

How can we make Chinese Consumers Like Table Olive Consumption: A Data Mining and Some Suggestions to the Researchers

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ABSTRACT: *Why table olive is still not popular with Chinese consumers after its Introduction to China for more than 50 years? As scientific output can reflect the application of their study objects, to showcase the situation of Chinese table olive studies and to find out the possible answers to this question, we performed a statistical analysis based on the Science Citation Index Expanded (SCI-E) database and the China Academic Journals Full-text Database (CJFD). Results show that the research and development of Chinese table olive are mainly focused on the introduction and the cultivation of olives trees (*Olea europaea* L.) as well as the extraction of their high-value pharmaceutical and organic components, but rarely involve specific processing issues. The Chinese papers published domestically mostly report the results of table olive processing studies and the preliminary development of products with Chinese characteristics, but studies on these types of products have not been carried out in a comprehensive and systematic way. We suggest that Chinese table olive researchers consolidate the exchange and study with non-Mediterranean countries such as Denmark, the UK, and the US, while maintaining communication with scientists in Mediterranean countries.*

Key words: Table Olives, Data mining, Scientific Database, Statistical analysis, China

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1. Introduction

China, as a non-Mediterranean country, introduced olives in 1960s. After over 50 years of cultivation and seed selection, Chinese table olives have maintained and developed the merits of the original Mediterranean fruits that are of large size, have a

high pulp content and stable yield, and have a more advantageous overall quality when compared to the simple oil products [1] [2], which lays a foundation for the intensive processing. However, higher stringency is required in the width and depth of relevant studies [3,4,5,6,7]. In order to objectively describe the status quo of domestic studies and absorb and borrow from international research experiences, this article used a literature analysis. We analyzed the research situation in this field using a quantitative analysis of the table olive papers both domestically and abroad, so as to provide support to Chinese investigators and industrial departments during their decision making processes, and also to provide references to scholars of the same profession worldwide in their attempts to understand the status quo of Chinese olive development research.

2. Materials and Methods

“Table olive” and its related products such as canned olives, olive snacks, olive food, and olive meal, etc. were confirmed as the analysis target, the retrieval words and strategies were identified on the basis of look-up and sorting-out of relevant products both domestically and abroad. The SCI-E Database was used to retrieve SCI papers, the China Academic Journals Full-text Database (CJFD) was used to retrieve Chinese papers, and the combined results were sorted and analyzed using relevant tools. The CJFD database is the largest and continuously updated Chinese journal database in the world, which has collected 10 287 China academic journals and the full-text paper amount has reached to more than 60 797 000 up to 2017. The analysis contents included: time trends, regions, research institutions, scientific discipline and journals, and research content. The information analytical tools mainly included Thomson Reuters’ Thomson Data Analyzer (TDA), China National Knowledge Infrastructure’s (CNKI) E-Study; Microsoft Excel was used for result sorting and map plotting. The retrieval time was July 27, 2017, and the retrieval results were 3846 SCI papers and 322 Chinese papers. After the irrelevant and repeated papers were excluded, 2345 effective SCI papers and 145 effective Chinese papers remained. Of the 2345 SCI papers, 2242 were article & proceedings papers and 103 were reviews; they were distributed as follows based on publication language: 2241 were in English, 66 in Spanish, 20 in Italian, nine in French, five in German, two in Turkish, and one each in Portuguese and Japanese.

3. Results and Analyses

3.1. Annual Trend

The annual trend for global SCI papers on table olives is shown in Figure 1. The period from 1949 to 1990 was the initial stage, during which 116 articles were published, and the mean annual publication rate was 2.83, showing a relatively slow increase. The number of SCI papers has increased rapidly during recent years due to the significant increase in retrieved literature from a growing number of SCI-indexed journals; this rapid increase also shows the increasing attention paid by investigators to table olive research, and demonstrates the recognition and emphasis of people from all social circles on the olive and its functions. As shown in Figure 2, Chinese research on table olives dates back to 1971. The changes in the number of papers annually correlates with the four development stages of the Chinese olive industry since the 1970s. Since 2014, there has been a significant increase in SCI papers from China published, but the studies rarely involved specific food processing technologies.

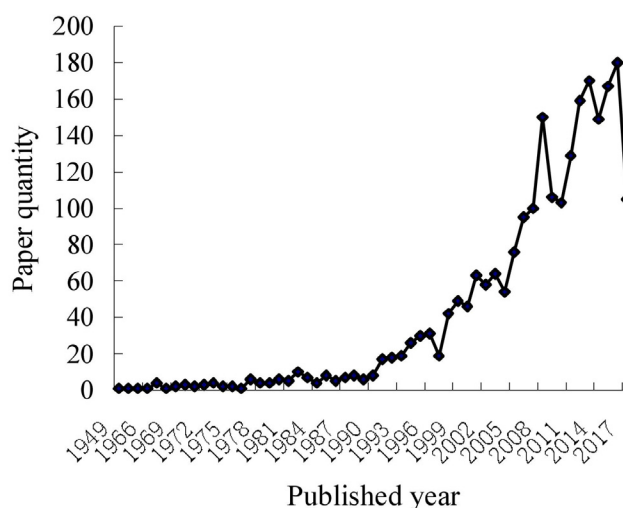


Figure 1. Annual trend of global SCI paper amount on table olives from 1949 to 2017

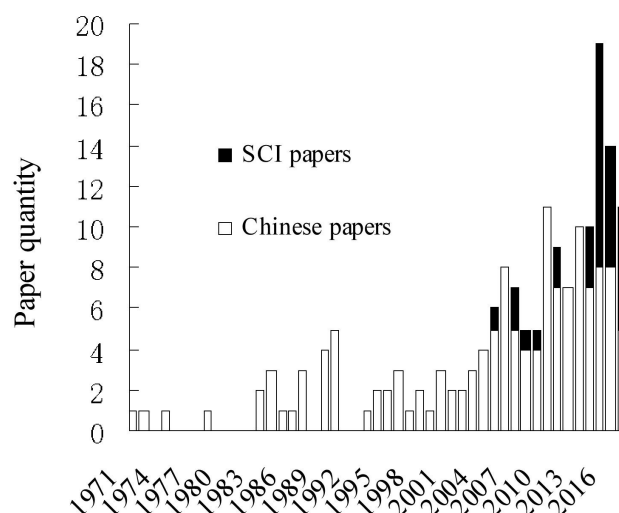


Figure 2. Annual trend of paper amount on table olives from China from 1971 to 2017

3.2. Distribution of countries and regions

Thirty-five countries and regions have separately published >10 SCI papers on table olives, and 14 are EU members. Non-Mediterranean countries including the UK, Germany, Belgium, Denmark, and the Netherlands have separately published >20 articles. In particular, the UK and Germany have published 97 and 52, respectively, showing their leading positions in the EU with respect to scientific research on olives. As shown in Table 1, the top 10 countries (regions) have published 2201 articles in total, accounting for 93.85% of the total SCI papers worldwide. With a larger number of published articles than some Mediterranean countries, the US has become one of the important countries of origin in the world olive market. American investigators have also attempted to surmount the limitations of local monsoon climates in the southeastern regions, such as the state of Georgia, by using the super-high-density techniques. The total citation frequency of papers is shown in Table 2. The top five countries in terms of the total citation frequency of papers were Spain, Italy, Greece, the US, and Portugal, all of which are either Mediterranean countries or a country with a region having a Mediterranean climate (US).

Countries and regions	Amount	Percentage / %	Ranking
Spain	731	31.17	1
Italy	466	19.87	2
Greece	322	13.73	3
U.S.A	182	7.76	4
Turkey	122	5.20	5
France	99	4.22	6
Portugal	92	3.92	7
England	74	3.16	8
Tunisia	60	2.56	9
Austrilia	53	2.26	10

Table 1. The top 10 countries (regions) of paper amount on table olives

Countries and regions	Amount	Total citation	Ranking
Spain	731	12362	1
Italy	466	10458	2
Greece	322	6693	3
U.S.A	182	4432	4
Portugal	92	2316	5
Australia	53	2093	6
England	74	2087	7
France	99	1794	8
Denmark	22	1516	9
Germany	52	1142	10

Table 2. The total citation frequency of papers on table olives in different countries (regions)

Countries and regions	Amount	Per-article citation	Ranking
Denmark	22	68.91	1
Australia	53	39.49	2
Netherlands	21	30.43	3
England	74	28.20	4
Morocco	21	27.90	5
Portugal	92	25.17	6
U.S.A	182	24.35	7
Israel	31	23.52	8
Italy	466	22.44	9
Germany	52	21.96	10

Table 3. The mean citation frequency of papers on table olives in different countries (regions)

The mean citation frequency of papers is shown in Table 3. It is interesting that some Non-Mediterranean countries such as Denmark, the Netherlands, the UK, and Germany have produced papers that have drawn wide attention, which might indicate a relatively high quality in the research topics and achievements, and thus results of these papers are worth incorporating into Chinese studies.

There have been 33 SCI papers published by Chinese scholars on table olives, accounting for 1.41% of the total, ranking China No. 13 worldwide. The total citation frequency and the per-article frequency of SCI papers in Taiwan were relatively high, but the research contents did not involve product processing or relevant mechanisms [8,9,10]. There were 145 Chinese papers describing domestic table olive research. The provincial-level administrative regions that have together published over five articles the top

five ranking provincial-level administrative regions are shown in Table 4. Gansu, Sichuan, and Yunnan are the top three ranked olive growing areas, and industrialization has been achieved there [11]; Beijing had a higher rank due to the concentration of multiple national management and research institutions.

Provincial administrative region	Amount	Ranking	Percentage /%
Gansu	16	1	11.03
Beijing	14	2	9.66
Yunnan	12	3	8.28
Sichuan	10	4	6.90
Shanxi	5	5	3.45
Shaanxi	5	6	3.45

Table 4. Citation situation of Chinese papers in different provincial administrative regions

3.3. Distribution of Research Institutions

The global table olive research institutions are distributed in several centers. The top 20 institutions in terms of paper publication are located in Mediterranean countries or countries with a Mediterranean climate, and their amount of publications accounted for 61.75% of the total; six in Spain, six in Italy, four in the US, two in Greece, and two in Portugal. The top five institutions were the Spanish National Research Council, the Spanish Institute of Oil and Fat, the California State University System, the Agricultural University of Athens (Greece), and the University of Córdoba in Spain. The top five institutions in terms of total citation frequency are shown in Table 5.

Institutions	Countries and Regions	Amount	Total citation Frequency	Ranking
National Research Council	Spain	399	6500	1
Institute of Oil and Fat	Spain	281	4945	2
the Agricultural University of Athens	Greece	76	1435	3
the California State University System	U.S.A	76	1414	4
the University of Córdoba	Spain	59	1305	5

Table 5. The top five institutions in terms of total citation frequency

The top five institutions in terms of per-article citation frequency are shown in Table 6. The top three institutions in terms of total citation frequency and per-article citation frequency have oil and fat technical research capabilities, showing that Mediterranean countries place high emphases on the development of top-quality olive and EVOO products such as anchovy-stuffed olives and canned covering olive oil.

Chinese research institutions were not among the top 100 in terms of the SCI paper amount and the total citation frequency. The top five Chinese research institutions in terms of SCI paper quantity were the Chinese Academy of Forestry, the Sichuan Agricultural University, the China Pharmaceutical University, Lanzhou University, and the Chinese Academy of Sciences. There were a total of 29 Chinese research institutions which accumulatively published over two research papers in Chinese. The top 10 in terms of papers in Chinese are shown in Table 7. The quantity of the articles published by the ten institutions accounted for 36.6% of the total of all Domestic Chinese articles; these articles together constitute the core study group in terms of domestic table olive research.

Institutions	Countries and Regions	Amount	Per-article citation	Ranking
Italian Grease Technology Laboratory	Italy	32	44.19	1
University of Perugia	Italy	31	39.55	2
National Research Council	Italy	31	31.77	3
The Polytechnic Institute of Bragança	Portugal	31	30.97	4
University of Porto	Portugal	34	27.82	5

Table 6. The top five institutions in terms of per-article citation frequency

Institutions	Paper quantity	Percentage /%	Ranking
Gansu Research Academy of Forestry S&T	9	6.21	1
Yunnan Academy of Forestry	7	4.83	2
Guansu Agricultural University	6	4.14	3
High-Tech Institute of the CAF	5	3.45	4
Institute of Chemical Industry of Forest Products of the CAF	5	3.45	5
Sichuan Agricultural University	5	3.45	6
Northwest Agriculture and Forestry University	4	2.76	7
China Agricultural University	4	2.76	8
the Research Institute of Forestry of the CAF	4	2.76	9
Central South University of Forestry and Tech	4	2.76	10

Table 7. The top 10 institutions in terms of paper quantity on table olives in Chinese

Ranking	Journals	Paper quantity	Percentage /%	Impact Factor, 2016	Jcr
1	Journal of Agricultural and Food Chemistry	126	5.37	3.154	Q1
2	Grasas Y Aceites	116	4.95	0.91	Q4
3	Food Chemistry	88	3.75	4.529	Q2
4	European Journal of Lipid Science and Tech	65	2.77	2.145	Q3
5	Food Microbiology	59	2.52	3.759	Q2

Table 8. The top 5 journals in terms of the quantity of published articles on table olives

3.4. Discipline and Journal Discipline

There were 20 journals in which over 20 papers were published in total. These journals, except for the Journal of Economic Entomology and Scientia Horticulturae (in the fields of entomology and horticulture), fell into the fields of food science and

nutrition, and have a mean factor of impact of 2.57; the American Journal of Clinical Nutrition had the highest impact factor, which was 6.926. Two types were in quarter 1 (Q1) of JCR, and seven types were in JCR Q2, reflecting the fact that international table olive research is generally focused on product processing and nutrition studies, as well as the close integration between research projects and product R&D. The top five journals in terms of the quantity of published articles are shown in Table 8, and the top five journals in terms of impact factor are also shown in Table 9.

Ranking	Journals	Paper quantity	Percentage /%	Impact Factor, 2016	Jcr
1	American Journal of Clinical Nutrition	22	0.94	6.926	Q1
2	Food Chemistry	88	3.75	4.529	Q2
3	Food Microbiology	59	2.52	3.759	Q2
4	British Journal of Nutrition	28	1.19	3.706	Q2
5	International Journal of Food Microbiology	40	1.71	3.339	Q2

Table 9. The top 5 journals in terms of impact factor

There were 23 Chinese journals in which >2 articles were published; the total was 82, which accounted for 56.57% of the total number of papers (145). Among them, 11 were core Chinese journals. As far as the journal discipline is concerned, 60 were published in agriculture and forestry journals, accounting for 73.2%, and 20 were published in food science and technology journals, accounting for 24.4%. This finding might show that Chinese research is still at the stage of development where it is transitioning from fundamental agriculture and forestry research to research on industrial development of product intensive processing. The top 10 Chinese journals are shown in Table 10.

Ranking	Journals	Paper quantity	Percentage/%
1	Nonwood Forest Research *	16	11.03
2	Forest Research *	9	6.21
3	Food Science *	6	4.14
4	Science and Technology of Food Industry *	5	3.45
5	Forest Inventory and Planning	4	2.76
6	Journal of West China Forestry Science	4	2.76
7	Cereals and Oils Processing	3	2.07
8	China Forest Products Industry *	3	2.07
9	Journal of Northwest A & F University(Natural Science Edition) *	3	2.07
10	Forestry of Gansu	3	2.07

Note: *. is Chinese “Core Journal” (2015 Edition)

Table 10. The top 10 Chinese journals in terms of the quantity of published articles on table olives

3.5. Research Content Analyses

After the analysis of the themes and contents of table olive SCI papers, the food processing-related research contents were divided into the following three major categories: (1) Cultivation and Harvesting, (2) Production and Processing, and (3)

Consumers and Markets, involving the following sub-categories: Breeding, Cultivation, Harvesting, Debittering, Sterilization Packing, Business Process Management (BPM), Product Quality, Environmental Protection, Consumers, and Markets, in which about 120 themes were studied. Spain, Italy, and Greece, as three typical Mediterranean countries, have long histories in olive cultivation and processing and they represent three typical kinds of traditional table olive preparation processes, namely Spanish Style Green, Natural Black, and Ripe Olives. Global table olive processing technology and modifications are generally made on the basis of the aforementioned three traditional processes, with the products involving the fields of Leisure Food & Snacks, Canned Food, Paste & Salad, and New Probiotic Foods, but sweet olives and olive wine, which are well received by Chinese consumers, are rarely reported [12,13,14,15]. Research projects on table olives worldwide from 1949 to 1990 mainly focused on the evaluation of the climate, soil, and fruit traits in different growing area as well as the promotion and inheritance of the three traditional table olive processing methods used in Europe. Technical innovation mainly covered variety identification, isoenzyme electrophoresis, cultivation and planting, regulated deficit irrigation, qualitative evaluation of table olive product quality, and chemical treatment of waste water from manufacturing plants. After 1991, the focus of the studies gradually shifted to yield improvement, high-density planting, mechanized harvesting, microelement addition, traditional process modification, molecular markers, DNA sequencing, qualitative analysis of product quality, BPM, and consumer perception. Since 2007, research has been concentrated on the development and breakthroughs in the traditional production and research fields, such as super-high-density planting and the corresponding management, indigenous flora cultivation, ultrasound-assisted debittering, the high static pressure sterilization technique, non-thermally treated packaging, low-alkaline and low-salt processing, liquid chromatography, and automation of production procedures; measures such as food safety systems, information systems, and business procedures have begun to be applied to the production and management of table olives.

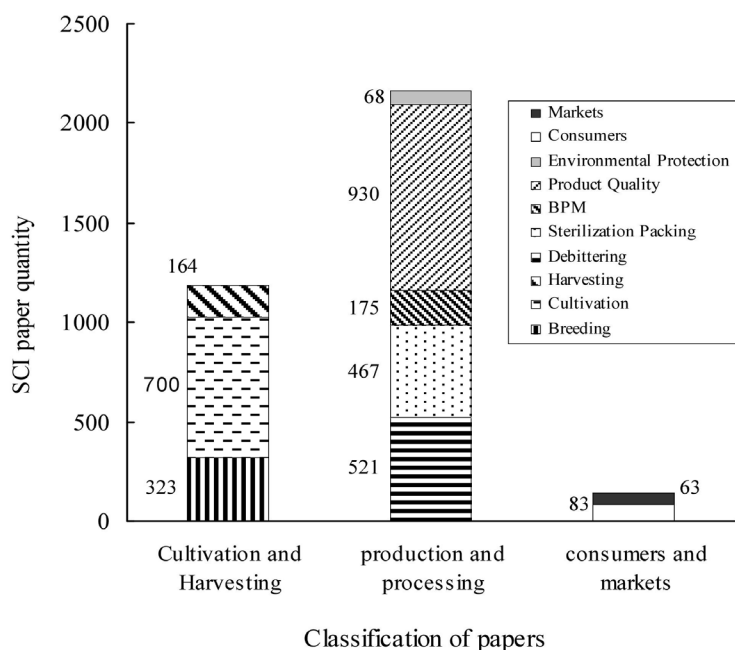


Figure 3. Global SCI paper quantity and classification on table olives from 1949 to 2017

As shown in Figure 3, the largest number of research papers deal with table olive production and processing, followed by planting and harvesting, and the number of consumer market-related research papers is relatively small. A total of 2161 papers are related to production flow studies: 930 investigated product quality and relevant subjects, explored the evaluation of product nutritional value, bioavailability, oxidation resistance evaluation, device analysis, foodborne pathogen control, pesticide residue control, and adulteration identification, and involved a new subject - the anti-*Helicobacter pylori* effects of table olives and oleuropein [16,17,18]. Another 521 papers investigated the debittering process, which, in addition to the traditional alkaline liquor debittering, has recently involved natural debittering, ultrasound-assisted debittering, debittering by microbes, indigenous flora cultivation, biological membrane formation mechanisms, and other new processes [19,20,21,22,23,24], indicating the emphasis of investigators on the optimization and innovation in the debittering process. There were 467 papers describing studies on disinfection/packaging/storage, and high static pressure disinfection and acrylamide formation mechanisms have been new research subjects in recent years [25,26,27]; 175 papers explored problems related to the application of

information technology such as BPM, and food safety systems and their application has been a new subject in the field of BPM [28, 29]; 68 papers focused on environmental protection and environmental evaluation, and investigated the waste water treatment process, and several recent papers have reported studies on the sustainability of olive production and processing by means of methods such as life cycle assessment (LCA) [30]. A total of 1187 papers involved research on planting and harvesting. Among these, 700 reported studies on olive cultivation, showing that olive planting still remains the focus of investigators and is the foundation of relevant industrial development. With the constant expansion in cultivation area, cultivation technology under different site conditions has become a study focus, and high density and super-high density planting has gradually developed into a high profile field in studies of table olives and olives for oil extraction due to the significant yield improvements and other benefits, although they frequently have a negative impact on the environment [31, 32, 33, 34]. In total, 164 papers reported studies on harvesting, and recent high-profile topics include mechanized harvesting technology and efficiency, and damage identification and reduction, especially the application of UAV photography technology in harvesting and the management of olive plantations [35, 36, 37, 38, 39]. Another 146 papers involved consumer and market studies, covering the topics of market investigation, consumer perception, and brand protection.

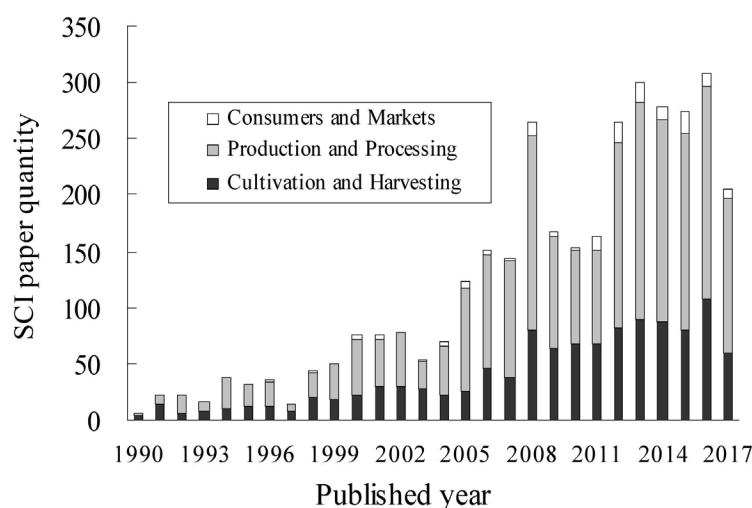


Figure 4. Annual trend of Global SCI paper quantity on table olives in the three major categories from 1990 to 2017

As shown in Fig. 4, the period from 1990 has witnessed a significant increase in the number of papers related to production and processing, which are playing an increasingly important role in table olive studies. Also, papers from this time period dealing with planting and harvesting maintained a steady growth in numbers, but the proportion is showing an obvious decline. Since 2008, papers involving consumer and market studies have maintained robust growth in terms of the number of papers published every year. The above characteristics show that the global table olive industry has generally evolved from planting to intensive processing of produce [40]. In addition, social and economic studies of consumer experience at the microcosmic level and brand protection have been also been reported.

The table olive SCI papers from China, with the exception of two articles which introduced an overview of EVOO microcapsule technology, did not involve specific processing studies, and their contents mainly involved the following four aspects: (1) introduction and cultivation, (2) pharmaceutical value, (3) component analysis, and (4) social events. There were a relatively large number of papers published in Chinese journals that involved studies on table olive processing, and the content analysis showed that the study themes could be summarized into six categories: (1) macroscopic market and policies, (2) fermented olive fruits, (3) introduction and cultivation, (4) international exchange, (5) olive wine, and (6) harvesting. The accumulative numbers of papers involving these six themes were 54, 27, 25, 22, 11 and 5 respectively, accounting for 37%, 19%, 17%, 15%, 8% and 4%, of the total number of Chinese papers. When compared to the mainstream research worldwide, Chinese studies stressed, in particular, investigation and guidance in the problems of macroscopic market and policy, introduction and cultivation, and also international observation and exchange. Major achievements have been made in terms of normal region selection, regional planning for planting, variety selection, florescence observation, and variety matching, but more efforts are needed in studies on product harvesting and the preparation of fermented olive fruits. China is one of the countries reporting the process for preparation of olive wine, and Chinese scholars have gained some experience in studies of products with Chinese characteristics,

such as olive wine brewing and candied olive preparation [41]. Table olive studies in China published during the last five years have mainly focused on the following four aspects: (1) introduction and cultivation, (2) dynamic monitoring of nutritional components during processing, (3) analysis of pomace components, and (4) quality improvement in olive wine. The studies on table olive food processing mainly involve zymotechnique optimization, packaging bottle screening, pasteurization, ultraviolet ray sterilization, nutritional component determination, and aroma component determination [42,43]. However, additional important studies will be carried out on the products with Chinese characteristics such as olive wine, canned sweet water, candied products, and sour and sweat fermented olive fruits.

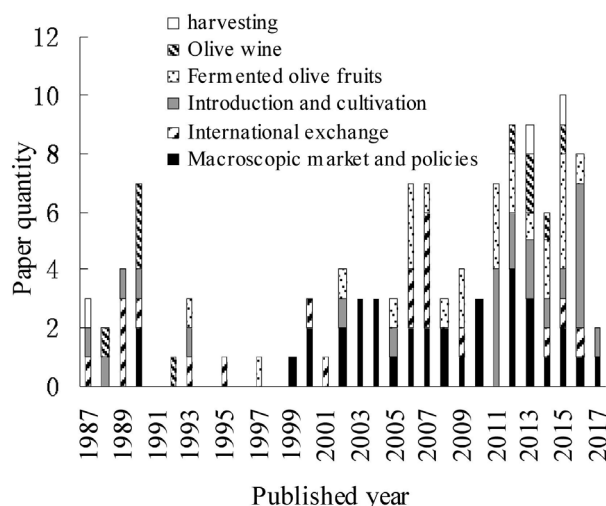


Figure 5. Annual trend of Chinese paper quantity on table olives in the six major categories from 1987 to 2017

As shown in Figure 5, there has been a growing number of Chinese papers on research into fermented olive fruits, but the fluctuation has been relatively obvious, and the annual trend did not show a steady growth trend. From 1988 to 2012, only five papers involved harvesting and management, which showed the lack of sufficient domestic attention to studies on the production chain. From 2012 to the present, the numbers of papers on macroscopic markets and policies has shown a declining trend; papers on the introduction and cultivation, in spite of fluctuation, remain the main force in this field, which is consistent with the policy support and the developing trend of expanded planting areas and increased seed input in the main growing areas. Currently, no study has focused on consumer decision-making and marketing, which is somewhat associated with the scale of production and processing enterprises and the regional limitations, and is an indication that production chain and value chain studies are insufficient on the whole during the upgrade of the domestic table olive industry from traditional planting to modern intensive processing of farm products.

4. Conclusion and Discussion

Analyses show that international SCI papers on table olive studies date back to 1949; the number of papers started to increase rapidly from 1991, and this growth appears to be particularly significant during recent years. Mediterranean countries, the EU, and the USA are the three major forces in table olive research. In terms of the total quantity of SCI papers and the research institution distribution, the Mediterranean countries stand out; four research institutions from Spain, Greece, and Italy ranked in the top four in terms of the quantity of publications and the total citation frequency, and the Spanish National Research Council ranked No.1 in terms of the quantity of publications and the total citation frequency. As far as the per-article citation frequency is concerned, non-Mediterranean countries including the UK, Denmark, and the Netherlands play important roles in table olive research, which somewhat indicates the relatively high quality of the research topics and achievements, and their papers are worth emulating for Chinese researchers. The US, as a rising star in the olive industry which ranks at the top in terms of the quantity of publications and the total citation frequency, is faced with a similar bottleneck to China during the promotion of olive planting and industrial expansion due to its monsoon climate, so it is worthwhile for Chinese scholars to communicate with their American peers and learn from their research experiences. When the discipline, journal, and research contents are taken into consideration, international table olive studies have paid more attention to the field of product processing than to introduction and cultivation, indicating that the international table olive industry has evolved from the traditional planting to a

modern industry that integrates traditional planting with intensive processing.

Our analyses show that SCI papers on table olive from China date back to 2005, while Chinese papers can date back to 1971. Although Chinese researchers and managers barely formed their core research group, and made some achieves in the fields of breeding, cultivating, and macroscopic political and marketing decisions, they did not carry out effective products and markets research about table olive. The products processing, production chains, and the accompanied markets and consumers studies were lack. The foreign table olive products are mostly slightly salty pickles with a soft mouth-feel, which does not completely satisfy the demands of Chinese consumers. So, it is clear that although more and more Chinese consumers have accepted Western-style food, they are not familiar with table olive products, and do not know how to choose the products suitable for them. Taking into account China's huge and diverse consumption market, the lasting potential in economic growth, and the huge potential in social development, olive investigators should carry out Chinese consumer and market studies at the microcosmic level and take the initiative to innovate the products by cooperating with each other worldwide. This will help them work together to tap the potential of Chinese consumers for table olives, and might ensure them have the ability to make the prediction, that China shall be the last big market for olive, become reality.

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