

How Can We Make Chinese Consumers like Table Olive: A Review 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 applications 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 statistical analyses based on the Science Citation Index Expanded (SCI-E) database and the China Academic Journals Full-text Database (CJFD). Results show that the R & D of China's table olive sector are mainly focused on the introduction and 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. However, the Chinese papers mostly report the results of table olive processing as well as the industrialization and the products with Chinese characteristics though the studies on these types of products have not been carried out in a comprehensive and systematic way. Chinese table olive researchers should consolidate the exchange and study with the non-Mediterranean countries, whose scientific output on table olives are worth of reference, such as Denmark, the UK, and the US, while maintaining communications with the scientists in Mediterranean countries.

Keywords: *table olive, production, processing, Mediterranean countries, China, bibliometric analysis, comparative study*

Cite This Article: ChunJiang Su, Junfeng Sun, and Wanze Zhu, "How Can We Make Chinese Consumers like Table Olive: A Review and Some Suggestions to the Researchers." *Journal of Food and Nutrition Research*, vol. 6, no. 4 (2018): 216-226. doi: 10.12691/jfnr-6-4-3.

1. Introduction

China, as a non-Mediterranean country with non-Mediterranean climate, introduced olive trees from the Mediterranean country of Albania in the 1960s, which has been regarded as an achievement in the World history of the introduction of agricultural crop resources. However, China's olive oil does not have a competitive edge when compared to the products from the Mediterranean countries, due to the limitations in climate and soil and the early stage of its development [1]. Chinese researchers involving in the studies of olive oil and table olives suggested that there are two major strategies to increase the competitiveness of China's high grade edible oil industries: one is to develop high-end woody edible oil plants, such as camellia seed oil as alternatives to olive oil [2]; the second is to develop products and services of table olives and olive leaves such as candied olives and health products derived from olive leaves [3,4,5,6,7]. Table olives are canned or fermented products or pomace brandy prepared from olive fruits or extra virgin olive oil (EVOO) or organic pomace.

In the past few decades, table olives and olive oil shared almost the same reputation in the world food

market and the olive-growing areas have been expanding to some Eastern Asian countries such as China and Japan. After over 50 years of cultivation and selection, the varieties of table olives in China had been proved to have good performances such as the large size of their fruits, and the relatively higher pulp content. Thus table olive has been regarded as a potential opportunity when the quality and production of the oil are not taken into account. In order to highlight the status and trends of the table olive related scientific output in China and absorb from international research achievements, we analyzed the research situation based on the analyses of the scholar articles and reviews both in China and in other countries throughout the World, which might to provide references to scholars when they show their interests on the understanding of the Chinese olive development research.

2. Materials and Method

The retrieval time of the Chinese papers and the SCI papers was both in July 27, 2017. The Science Citation Index Expanded (SCI-E) database was used to retrieve global scientific articles and reviews, the China Academic Journals Full-text Database (CJFD) was used to retrieve Chinese scientific and technological articles. The analysis

contents included: time trends, country and region, research institutions, scientific disciplines and journals, and the content. *Table olive* and its related productions, such as *canned olives*, *olive snacks*, *olive food*, and *olive meal*, were included in the retrieving. Thus the SCI article retrieval strategy was identified as: TS = (“*Olea europaea*” or “olive tree” or “table olives” or “table olive” or “olive orchard” or “virgin olive”) and TS = (fruit or meal or paste or canned or snacks or dinner or vegetable or food or buffet or salad), database= SCI - E, and time span = 1900~2017. While the Chinese studies on table olives include products such as olive wine, canned olives, and candied olives, the retrieval strategy was identified as: ((full text = “table olive” or full text = “olive wine”) or full text = “canned olives” or full text = “candied olives”) or (abstract = “table olive”) or abstract = “table olives”), matching mode = accurate, special navigation = Journal; No limit to the year of publication and time of update. The retrieval results were 3846 SCI papers and 322 Chinese papers. Among the 3846 SCI papers, 726 papers are duplicates or not including table olive, almost 400 are not about table olives but other productions related to them. And there nearly half of the Chinese papers who are repeated reports. After the irrelevant and repeated papers were excluded, 2345 effective SCI papers and 145 effective Chinese papers remained. Among the 2345 SCI papers, 2242 were article & proceedings and 103 were reviews and 2241 were in English, only 66 in Spanish, 20 in Italian indicating that many non-native speakers of English also use English as their writing language.

3. Results and Analyses

3.1. Annual Trend

The annual trend of global SCI papers on table olives is shown in Figure 1. The period from 1949 to 1990 was the initial stage. The period from 1991 to 2006 was the rapid development stage. In 2007, the number of papers exceeded 100. There were 180 papers published in 2016, which was an increase of 80% when compared to 2007, and there were 105 papers published in 2017 up to the date of July 27. The increase of the number of SCI articles and reviews might show the increasing attentions paid by investigators to table olive researches.

As shown in Figure 2, Researches on table olives in China can date back to the 1970s. The annual trend of the paper number could be divided into four stages since the year of 1971. There were 4 articles published during 1971 to 1980, 19 papers published from 1981 to 1990, 16 were published from 1991 to 2000. In the period from 2011 to the present, 131 papers were published and the SCI papers began to be published, which showed the rapid development. Since 2014, the number of SCI papers from China has been a significant increase. However, they rarely discussed food technologies. With the founding of China’s Olive Industry Innovation Strategic Alliance (COISA) in 2016, the cooperation between the COIIS and the International Olive Council (IOC) is expected, which might make the number of Chinese SCI papers increase.

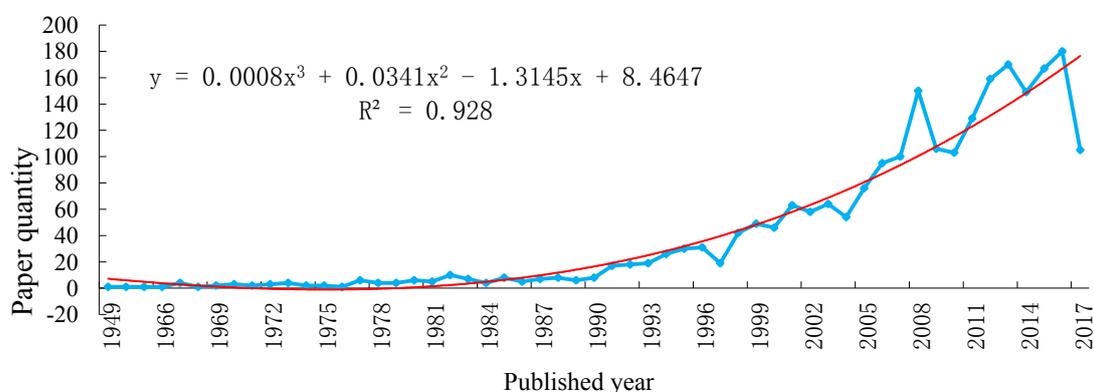


Figure 1. Annual trend of global SCI paper quantity on table olives from 1949 to 2017

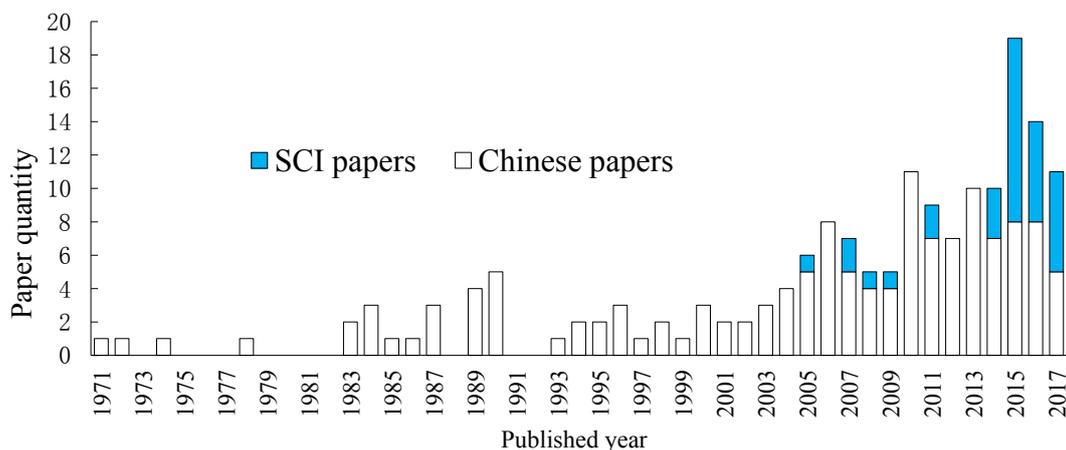


Figure 2. Annual trend of paper quantity on table olives from China from 1971 to 2017

3.2. Distributions

As shown in Figure 3, there are 35 countries or regions, 14 of them are EU Members, separately published more than 10 SCI papers. Non-Mediterranean countries such as the UK, Germany, Belgium, Denmark, and the Netherlands separately published more than 20 articles. The UK and Germany played the leading roles in the EU through the number of their articles. The countries (regions) ranked 1 to 10 published more than 2000 articles, accounting for nearly 94% of the total. Spain, Italy, and Greece are the top 3 countries, which published nearly 65% of the total. Spain was the earliest country

engaged in the production and export of table olives, which had published individually 93% of the sum of the amount of Italy and Greece. The US and Turkey published about 180 and 120 papers, respectively. The United States is one of the earliest countries to develop table olive sector for the poor quality of olive oil in the areas of West Coast, such as California, and has become one of the most important countries outside of the Mediterranean regions in the world table 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.

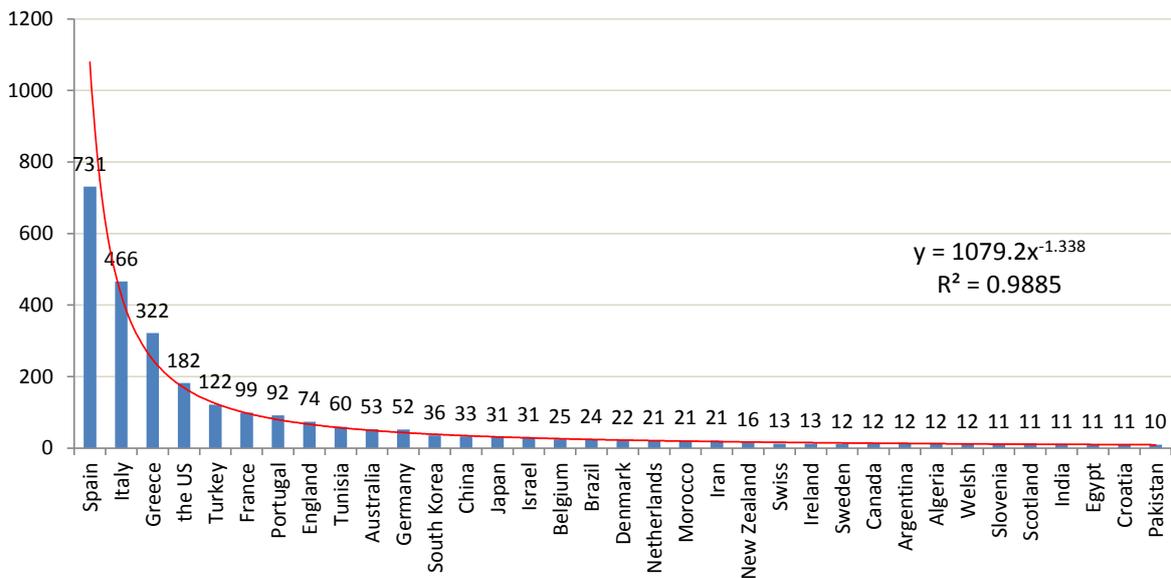


Figure 3. Global SCI papers distribution in the top 33 countries and regions

Table 1. The total citation frequency of papers on table olives in different countries

No.	Countries	Paper number	Total citation	Ranking	Per-article citation	Ranking
1	SPAIN	731	12362	1	16.91	14
2	ITALY	466	10458	2	22.44	9
3	GREECE	322	6693	3	20.79	11
4	USA	182	4432	4	24.35	7
5	PORTUGAL	92	2316	5	25.17	6
6	AUSTRALIA	53	2093	6	39.49	2
7	ENGLAND	74	2087	7	28.20	4
8	FRANCE	99	1794	8	18.12	12
9	DENMARK	22	1516	9	68.91	1
10	GERMANY	52	1142	10	21.96	10
11	TURKEY	122	981	11	8.04	19
12	TUNISIA	60	756	12	12.60	15
13	ISRAEL	31	729	13	23.52	8
14	NETHERLANDS	21	639	14	30.43	3
15	MOROCCO	21	586	15	27.90	5
16	JAPAN	31	528	16	17.03	13
17	SOUTHKOREA	36	312	17	8.67	18
18	BELGIUM	25	304	18	12.16	16
19	PEOPLESRCHINA	33	242	19	7.33	20
20	IRAN	21	197	20	9.38	17
21	BRAZIL	24	96	21	4.00	21

The total citation frequencies as well as the mean citation frequencies of the papers were shown in Table 1. The top five countries in terms of the total citation frequencies are either Mediterranean countries or belong to Mediterranean climate areas. Mediterranean countries published a lot of table olive papers, with high citation frequencies and high influences, which might show that the Mediterranean countries are still the most important ones for table olives. Non-Mediterranean countries including 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 these papers are worth to references in China. Chinese scholars published 33 SCI papers on table olives. The total citation frequency of Chinese SCI papers was 242 times, exceeding that of Iranian and Brazilian papers, but the mean citation frequency per article was 7.33 times, which is relatively low. The top five regions in China in terms of SCI papers were Jiangsu, Sichuan, Taiwan, Gansu, and Beijing. 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 processes [8,9,10]. There were 145 Chinese papers in total, and the top five regions were Beijing, Gansu, Yunnan, Sichuan, and Shanxi province, and this distribution is undoubtedly because of their different industrializations. Gansu, Sichuan, and Yunnan province are the top three ranked olive growing areas, and the industrialization has been achieved there [11]; Beijing is the concentration of multiple national management and research institutions.

The top 20 institutions in terms of per-article citation frequency and total citation frequency were shown in Table 2. The top 20 institutions in terms of paper

publication are located in Mediterranean countries or countries with a Mediterranean climate, and their quantity of publications accounted for nearly 62% of the total. 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 quantity 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 were the Gansu Research Academy of Forestry Science and Technology, the Yunnan Academy of Forestry, Guansu Agricultural University, the High-Technology Institute of the Chinese Academy of Forestry, the Institute of Chemical Industry of Forest Products of the Chinese Academy of Forestry, Sichuan Agricultural University, the Northwest Agriculture and Forestry University, China Agricultural University, the Research Institute of Forestry of the China Academy of Forestry, and the Central South University of Forestry and Technology, which had separately published over four articles; 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.

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

NO.	Institutions	Countries	Number	Total citation	Ranking	Per-article citation	Ranking
1	National Research Council	Spain	399	6500	1	16.29	14
2	Institute of Oil and Fat	Spain	281	4945	2	17.60	11
3	the California State University System	U.S.A	76	1265	6	16.64	12
4	the Agricultural University of Athens	Greece	76	1435	3	18.88	7
5	Univ Cordoba	Spain	59	1305	5	22.12	6
6	Univ Thessaloniki	Greece	51	951	10	18.65	8
7	Univ Bari	Italy	48	612	14	12.75	17
8	Univ Foggia	Italy	44	431	18	9.80	19
9	Univ California Davis	U.S.A	40	652	13	16.30	13
10	Univ Jaen	Spain	40	608	15	15.20	15
11	Univ Granada	Spain	37	660	12	17.84	9
12	USDA	U.S.A	37	395	19	10.68	18
13	Univ Sevilla	Spain	35	290	20	8.29	20
14	Univ Porto	Portugal	34	946	11	27.82	5
15	Univ Pisa	Italy	33	476	17	14.42	16
16	Univ California Berkeley	U.S.A	33	588	16	17.82	10
17	Italian Grease Technology Laboratory	Italy	32	1414	4	44.19	1
18	Univ Perugia	Italy	31	1226	7	39.55	2
19	The Polytechnic Institute of Bragança	Portugal	31	960	9	30.97	4
20	National Research Council	Italy	31	985	8	31.77	3

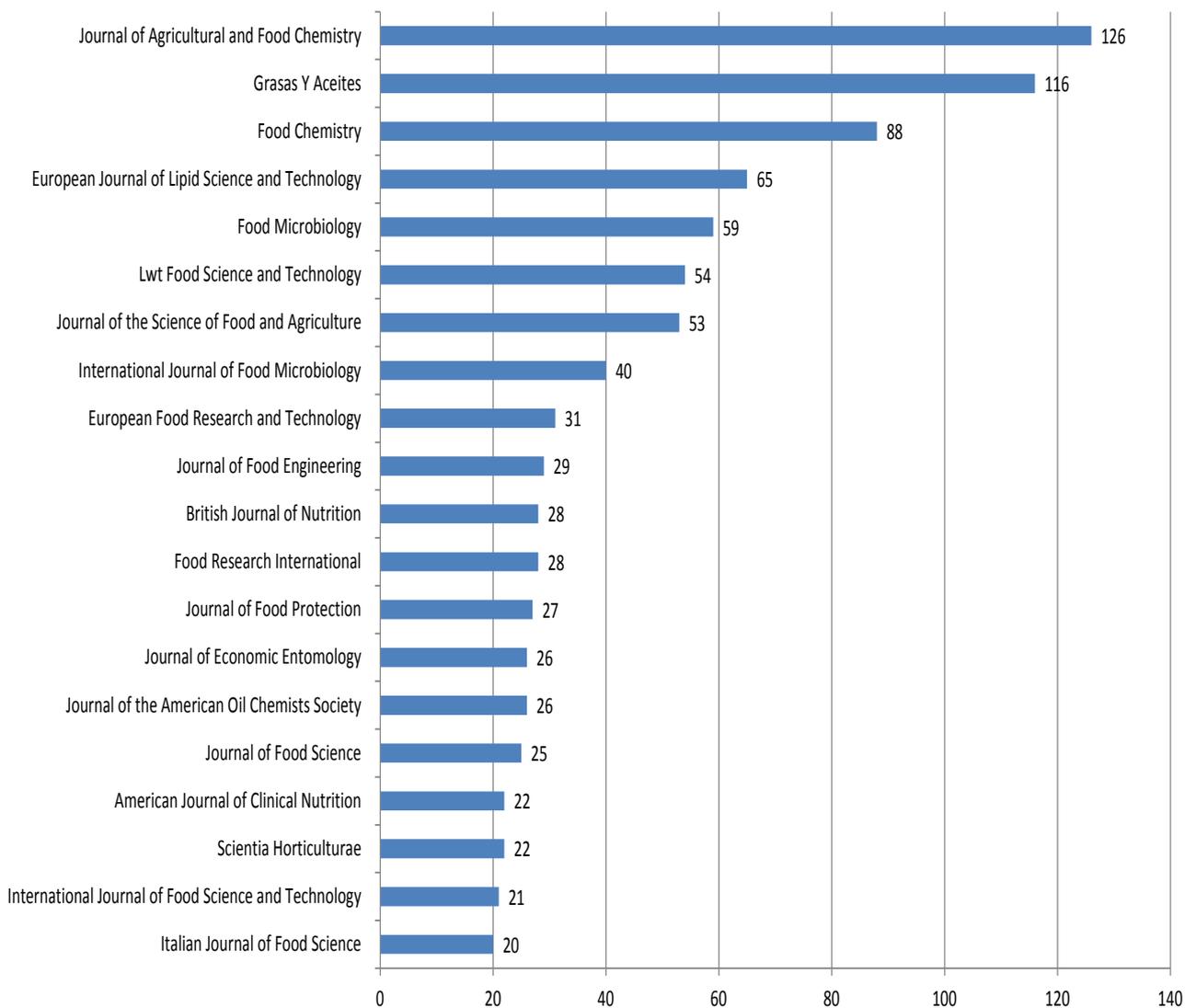


Figure 4. The top 20 journals in terms of the number of published articles

The international SCI research papers on table olives were mainly published in journals of agriculture and food, biochemistry, microbiology, biotechnology, nutrition, environmental science, and plant science et al. There were 20 journals in terms of their paper number of the table olive research. 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 of 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. The SCI papers concerned with table olives studies in China were mainly published in botany, gene science, molecular biology and biochemistry, food and nutrition science, agriculture and forestry science and technology, and pharmacology journals. The Chinese journals in which domestic table olive papers were published are mainly in the fields of forestry science and technology, forest product industry, food science and technology, cooking oil processing, and chemical

engineering. 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). Of these, the following journals published >4 articles: *Economic Forest Researches*, *Journal of Forestry Research*, *Food Science*, *Science and Technology of Food Industry*, *Journal of West China Forestry Science*, and *Central South Forest Inventory and Planning*, which are the top six in the ranking, and in which the total quantity of published papers accounted for 30.35% of the total. Of the aforementioned 23 journals, 11 were core Chinese journals, which published 52 papers, accounting for 65% of the total number of table olive research papers published in core journals from 1971 to 2017. 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%. These findings 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 20 journals in terms of the number of published articles are shown in [Figure 4](#).

Table 3. The categories and the related key words of the papers content

Classes	Types	Categories and key words
Cultivate and Havresting	Breeding	Varieties and Breeding
		Cross-breeding breeding
		New table olive genotypes
		DNA maker
		Molecular Markers
	Cultivation	Prune
		Irrigation
		Effect of fertigation
		Water stress
		Yield
		Fruit size and quality
		Zn, Fe and B applications
		pest
		Olive fruit fly and olive fly
	Harvesting	Mechanically harvested
		Trunk shaker harvesting
		Mechanical Harvesting in Superhigh-density Hedgerows
		Fruit loosening agents
		Abscission control
		Non-destructive determination of impact bruising
		Vis-NIR spectroscopy
Production process	Debittering	Debitter naturally
		Traditional process
		Microbiologically debittered
		Riping
		Oleuropein hydrolysis
		Ultrasound-assisted debittering (UAD)
		Lye and alkaline treatment
		Anaerobic processing
		Brining and Fermentation
		Brines Control
		Reduced salt
		Stability of color
		Pigments and colour changes
		Color fixation
		Natural fermented
		Bacterial population PCR-DGGE
		DNA maker
		Molecular Markers
		Yeast strains
		Lactic acid bacteria and Lactobacillus
		Yeast cocktail
		Fermentation at low temperature
		Potential probiotic
		Bacteriophages
		Biofilm formation
		Indigenous Microflora
		Enzyme Microorganism
		Without fermentation
		Herbal extracts
		Monosodium glutamate
Temperature and salt		
Cracked Table Olives		
Zn fortified table olive product		
ZnCl ₂		

	Sterilization Packing	Drying methods
		Oven-dried
		Preservation
		Pasteurized
		Natural antimicrobials
		Non-thermally treated packaging
		Storage
		Temperature
		Browning
		Preservative
		High hydrostatic pressure treatments (HHP)
		Reducing acrylamide
		Shelf-life
		Business process control
	Magnetic resonance imaging (MRI)	
	Monitor (non-invasively)	
	Information and Communication Technologies	
	Production chain	
	Value chain	
	Sector	
	Economic margins	
	Food safety systems	
	Product quality and its correlation	Polyphenolic compounds
		Nutritional composition
		Nutritional value
		Sugar composition
		Fatty Acid
		Proteins and amino acids
		Mineral nutrient
		vitamin
		Dietary fibre
		Bioaccessibility
		Antioxidant
		Antioxidant effect
		Antioxidant capacity
		Antioxidant compounds
		Volatile profiles and aroma
		Sensory analysis
		Anti Helicobacter Pylori
		Sensory evaluation
		Characteristic sensory
Instrumental analysis		
Electronic tongue		
Electronic nose		
Preservative		
Pathogen		
Foodborne pathogenic bacteria		
Pesticide in food		
Pesticide residues		
Color adulteration identification		
Liquid chromatography analysis		
Heavy Metals		

	Environmental protection	Treatments for wastewaters
		Biological treatments for wastewaters
		Membrane distillation technology
		Direct contact membrane distillation process (DCMD)
		Adsorption Resin Technology
		Centrifugal Partition Chromatography
		Oxidation process
		Wet air oxidation
		Ozone and advanced oxidation
		Environmental impact
		Life cycle assessment (LCA)
Consumers and markets	Consumers	Socioeconomic and demographic characteristics
		Consumer perception
		Fermented vegetable
	Markets	Geographical indications
		Protected Designation of Origin (PDO)
		Traceability
		Market and legal

3.3. Content

We found out that the table olive related research contents can be divided into 3 major categories of Cultivation & Harvesting, Production & Processing, and Consumers & Markets, and 14 sub-categories as Breeding, Cultivation, Harvesting, Debittering, Sterilization Packing, Business Process Management (BPM), Product Quality, Environmental Protection, Consumers, and Markets. However, Sweet olives and olive wine, which are well received by Chinese consumers, are rarely reported [12,13,14,15]. There are 2161 papers related to the production & processing studies. Among them, 930 investigated product quality and relevant subjects [16,17,18]; 521 papers investigated the debittering processes [19-24]. 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 technologies [28,29]; 68 papers focused on environmental protection and environmental evaluation, 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. 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]. 146 papers involved consumer and market studies, covering the topics of market investigation, consumer perception, and brand protection. The categories and the related key words of the papers content were shown in Table 3.

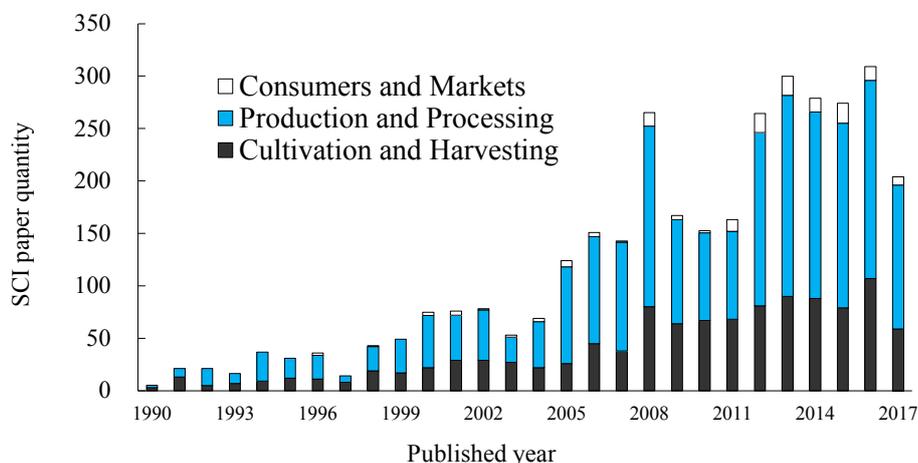


Figure 5. Annual trend of the number of Global SCI papers (1990~2017)

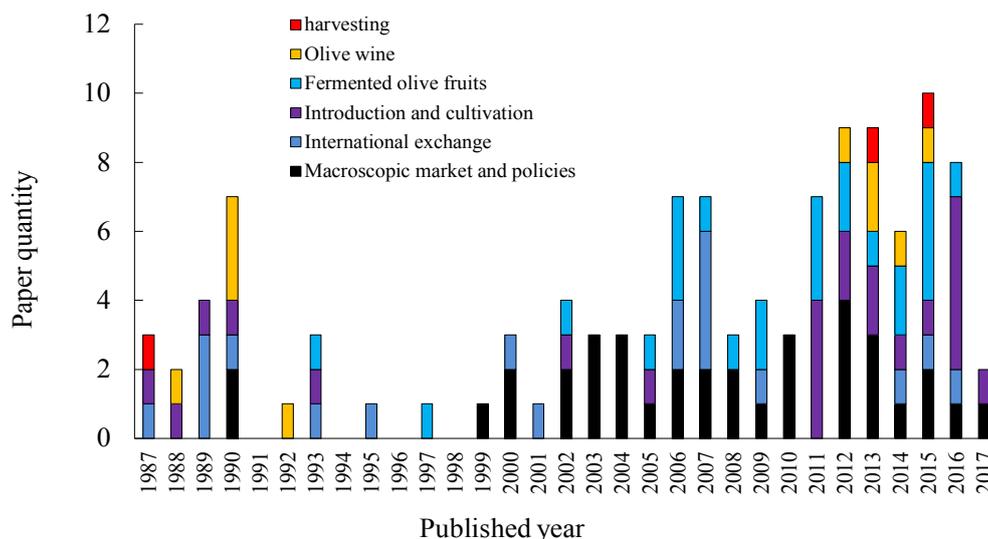


Figure 6. Annual trend of Chinese paper quantity on table olives in the six major categories from 1987 to 2017

As shown in Figure 5, 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 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. 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 (Figure 6). When compared to the mainstream research worldwide, more efforts are needed in harvesting and the fermented olive fruits. China is the first country to report 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]. Domestic table olive studies 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.

Currently, no domestic study has focused on table olive BPM or 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 table olive industries in China from traditional planting to modern intensive processing of farm products. Therefore, more effort needs to be applied to studies on consumer decisions and marketing. In provinces where table olive industrial development has been essentially achieved, including Gansu, Sichuan, and Yunnan, social and economic studies at the microcosmic levels of industrial sustained development, ecological environmental protection, manufacturer behavior, and enterprise ethics are needed.

4. Conclusion

Why table olive is still not popular with Chinese consumers? Perhaps this is mainly because that the imported table olives and their related products, studies, processes, and even the advertisement did not satisfy the demands of Chinese consumers. And the Chinese scientific and technologies innovations were limited too. Thus Chinese consumers couldn't realize the function and the delicious of table olives though they might show their positive attitudes on the Western-style food such as Pisa, Hamburger, and Spaghetti, et al. However, China has a long history of pickle processing as well as a strong culture of fermentation and brewing, consumers should not feel strange about table olives, a healthful fruit pickle from Mediterranean countries. Thus it is necessary to modify their characteristics according to the consumer's preferences and to carry out studies on marketing. Some studies in China recognized that Chinese consumers favor sweet flavors, and had produced the products of olive wine, candied olives, olive dairy products, olive jam, and sour and sweet fermented olive fruits. However, few comprehensive and systematic studies have been carried out on these products, and the market feedback has also been limited. We suggest that (1) these kinds of studies on the Chinese characteristics products should be carried

out in a comprehensive and systematic way, and (2) Chinese table olive researchers should consolidate the exchange and study with the non-Mediterranean countries, whose scientific output on table olives are worth of reference, such as Denmark, the UK, and the US, while maintaining communications with the scientists in Mediterranean countries.

Acknowledgments

This work is supported by the International Cooperation Project of Sichuan Provincial Science and Technology Department, P.R.C (2013HH0017) and the Youth Program Special Fund of Central Colleges and Universities Basic Scientific Research Expenses of the Southwest Minzu University (2017NZYQN21).

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