz B, Yahia EM, Nuñez-Vilchis A. Identification and quantification of fatty acids and lipid-soluble phytochemicals using GC-MS, HPLC-MS, and FTIR and their association with quality parameters during avocado ripening. J Food Sci 2023;88:119–32. https://doi.org/10.1111/1750-3841.16390.

[18] Tang F, Green HS, Wang SC, Hatzakis E. Analysis and authentication of avocado oil using high resolution nmr spectroscopy. Molecules 2021;26:310. https://doi.org/10.3390/molecules26020310.

[19] Tang F, Banker T, Green HS, Wang SC, Hatzakis E. Analysis and authentication of avocado oil by low-field benchtop

NMR spectroscopy and chemometrics. J Food Sci 2024;89:4276–85. https://doi.org/10.1111/1750-3841.17142.
[20] Green HS, Wang SC. Purity and quality of private labelled avocado oil. Food Control 2023;152:109837. https://doi.org/10.1016/j.foodcont.2023.109837.
[21] Green HS, Wang SC. Evaluation of proposed CODEX purity standards for avocado oil. Food Control 2023;143:109277. https://doi.org/10.1016/j.foodcont.2022.109277.
[22] Báez-González JG, Gallegos-Garza MM, Gallardo-Rivera CT, Treviño-Garza MZ, Amaya-Guerra CA, Rodríguez-Rodríguez J, et al. Physicochemical characterization and thermodynamic analysis of avocado oil enhanced with Haematococcus pluvialis extract. Foods 2024;13:3184. https://doi.org/10.3390/foods13193184.
[23] Lin X, Li Z. Key components and multiple health functions of avocado oil: a review. J Funct Foods 2024;122:106494. https://doi.org/10.1016/j.jff.2024.106494.
[24] Flores M, Saravia C, Vergara CE, Avila F, Valdés H, Ortiz-Viedma J. Avocado oil: characteristics, properties, and applications. Molecules 2019;24:2172. https://doi.org/10.3390/molecules24112172.
[25] Green HS, Wang SC. Tandem triacylglycerol (TAG) and PCA adulteration detection approach for avocado oil. Food Anal Methods 2023;16:850–6. https://doi.org/10.1007/s12161-023-02468-7.
[26] Yin M, Xu C, Ma J, Ye J, Mo W. A bibliometric analysis and visualization of current research trends in the treatment of cervical spondylotic myelopathy. Glob Spine J 2021;11:988–98. https://doi.org/10.1177/2192568220948832.
[27] Aguilar-Vasquez EA, Herrera-Rodriguez TC, González-Delgado ÁD. Comprehensive utilization of avocado in biorefinery: a bibliometric and co-occurrence approach 2003–2023. Sustainability (Switzerland) 2024;16:9414. https://doi.org/10.3390/su16219414.
[28] Fernando D, Marbun P, Hastuti AAMB, Rohman A. Current trends and future directions in avocado oil research: an overview and a bibliometric analysis across two time points. Oil Crop Sci 2025;10:25–43. https://doi.org/10.1016/j.ocsci.2025.02.003.
[29] Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. Br Med J 2021;372. https://doi.org/10.1136/bmj.n71.
[30] Anzaldo Montoya M, Iraida Hernández-García Y, Guillermo Hernández-Montiel L, Hernández-Adame L, Parque del, Luis Potosí S. Agronanotechnology in the arid zones of northern Mexico: research, challenges, and new trends. J Prof Assoc Cactus Develop 2024;26:1–29. https://doi.org/10.56890/jpacd.v26i.53.
[31] Moral-Muñoz JA, Herrera-Viedma E, Santisteban-Espejo A, Cobo MJ. Software tools for conducting bibliometric analysis in science: an up-to-date review. Profesional de La Informacion 2020;29. https://doi.org/10.3145/epi.2020.ene.03.
[32] Meyer MD, Terry LA. Fatty acid and sugar composition of avocado, cv. Hass, in response to treatment with an ethylene scavenger or 1-methylcyclopropene to extend storage life. Food Chem 2010;121:1203–10. https://doi.org/10.1016/j.foodchem.2010.02.005.
[33] Meyer MD, Terry LA. Development of a rapid method for the sequential extraction and subsequent quantification of fatty acids and sugars from avocado mesocarp tissue. J Agric Food Chem 2008;56:7439–45. https://doi.org/10.1021/jf8011322.
[34] Green HS, Wang SC. First report on quality and purity evaluations of avocado oil sold in the US. Food Control 2020;116. https://doi.org/10.1016/j.foodcont.2020.107328.
[35] Guzmán-Gerónimo RI, Ayala-Tirado RC, Mendoza-López R, Cocotle-Ronzón Y, Herrera-Meza MDS. A novel mayonnaise-type dressing added with avocado pulp and oil as health ingredients processed with ultrasound. CyTA - J Food 2022;20:60–5. https://doi.org/10.1080/19476337.2022.2051606.
[36] Tlay RH, Al-Baidhani AMS, Abouyounes AE. A study of the physical, chemical, and biologically active properties of avocado pulp (Persea americana), and its use in the preparation of some functional dairy products. Basrah J Agri Sci 2024;37:164–82. https://doi.org/10.37077/25200860.2024.37.1.13.
[37] Machado M, Rodríguez-Alcalá LM, Maria Gomes A, Pintado M. Does the nature of added bioactive lipids affect the biological properties of yogurts?—case study coconut and avocado oils. Appl Sci (Switzerland) 2023;13:3101. https://doi.org/10.3390/app13053101.
[38] Lu Q-Y, Zhang Y, Wang Y, Wang D, Lee R-P, Gao K, et al. California hass avocado: profiling of carotenoids, tocopherol, fatty acid, and fat content during maturation and from different growing areas. J Agric Food Chem 2009;57:10408–13. https://doi.org/10.1021/jf901839h.
[39] Plaza L, Sánchez-Moreno C, De Pascual-Teresa S, De Ancos B, Cano MP. Fatty acids, sterols, and antioxidant activity in minimally processed avocados during refrigerated storage. J Agric Food Chem 2009;57:3204–9. https://doi.org/10.1021/jf900541r.
[40] Ozdemir F, Topuz A. Changes in dry matter, oil content and fatty acids composition of avocado during harvesting time and post-harvesting ripening period. Food Chem 2004;86:79–83. https://doi.org/10.1016/j.foodchem.2003.08.012.
[41] Vekiari SA, Papadopoulou PP, Lionakis S, Krystallis A. Variation in the composition of Cretan avocado cultivars during ripening. J Sci Food Agric 2004;84:485–92. https://doi.org/10.1002/jsfa.1595.
[42] Onyedikachi UB, Nkwocha CC, Ejiofor E, Nnanna CC. Investigation of chemical constituents, antioxidant, anti-inflammatory and nutritional properties of oil of Persea americana (Avocado) seeds. Food Chem Adv 2024;5:100770. https://doi.org/10.1016/j.focha.2024.100770.
[43] Gonçalves D, Gouveia CSS, Ferreira MJ, Ganança JFT, Pinto DCG. Pinheiro de Carvalho MAA. Comparative analysis of antioxidant and fatty acid composition in avocado (Persea americana Mill.) fruits: Exploring regional and commercial varieties. Food Chem 2024;442:138403. https://doi.org/10.1016/j.foodchem.2024.138403.
[44] Rozan MAA-G, Boriy EG, Bayomy HM. Chemical composition, bioactive compounds and antioxidant activity of six avocado cultivars Persea americana Mill. (Lauraceae) grown in Egypt. Emir J Food Agric 2021;33:815–26. https://doi.org/10.9755/ejfa.2021.v33.i10.2772.
[45] Nasri C, Halabi Y, Harhar H, Mohammed F, Bellaouchou A, Guenbour A, et al. Chemical characterization of oil from four Avocado varieties cultivated in Morocco. OCL - Oilseeds Fats, Crops, Lipids 2021;28:19. https://doi.org/10.1051/ocl/2021008.
[46] Olmedo P, Núñez-Lillo G, Ponce E, Alvaro JE, Baños J, Carrera E, et al. Metabolite profiling and hormone analysis of the synchronized exocarp-mesocarp development during ripening of cv. 'Fuerte' and 'Hass' avocado fruits. Food Biosci 2024;60:104454. https://doi.org/10.1016/j.fbio.2024.104454.
[47] Lara-Márquez M, Báez-Magaña M, Raymundo-Ramos C, Spagnuolo PA, Macías-Rodríguez L, Salgado-Garciglia R, et al. Lipid-rich extract from Mexican avocado (Persea americana var. drymifolia) induces apoptosis and modulates the inflammatory response in Caco-2 human colon cancer cells. J Funct Foods 2020;64:103658. https://doi.org/10.1016/j.jff.2019.103658.
[48] Alkhalaf MI, Alansari WS, Ibrahim EA, ELhalwagy MEA. Anti-oxidant, anti-inflammatory and anti-cancer activities of avocado (Persea americana) fruit and seed extract. J King Saud Univ Sci 2019;31:1358–62. https://doi.org/10.1016/j.jksus.2018.10.010.
[49] Dreher ML, Davenport AJ. Hass avocado composition and potential health effects. Crit Rev Food Sci Nutr 2013;53:738–50. https://doi.org/10.1080/10408398.2011.556759.
[50] Reeves CJ, Menezes PL, Jen T-C, Lovell MR. The influence of fatty acids on tribological and thermal properties of natural oils as sustainable biolubricants. Tribol Int 2015;90:123–34. https://doi.org/10.1016/j.triboint.2015.04.021.
[51] Pedreschi R, Muñoz P, Robledo P, Becerra C, Defilippi BG, van Eekelen H, et al. Metabolomics analysis of postharvest

ripening heterogeneity of "Hass" avocadoes. Postharvest Biol Technol 2014;92:172–9. https://doi.org/10.1016/j.postharvbio.2014.01.024.
[52] Donetti M, Terry LA. Biochemical markers defining growing area and ripening stage of imported avocado fruit cv. Hass. J Food Compos Anal 2014;34:90–8. https://doi.org/10.1016/j.jfca.2013.11.011.
[53] Dos Santos MAZ, Alicieo TVR, Pereira CMP, Ramis-Ramos G, Mendonça CRB. Profile of bioactive compounds in avocado pulp oil: influence of the drying processes and extraction methods. JAOCS, J Am Oil Chem Soc 2014;91:19–27. https://doi.org/10.1007/s11746-013-2289-x.
[54] Krumreich FD, Borges CD, Mendonça CRB, Jansen-Alves C, Zambiazi RC. Bioactive compounds and quality parameters of avocado oil obtained by different processes. Food Chem 2018;257:376–81. https://doi.org/10.1016/j.foodchem.2018.03.048.
[55] Ramos-Aguilar AL, Ornelas-Paz J, Tapia-Vargas LM, Gardea-Béjar AA, Yahia EM, Ornelas-Paz JDJ, et al. Effect of cultivar on the content of selected phytochemicals in avocado peels. Food Res Int 2021;140:110024. https://doi.org/10.1016/j.foodres.2020.110024.
[56] King-Loeza Y, Ciprián-Macías DA, Cardador-Martínez A, Martín-del-Campo ST, Castañeda-Saucedo MC, Ramírez-Anaya JDP. Functional composition of avocado (Persea americana Mill. Var Hass) pulp, extra virgin oil, and residues is affected by fruit commercial classification. J Agric Food Res 2023;12:100573. https://doi.org/10.1016/j.jafr.2023.100573.
[57] Del Castillo-Llamosas A, Rodríguez-Martínez B, del Río PG, Eibes G, Garrote G, Gullón B. Hydrothermal treatment of avocado peel waste for the simultaneous recovery of oligosaccharides and antioxidant phenolics. Bioresour Technol 2021;342:125981. https://doi.org/10.1016/j.biortech.2021.125981.
[58] Soledad C-PT, Paola H-C, Carlos Enrique O-V, Israel R-LI, GuadalupeVirginia N-M, Raúl Á-S. Avocado seeds (Persea americana cv. Criollo sp.): lipophilic compounds profile and biological activities. Saudi J Biol Sci 2021;28:3384–90. https://doi.org/10.1016/j.sjbs.2021.02.087.
[59] Azhar A, Nanda RF, Syukri D. Effect of avocado (Persea americana Mill.) Seed oil on lip balm characteristics. Asian J Plant Sci 2023;22:651–64. https://doi.org/10.3923/ajps.2023.651.664.
[60] Agomuo E, Amadi P. Nutritional properties of oils from various parts of three varieties of pears consumed in south east Nigeria. Acta Univ Cibiniensis Ser E Food Technol 2018;22:3–12. https://doi.org/10.2478/aucft-2018-0007.
[61] Amado DAV, Detoni AM, De Carvalho SLC, Torquato AS, Martin CA, Tiuman TS, et al. Tocopherol and fatty acids content and proximal composition of four avocado cultivars (persea americana mill). Acta Aliment 2019;48:47–55. https://doi.org/10.1556/066.2019.48.1.6.
[62] Wang M, Yu P, Chittiboyina AG, Chen D, Zhao J, Avula B, et al. Characterization, quantification and quality assessment of avocado (Persea americana Mill.) Oils. Molecules 2020;25:1453. https://doi.org/10.3390/molecules25061453.
[63] Pedreschi R, Hollak S, Harkema H, Otma E, Robledo P, Westra E, et al. Impact of postharvest ripening strategies on "Hass" avocado fatty acid profiles. South Afr J Bot 2016;103:32–5. https://doi.org/10.1016/j.sajb.2015.09.012.
[64] Ramos-Aguilar AL, Ornelas-Paz J, Tapia-Vargas LM, Gardea-Béjar AA, Yahia EM, Ornelas-Paz JDJ, et al. Comparative study on the phytochemical and nutrient composition of ripe fruit of Hass and Hass type avocado cultivars. J Food Compos Anal 2021;97:103796. https://doi.org/10.1016/j.jfca.2020.103796.
[65] de Oliveira ECS, Dalmau LM, de Almeida Costa CAR, de Almeida Junior LD, Ballard CR, Maróstica Junior MR, et al. Dietary intervention with avocado (Persea americana Mill.) ameliorates intestinal inflammation induced by TNBS in rats. Inflammopharmacology 2023;31:485–98. https://doi.org/10.1007/s10787-022-01128-2.
[66] Vilca R, Espinoza-Silva C, Alfaro-Cruz S, Ponce-Ramírez JC, Quispe-Neyra J, Alvarado-Zambrano F, et al. Hass and Fuerte avocado (Persea americana sp.) oils extracted by supercritical carbon dioxide: bioactive compounds, fatty acid content, antioxidant capacity and oxidative stability. J Supercrit Fluids 2022;190:105750. https://doi.org/10.1016/j.supflu.2022.105750.
[67] Giraldo L, Moreno-Piraján JC. Lipase supported on mesoporous materials as a catalyst in the synthesis of biodiesel from Persea americana mill oil. J Mol Catal B Enzym 2012;77:32–8. https://doi.org/10.1016/j.molcatb.2012.01.001.
[68] Tan CX, Tan SS, Tan ST. Influence of geographical origins on the physicochemical properties of hass avocado oil. JAOCS, J Am Oil Chem Soc 2017;94:1431–7. https://doi.org/10.1007/s11746-017-3042-7.
[69] Méndez Hernández C, Ríos Mesa D, Rodríguez-Galdón B, Rodríguez-Rodríguez EM. Study of environmental factors on the fat profile of Hass avocados. J Food Compos Anal 2023;123:105544. https://doi.org/10.1016/j.jfca.2023.105544.
[70] Green HS, Wang SC. Extra virgin grade avocado oil can be achieved using whole fruits or only mesocarp. Appl Food Res 2022;2:100190. https://doi.org/10.1016/j.afres.2022.100190.
[71] Méndez-Zúñiga SM, Corrales-García JE, Gutiérrez-Grijalva EP, García-Mateos R, Pérez-Rubio V, Heredia JB. Fatty acid profile, total carotenoids, and free radical-scavenging from the lipophilic fractions of 12 native mexican avocado accessions. Plant Foods Hum Nutr 2019;74:501–7. https://doi.org/10.1007/s11130-019-00766-2.
[72] Caballero E, Soto C, Olivares A, Altamirano C. Potential use of avocado oil on structured lipids MLM-type production catalysed by commercial immobilised lipases. PLoS One 2014;9:e107749. https://doi.org/10.1371/journal.pone.0107749.
[73] Nurul Ain O, Marina AM, Sakinah H. The effect of avocado puree as fat replacer on the physical quality of muffin. Malays Appl Biol 2016;45:11–6.
[74] Machado M, Sousa S, Morais P, Miranda A, Rodriguez-Alcalá LM, Gomes AM, et al. Novel avocado oil-functionalized yogurt with anti-obesity potential: technological and nutraceutical perspectives. Food Biosci 2022;50:101983. https://doi.org/10.1016/j.fbio.2022.101983.
[75] Shamlan G. Ethanolic and aqueous extracts of avocado (Persea americana) Seeds Attenuates Doxorubicin-Induced cardiotoxicity in male albino rats. Arabian J Sci Eng 2021;46:5265–74. https://doi.org/10.1007/s13369-020-04994-6.
[76] Pacheco LS, Li Y, Rimm EB, Manson JE, Sun Q, Rexrode K, et al. Avocado consumption and risk of cardiovascular disease in US adults. J Am Heart Assoc 2022;11:e024014. https://doi.org/10.1161/JAHA.121.024014.
[77] Silva-Platas C, García N, Fernández-Sada E, Dávila D, Hernández-Brenes C, Rodríguez D, et al. Cardiotoxicity of acetogenins from Persea americana occurs through the mitochondrial permeability transition pore and caspase-dependent apoptosis pathways. J Bioenerg Biomembr 2012;44:461–71. https://doi.org/10.1007/s10863-012-9452-1.
[78] Corzzini SCS, Barros HDFQ, Grimaldi R, Cabral FA. Extraction of edible avocado oil using supercritical CO2 and a CO2/ethanol mixture as solvents. J Food Eng 2017;194:40–5. https://doi.org/10.1016/j.jfoodeng.2016.09.004.
[79] Martínez-Padilla LP, Franke L, Xu X-Q, Juliano P. Improved extraction of avocado oil by application of sono-physical processes. Ultrason Sonochem 2018;40:720–6. https://doi.org/10.1016/j.ultsonch.2017.08.008.
[80] Rueda A, Seiquer I, Olalla M, Giménez R, Lara L, Cabrera-Vique C. Characterization of fatty acid profile of argan oil and other edible vegetable oils by gas chromatography and discriminant analysis. J Chem 2014;2014:843904. https://doi.org/10.1155/2014/843908.
[81] Maldonado A, Riquelme N, Muñoz-Fariña O, García O, Arancibia C. Stability and bioaccessibility of α-tocopherol-enriched nanoemulsions containing different edible oils as carriers. LWT 2023;174:114419. https://doi.org/10.1016/j.lwt.2022.114419.
[82] Berasategi I, Barriuso B, Ansorena D, Astiasarán I. Stability of avocado oil during heating: comparative study to olive oil. Food Chem 2012;132:439–46. https://doi.org/10.1016/j.foodchem.2011.11.018.