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The olive (*Olea europaea* L.) industry in China: its status, opportunities and challenges

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Abstract Olive groves are among the most significant agroforestry systems for ecological, social and economic benefits not only in the Mediterranean area but also in China. Over the long course of olive cultivar introduction, the great majority of global olive development has taken place in Mediterranean regions, and later, it spread to the rest of the world, including China. A true picture of the current status of the olive industry in China is still lacking. This unique study aims to gain a better understanding of the opportunities and challenges in the Chinese olive industry. This study involved both a literature review as well as a field investigation to analyze the study questions, and it consisted of the historical perspective, current status, trends, policies, opportunities and challenges. The introduction and domestication of the olive has been performed in China since 1964. The olive is a suitable tree with a high survival rate in many regions in the southern part of the country, but the olive industry was just recently built up in Gansu, Sichuan, Yunnan after 2000 because only a few areas could produce olive fruit-bearing trees. By 2030, the total plantation areas are expected to increase from 66,400 ha (2016) to approximately 193,400 ha. In the past, approximately 165 cultivars were introduced, among which 28 cultivars that exhibited excellent performance were preliminarily selected. Among the

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dominant areas for these olives, Longnan has been shown to be the best representative region through the rapid development of its olive industry. Olive oil imports exceeded 90% of total consumption in China, and this import volume increased rapidly by 60 to 70%, except in the last 3 years. A lack of research advances still remains a large challenge for the scientific community. Olive is one of the most important fruit trees can grow in agroforestry systems. At present, the Chinese olive industry is at its initial stage of development, it will be a great potential in the next 20 years especially for olive agroforestry in the low olive fruit production areas. Whether developing olive monoculture or agroforestry more practical measures should be made in the future. This study analyzes the Chinese olive industry from an ultra-modern global perspective, with the aim of providing effective measures through a multi-analysis of low production. This study may help to enhance the olive industry.

Keywords Olive · Agroforestry · Status · Opportunities · Challenges · China

Introduction

Olives (*Olea europaea* L.), camellias (*Camellia oleifera* Abel.), oil palms (*Elaeis guineensis* Jacq.) and coconuts (*Cocos nucifera* L.) are the four primary woody oil plants in the world (Deng 2010; Ruan et al. 2014), and olive is the sixth most important oil crop (Abdelhamid et al. 2013). Olive groves are among the most significant agroforestry systems in the Mediterranean area (Pérez-Priego et al. 2014; Rühl et al. 2011), and they can provide important ecological benefits (Velázquez-Martí et al. 2014) as well as providing goods and other services (Dixon 1995; Pérez-Priego et al. 2014; Herder et al. 2015). Previous few studies have reported the introduction of agroforestry systems in olive orchard, olive trees have been grown with cereals, legumes, forage and other vegetables in Morocoo (Daoui et al. 2012; Daoui and Fatemi 2014), Tunisia (Abid Karray et al. 2008), Greece (Lawson et al. 2005; Pantera et al. 2015; Pantera et al. 2016; Mantzanas et al. 2016), Italy (Rühl et al. 2011; Rosati 2014; Rosati and Mantovani 2016) and China (Long and Lin 1997; Yang et al. 2016); free-range poultry (i.e. Chicken) in olive orchard was possible to provide a higher meat quality and that might be increasingly popular to improve sustainability in agriculture (Rosati 2014; Paolotti et al. 2016). Therefore, the olive is one of the most important fruit trees that is grown in agroforestry systems (Daoui and Fatemi 2014; Rühl et al. 2011). In comparison with the products of other woody oil plants, olive oil is the only vegetable oil that can be directly eaten after the cold-pressing of fresh olive fruits (Shi 2007; Han et al. 2010; International Olive Council 2010; Ramadan et al. 2012). It has been 3000 years since humans began to plant olive trees. These trees are primarily distributed throughout Mediterranean countries such as Spain, Italy, Greece, Egypt, Libya, Turkey and Iran, where there are Mediterranean subtropical climates with dry, hot summers and wet, warm winters (Mooney et al. 1974; Grigg 2001). The olive planting area of countries along the Mediterranean coast make up 95–97% of the total cultivated area in the world (8.70–10.5 million ha) (Tous and Ferguson 1996; Bartolini et al. 2002), of which approximately 90% (7.83 million ha) of olive trees can fruit normally (Tous and Ferguson 1996). The olive is a highly valuable plant that is part of a non-wood forest; it has been introduced to China (Deng 2010; He 2011; Chen et al. 2015), and it should be developed as a priority (Li et al. 2010; He 2011; Abdelhamid et al. 2013). The olive cultivar introduction that occurred in China in 1964 was first contributed by former Chinese Premier Mr. Enlai Zhou, who introduced approximately 10,320 olive seedlings from Albania, including five cultivars called *Mixaj*, *Kaliniot*, *Elbasan*, *Berat* and *Frantoio De Crosini* across 544 introduction points in China's subtropical regions over 16 provinces, municipalities and autonomous regions. These regions included Yunnan, Guizhou, Sichuan, Chongqing, Gansu, Shaanxi, Hubei, Hunan, Jiangsu, Zhejiang, Jiangxi, Anhui, Fujian, Guangxi, Guangdong and Shanghai (Xu 2001; Xu and Wang 2004; International Olive Council 2010; Deng and Yu 2011), and this introduction was said to have great scientific significance that opened up a new prospect for olive development in China. In 1979, 70 new cultivars were introduced (Deng and Yu 2011), which laid a solid foundation for olive development. These achievements have been reported, and their primary course of development has been discussed recently (Xu 2001; Xu and Wang 2004; Deng and Yu 2011). At present, the variety of olive products is increasing every day, and these products primarily consist of olive oil, preserved olive fruit, canned olive fruit, olive leaf tea, medicine, health products, food and industrial raw materials (McEvoy et al. 1999; Wang et al. 2013). Because of the high consumption of olive products, approximately 70% of the total olive output is coming from Mediterranean countries, of which approximately 30% can be made available for export to other countries (McEvoy et al. 1999). Therefore, the expansion of the olive industrial system and the international olive market are consistently increasing, especially in China, where the speed of this market's development is faster than it is in many other regions of the world (Radnic 2011; European Commission 2012; Barjol 2013; Carrasco 2014; Ayca 2015). The advantages of olive industry development in China will be distinct. It has been predicted that from 2008 to 2050, the total vegetable oil production in China could exceed the transition shift of accelerated and decelerated growth in 2010 of (41.14 million tons), which will continue to grow rapidly for 40 years, to reach the saturation value (82.28 million tons) in 2050 (Yang 2008). Even though the growth of the Chinese olive oil industry is tied to that of other oil plants, the saturation point of production would not be reached until 2050. Notably, olive oil boasts huge potential values because of the large population and because of improvements in living standards, and thus, China will be the largest potential consumer of olive oil (Soons and Gunnarsson 2004; Radnic 2011; Carrasco 2014; Ayca 2015). However, the current status of the olive industry in China has not reached an acceptable standard, and many technical issues still need to be addressed. Does China have the potential to develop an olive industry? How large will the scale of the olive industry be expected to be in the future? How can a well-developed olive industry be created by exploring the potential role of agroforestry? What factors are limiting the development of the olive industry?

This paper reviews the development of the olive industry in China, and it analyzes the aforementioned problems (Fig. 1) as follows: (1) it summarizes the current status of the olive industry in China, (2) makes an attempt to explore opportunities especially potential role of agroforestry for olive industry development in China and analyzes China's latest plans for olive development and (3) discusses the possible challenges involved in the development of the olive industry in China.

Materials and methods

Olives typically live in Mediterranean subtropical climates, which are dry and hot in the summer and wet and warm in the winter, whereas China has a semi-tropical climate. The climatic conditions of the primary suitable regions for olive production are summarized in (Table 1) (Ning et al. 2008; Xiao et al. 2009; Shi et al. 2011; Zhu et al. 2011; Wang et al. 2012; http://data.cma.cn/site/index.html). On a production basis, the olive regions have been classified into two levels (1st and 2nd) for consideration as common growing zones (Fig. 2) (Xu 2001; Xu and Wang 2004; Deng and Yu 2011).

The statistics for the suitable regions, cultivation areas, fruit production, cultivation techniques, industry values, olive plantation and processing companies, olive agroforestry patterns, past and present scientific research and policies for the olive-growing regions of China have been collected through personal interviews of officials or from annual reports/publications by olive institutions and the forestry departments of local governments. These organizations include the Olive Research Institute of Longnan in Gansu, Sichuan Academy of Forestry, Yunnan Academy of Forestry, the Weather Bureau in Longnan, Yongren Forestry Department and others, whereas the data on the dominant cultivars have been collected by making personal visits to the above-mentioned departments as well as by performing personal interviews with the local people (farmers and owners of olive orchards) and personal observations. The olive oil extraction yield can be calculated with the help of the following formula (Eq. 1):

$$\mathrm{EY} = \frac{100 \times \mathrm{W}_{oil}}{\mathrm{W}_{olives}} \quad (1)$$

The extraction yield ranged from 13.50 to 34.44 kg of olive oil from 100 kg of olive fruits, depending on the cultivars and climatic and topographic conditions (Cui et al. 1993; Amirante et al. 2001; Abenoza et al. 2013; Clodoveo and Hbaieb 2013; Leone et al. 2015). Therefore, to evaluate the true yield volume of olive oil, a 15% extraction yield was used in this paper in accordance with the available factory processing

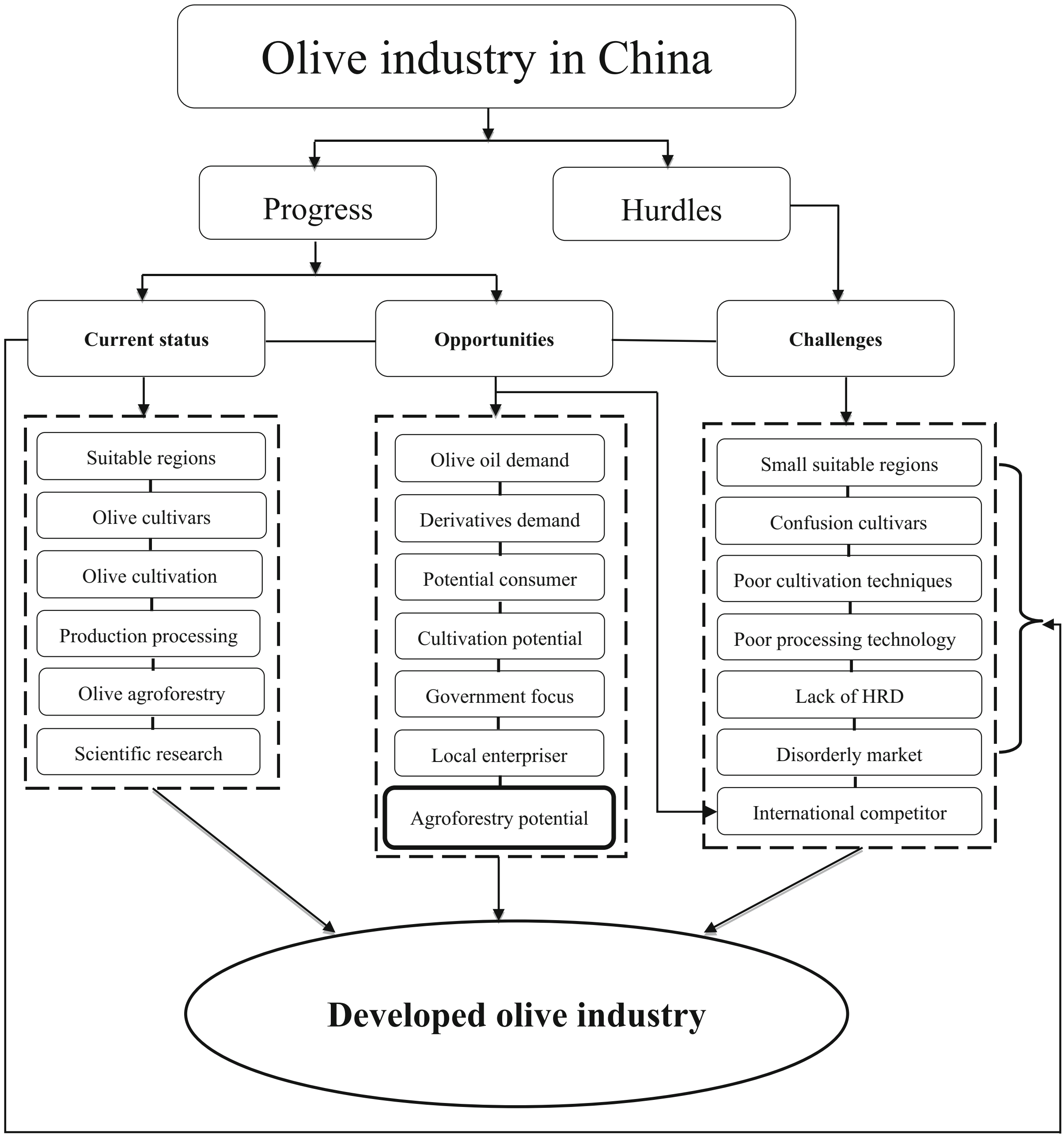

Fig. 1 Conceptual framework representing the olive industry in China and its associated factors within a broader prospective of rapid development

mechanisms in China. Data about the consumer market were analyzed with the help of close-ended questionnaires as attached in ESM 1; for this purpose, approximately 1000 complete questionnaires were collected from Beijing (25.30%), Shaanxi (31.30%), Yunnan (17.40%) and other provinces (26.00%). For the seller response, approximately 500 questionnaires (ESM 2) were collected from Beijing (29.60%), Shaanxi (41.20%) and Gansu province (29.20%). The olive fruit production data have been summarized from the SAF (State Forestry Administration of China, 2007–2015) (Zhu 2007, 2008, 2009; Zhao 2010;

Table 1 Comparison of climatic conditions in the Mediterranean regions with suitable growing regions of China

Country (Location)		Annual average temperature (°C)	Annual precipitation (mm)	Annual sunlight (h)	Temperature (°C)		Relative humidity (%)
					Jan average	Min value	
Spain	Jaén	17.3	592.0	2527.0	8.0	2.0	68.0
	Sevilla	18.7	554.0	2906.0	11.2	5.7	68.3
	Toledo	15.3	359.0	3686.5	6.4	1.6	61.6
Italy	Catania	18.2	758.0	2493.0	10.9	−0.8	55.0
Greece	Crete	18.3	379.0	2756.0	8.1	−5.7	57.0
Albania	Funarës	16.8	972.0	2685.0	9.2	−4.9	76.0
	Ave.	17.4	602.3	2842.3	9.0	−0.4	64.3
China	1-Gansu	14.7	467.0	1782.5	4.2	−8.0	69.5
	2-Yunnan	16.0	835.3	2603.3	8.3	−6.6	65.0
	3-Sichuan	16.4	1036.3	1334.2	6.0	−6.5	74.2
	4-Shaanxi	14.3	754.0	1642.0	2.2	−9.3	79.0
	5-Hubei	16.7	1105.3	1647.7	4.7	−12.1	75.3
	6-Guizhou	15.0	1284.0	1590.0	4.7	−7.9	81.0
	7-Guangxi	20.3	1502.0	2407.0	10.3	−1.3	77.0
	8-Hunan	17.7	1343.1	NA	5.6	−8.9	78.5
	9-Jiangxi	17.4	1712.0	1868.0	4.6	−7.7	83.0
	10-Fujian	20.0	1441.1	NA	11.1	−1.9	77
	11-Zhejiang	18.6	1730.0	1607.0	8.7	−4.5	78.0
	12-Jiangsu	15.3	1052.0	2158.0	2.0	−13.1	77.0
	Ave.	16.9	1188.5	1864.0	6.0	−7.3	76.2

These climate data only represent the olive-suitable regions of 12 provinces in China

NA not available

Zhang 2011, 2012, 2013, 2014, 2015). Import market data have been analyzed from the government's Web of Customs Informationhttp://www.haiguan.info/ (http://www.haiguan.info/). The final results have been summarized using SigmaPlot 12.5 and Microsoft Excel 10 software.

Current status

Suitable regions for growing olives

There is a great deal of difference between the Chinese climate and terrain features in relation to the locations of origin for olives (Shi et al. 2011). Olives originate in places with the dry, hot summers and wet, warm winters of the Mediterranean regions, whereas the suitable regions for olive growth in China have hot and rainy summers and cold and dry winters (Mooney et al. 1974; Xiao et al. 2009; Ning et al. 2010). However, these regions are not so different in terms of their average annual temperatures (Xiao et al. 2009; Wang et al. 2012). The introduction of olives to China has been successful because the fruit output from a single tree of some cultivars is far higher than that of the same cultivars in olive origin countries, with some cultivars showing good results, in terms of production, that can overcome the theoretical need for climate similarities (Xu and Wang 2004), and other reasons may also lead to this discrepancy between in China and the Mediterranean, such as the differences of cultivation technique, soil condition, terrain and altitude.

Lower-fertility soil conditions are also acceptable for olives, which require calcium but are not resistant to acidity, which requires a certain amount of dryness (Deng and Yu 2011; Kotze 2012; Tubeileh et al. 2014; Tugendhaft et al. 2016). Olives are not resistant to the waterlogged soil in China, and it is also suitable to grow olives in alkaline calcium soil that

Fig. 2 Olive provincial divisions in China. The 12 provinces are marked on the map where introductory experiments were performed in 1979, and these areas were declared suitable for olive growth. The numbers in Fig. 2 correspond to Table 2 for the labeling of the provinces

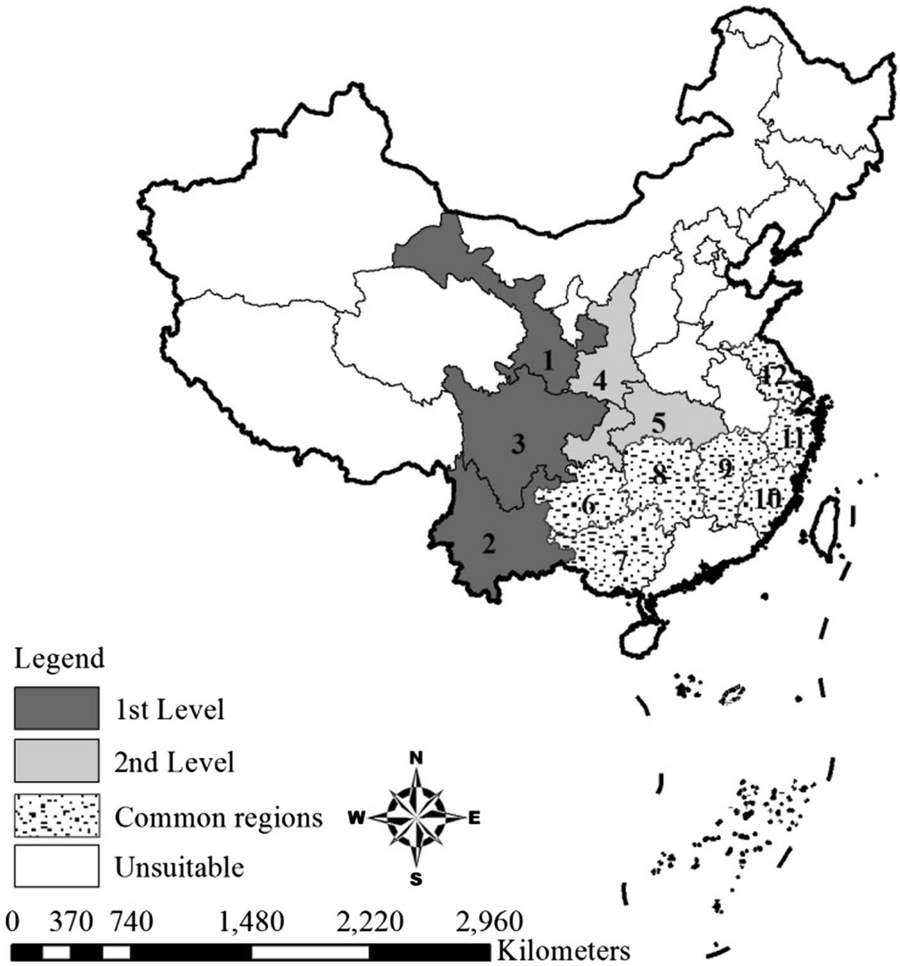

Table 2 Olive growing zones in China

Level	Province	No.	Major Cities
1st	Gansu	1	Wudu, Wenxian, Daixian, Kangxian, Zhouqu
	Yunnan	2	Yongren, Lijiang, Daju, Yongsheng, Binchuan, Ershan
	Sichuan	3	Xichang, Guangyuan, Qingchuan, Santai, Kaijiang
2nd	Sichuan	3	Jintang, Renshou, Mianyang, Langzhong, Luzhou, Bazhong
	Shaanxi	4	Chenggu, Shannan, Hanzhong, Ankang
	Hubei	5	Wuhan, Yichang, Shiyan, Badong
	Chongqing	3	Fengjie, Hechuan, Wanzhou, Wushan
	Yunnan	2	Kunming, Diqing, Ninglang
Common	6. Guizhou (Dushan, Bijie, Duyun) 7. Guangxi (Liuzhou) 8. Hunan (Hengnan, Changsha) 9. Jiangxi (Nanchang) 10. Fujian (Minhou) 11. Zhejiang (Wenzhou, Jinhua) 12. Jiangsu (Nanjing)		

develops from lime rock. Therefore, olives have narrow suitable regions in which they can grow in China (Xiao et al. 2009; Shi et al. 2011). At present, the olive planting area in China is classified into two levels and six suitable belts for olive cultivation (Xu 2001; Deng and Yu 2011). The first level includes the

Table 3 Important cultivars in dominant growing areas of China

No.	Cultivar	Source	Roles	No.	Cultivar	Source	Roles
1	*Ascolana Tenera*	Italy	T	15	*Arbequina*	Spain	O
2	*Berat*	Albania	T	16	*Arbosana*	Spain	O
3	*Coratina*	Italy	O	17	*Cornicabra*	Spain	O
4	*Crimean*	Russia	O/T	18	*Empeltre*	Spain	O
5	*Elbasan*	Albania	O/T	19	*Hojiblanca*	Spain	O/T
6	*Frantoio De Crosini*	Italy	O	20	*Koroneiki*	Spain	O
7	*Grossane*	France	O/T	21	*Manzanillo*	Spain	T
8	*Gordal Sevillana*	Spain	T	22	*CG-32**	Local	O/T
9	*Kaliniot*	Albania	O/T	23	*EZ-8**	Local	O/T
10	*Leccino*	Italy	O	24	*JF-6**	Local	O/T
11	*Mixaj*	Albania	O	25	*JF-7**	Local	O/T
12	*Picholine*	France	O/T	26	*JF-4**	Local	O/T
13	*Picual*	Spain	O	27	*JF-1**	Local	O/T
14	*Pendoline*	Italy	O	28	*ZS-24**	Local	O/T

No. 1–21 are introduced cultivars, and no. 22–28 with the asterisks are seedling cultivars developed by sexual reproduction in China. All of the above cultivars can blossom and fruit normally with excellent performance in dominant suitable regions of China

O oil, *T* fruit, *O/T* both oil and fruit

dry and hot valley area of Jinsha River such as Yunnan and Sichuan and the low hill river valley area of the southern slope in West Qin Ridge at Gansu. The second level includes the upstream areas of the Han River and the area west of the Qin Ridge south slope at Shaanxi, the Jialing River valley of Daba Hill's south slope at Sichuan basin, the low hill of the river valley areas of the Yangtze River in Hubei, Chongqing and the areas surrounding Kunming (Xu 2001; Xu and Wang 2004; International Olive Council 2010; Deng and Yu 2011). Common growing regions include the following: Guizhou, Guangxi, Hunan, Jiangxi, Fujian, Zhejiang, and Jiangsu are located in these 7 provinces in which introductory trials have been performed and the trials showed that olive adaptability is much lower than that of levels 1 and 2 in the suitable regions. In these common growing regions, olive saplings can survive, but they are subjected to development issues such as slow growth, few fruits or even an inability to bear fruits at all (Table 2).

The olive fruit production of the level 1 and 2 suitable regions represents approximately 95% of the total production of the whole country, whereas in the common growing regions, the fruit output is only 5%. Three different color depths show the provincial division of olives in China, from which one can clearly see the scope of 12 provincial suitable regions (Fig. 2), among which the key development areas for olives in China are primarily composed of suitable growing regions in the three provinces of Yunnan, Gansu, and Sichuan. Those regions boast huge development potential and will be key investment areas. In these good potential areas, the oil extraction rate of some olive cultivars exceeds 20%, and the quality of the oil is also very good (He and Gu 1984). In addition, olive cultivation does not occupy scarce farmlands, and the most suitable regions for planting olives are located in the western part of China, which is of great significance for the water and soil conservation as well as the economic and social development of the western Chinese region.

Selected olive cultivars

In the beginning of the twenty-first century, olive cultivation in China received international recognition. Before 2010, 14 olive cultivars were adapted to the natural conditions of suitable growing regions that have been preliminarily selected from a total of 158 cultivars (Deng 2010), whereas in 2011, 7 new cultivars were introduced successfully to Longnan from Spain (Li et al. 2014; Chen et al. 2015). After the introductory trials for all 165 cultivars, only these 21 introduced cultivars could develop fruit normally under most suitable growing regions, and they became the primary cultivars that are currently growing in China (Table 3).

There are another 7 seedling cultivars that are grown in the primary planting areas (Table 3). They are composite olive seeds collected from unknown superior families, and the seedling cultivars were produced by sexual reproduction that have the

Table 4 Area-wise adaptability of major cultivars in the primary growing regions of China

Dominant regions	Adaptability level	Cultivars
Chuxiong, Lijiang of Yunnan	1st	*Frantoio De Crosini, Picholine, AscolanaTenera, Leccino, Picual, Koroneiki, Arbosana, Arbequina, Coratina, Pendoline, Mixaj, Elbasan, CG-32*, EZ-8*, JF-6**
Longnan of Gansu	1st	*Leccino, Frantoio De Crosini, Picholine, Ascolana Tenera, Pendoline, Picual, Coratina, Gordal, Hojiblanca, Arbequina, Manzanillo, Cornicabra, Arbosana, Koroneiki, Empeltre, Sevillana, Crimean, CG-32*, EZ-8*, ZS-24**
Xichang, Guangyuan, Dazhou, Liangshan, Mianyang of Sichuan	2nd	*Frantoio De Crosini, Coratina, Moraiolo, Picholine, Hojiblanca, Picual, Hojiblanca, Arbequina, Manzanillo, Koroneiki, Mixaj, Berat, ZZ-6*, ZZ-8*, HO-5*, HO-9**
Hanzhong, Ankang of Shaanxi	2nd	*Frantoio De Crosini, Grossana, Mixaj, Koroneiki, CG-32*, CG-31*, CG-35*, HZ-29*, EZ-8**
Wuhan, Yichang of Hubei	2nd	*Pendoline, Kaliniot, Picual, Coratina, Berat, CG-32*, EZ-8*, JF-7*, JF-6*, JF-4*, JF-1*, ZS-24**

Updated through the end of 2004

*Stands for the fine seedling local cultivars, which can blossom and set fruit normally with excellent performance

potential for fruit setting. Later on, asexual reproduction methods were employed to save the excellent characteristics of these seedling families. After a series of trials, superior cultivars that could flower normally and fruit in certain regions have finally been obtained. These cultivars featured a high fruit setting rate. Therefore, these 7 cultivars have been propagated as fine germplasm resources.

These 21 major cultivars are suggested to grow normally in the five major provinces (Table 4), but it is not possible to introduce them into other regions that have different climate and terrain conditions. The expression of the excellent characteristics of these major cultivars might be limited, and they might result in decreased output or even flowerlessness and fruitlessness (Zhong and Chen 1986).

Hence, it is necessary to employ the full adaptability of cultivars and apply local cultivars on a large scale. Therefore, by fully employing the adaptability of cultivars within the suitable growing regions and spreading the local, superior cultivars on a large scale, it would be possible to enhance the production and quality of olives effectively, and they will then form the foundation for plantations in the suitable regions.

Current status of olive cultivation

According to the statistics from the National Forestry Bureau of China, olive fruit production in China rapidly increased from 2246 to 27,907 tons from 2007 to 2015, and it is easy to calculate the same trend for olive oil production for approximately 15% of the total fruit production. Gansu and Sichuan are the dominant contributors to the Chinese olive industry, and other provinces are responsible for a much smaller proportion of the olive fruit production. Therefore, the annual growth rate exceeds approximately 30% every year, especially from 2010 to 2015 (Fig. 3) (Zhu 2007, 2008, 2009; Zhao 2010; Zhang 2011, 2012, 2013, 2014, 2015). These yield data are predictably and rapidly rising because approximately 51.51% of the cultivated area is in the sapling stage. This new cultivation area increased from 2010 (32,200 ha) to 2016 (66,400 ha), out of which approximately 34,200 ha consisted of under-6-year-old trees. These increasing numbers of growing trees will start setting fruit after 5–10 years, and thus a quick rise in fruit yield will occur in the future, which will set a solid foundation for the development of the Chinese olive industry (Table 5). Although the Chinese olive industry has been set up late, and the scales of cultivation have been smaller than they are in Mediterranean countries, a rapid development trend has been observed for the olive industry in China.

Longnan in Gansu province is one of the most representative olive production regions in China, and it exhibits an increase in the total olive cultivation areas and fruit setting areas. Its fruit and olive oil

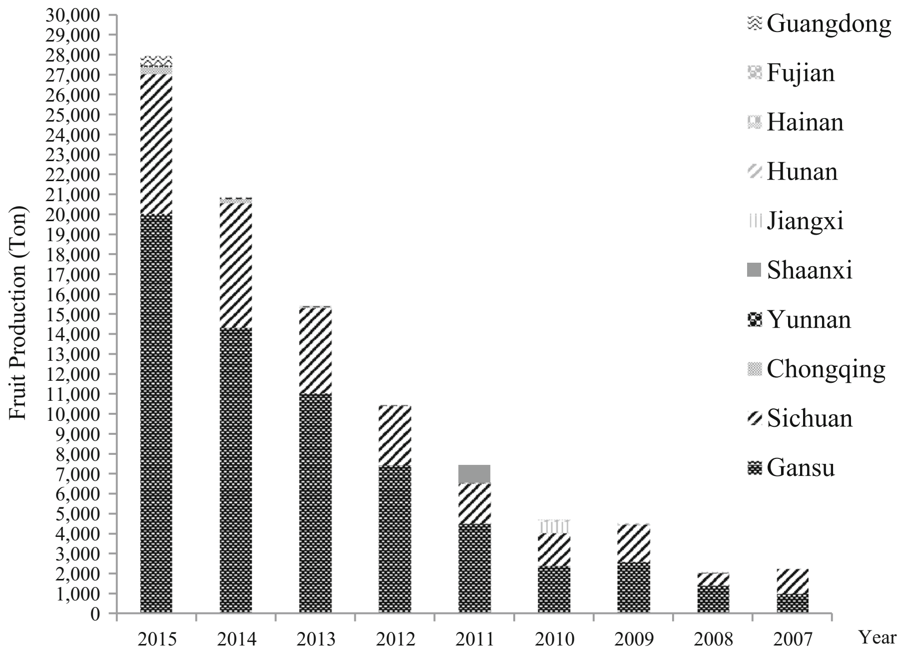

Fig. 3 Fresh olive fruit production in China (SFA 2007 to 2015)

Table 5 Cultivated areas in the dominant olive-growing provinces of China

Dominant province	Cultivated area (10^4 ha)				
	2010	2012	2014	2016	2030
Gansu	1.42	2.00	2.92	3.67	6.67*
Sichuan + Chongqing	1.71	2.15	1.93	2.30	8.00*
Yunnan	0.09	0.16	0.53	0.67	4.67*
Total	3.22	4.31	5.38	6.64	19.34*

Data for cultivated areas in China that were just collected from 4 dominant provinces

*Government planning

production changed with the same trend from the 2007 to 2015 period, except for a reduction in 2010 (which was likely caused by a dry season or alternate bearing). The olive cultivation areas were increased from 2007 to 2015, from 7300 to 34,700 ha, and the fruit setting area rose from 1700 to 12,700 ha in Longnan, which are the dominant reasons why the fruit production rose to 25,900 tons and olive oil production reached up to 3890 tons in 2015 at Longnan (Fig. 4). When these large numbers of young trees are grown and they start setting fruit after 5–10 years, the olive fruit production in China will increase rapidly and predictably. The olive production of Longnan grew very rapidly, such that the gross value of olive fruit in 2015 (¥1.55×10^8) showed a sharp rise of approximately 17.27 times the value from 2007, and the gross value of olive oil in 2015 (¥6.99×10^8) was also 20.56 times more than it was in 2007. The mean value of olive oil from a single hectare of land (¥5.51×10^4 ha^{-1}) in 2015 was 3 to 4 times more than that of the olive fruit (¥1.22×10^4 ha^{-1}) from the same year, which showed a 2-fold increase in the mean olive fruit and olive oil production from 2007 to 2015. This result showed that the profit and scales of olive cultivation increased, and the rise in productivity from a single cultivation area showed a dominant trend in the olive industry of Longnan (Fig. 5).

Production processing status

The olive cultivation or production methods in China were well-matched with the industrial approaches to non-wood forest orchards (He 2011; Deng et al. 2015). At least 20 olive planting and processing enterprises have been built in China, with 9 in Gansu province, 6 in Sichuan and 5 in Yunnan (Supplementary Material 3). Many companies have actively invested in the olive industry in different ways such as through a joint-stock system, joint venture or privately run companies, which have primarily adopted integrated industrial modes such as "company + orchard + farmer + scientific

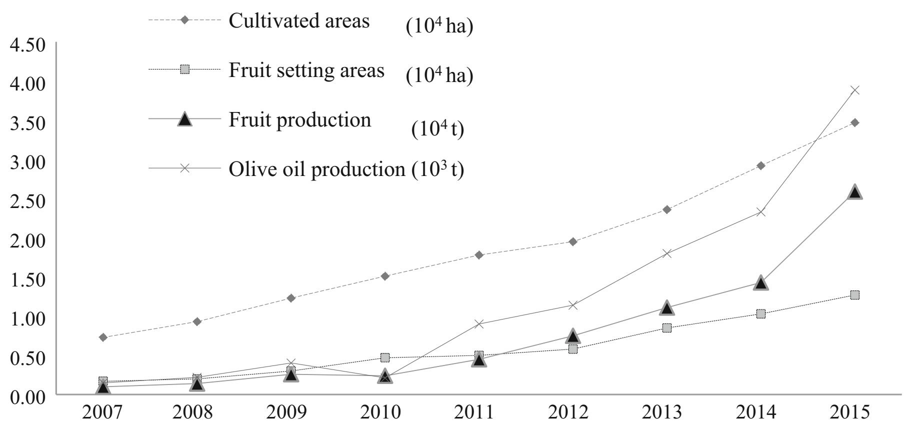

Fig. 4 Cultivated areas and production in Longnan

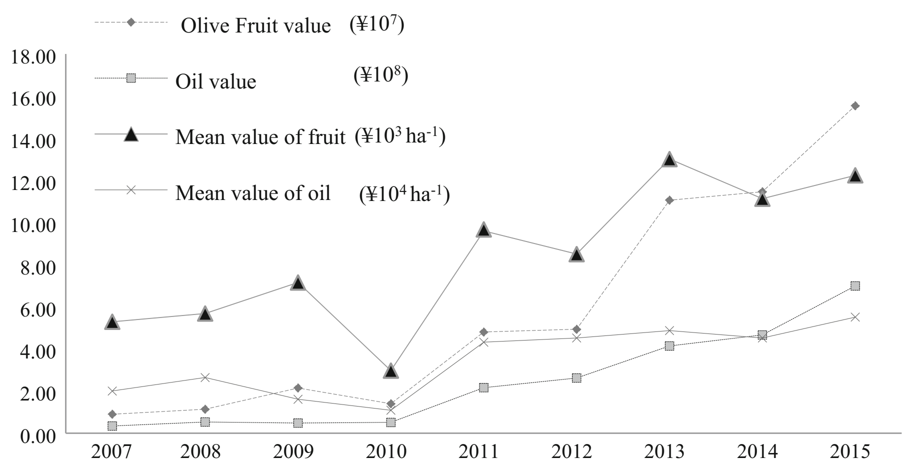

Fig. 5 Production values for the olive industry in Longnan

research" and developed a series of products such as olive oil, olive oil pills, olive wine, olive tea and olive cosmetics. Moreover, additional agricultural-products (i.e. cereal, legume and poultry meat) could be also provided by olive agroforestry in planting enterprises. The local government has offered supportive plans to develop olive industry systems (Carrasco 2014), and it has taken a dominant role in solving the economic issues associated with agriculture, farmers and rural development in western China.

Olive agroforestry pattern

The olive agroforestry patterns in the dominant olive-growing provinces of China have been collected in Table 6. Based on the local statistics in 2016, 39.60% of olive cultivation areas (approximately 26,300 ha) were practiced by intercropping with other crops and earning more income than the pattern of olive-monoculture. Several olive agroforestry patterns have been used on both hilly and flatland in China, such as olive-perennial plants (i.e. pepper, peach and plum), olive-annual crops (i.e. potato, sweet potato, soybean, broad bean, geraniums, rapeseed, maize, wheat, pea, peanut, herbal medicine and other vegetables) and the olive-poultries feeding pattern (i.e. chicken) (Table 6). In the mountainous Gansu, Sichuan, and Yunnan provinces of China, approximately 93.75% of the olive cultivation areas were located on hills, while the remaining areas (approximately 6.03%) were on flatland. In addition, because the majority of originally cultivated land for olive trees was similar to Afforestation-Ground and Barren-Mountain, this kind of land was first used for the cultivation of woody crops like the olive tree. Additionally, some sloping croplands have been transformed to cultivate woody plants including olive trees after 1999. This transformation process was applied to that of the government's

Table 6 Olive agroforestry patterns in the dominant olive-growing provinces of China

Province	Olive cultivation areas (10^4 ha)						Olive agroforestry patterns	
	On the hill		On the flatland		Total		On the hill	On the flatland
	M	I	M	I	M	I		
Gansu	2.47	0.80	0.13	0.27	2.60	1.07	4 m × 5 m[a] Pepper (*Zanthoxylum bungeanum* Maxim.)[b] Potato (*Solanum tuberosum* L.) and soybean (*Glycine max* Linn. Merr.)[c] Chicken (*Gallus domesticus*)[d]	5 m × 6 m[a] Rapeseed (*Brassica napus* L.), wheat (*Triticum aestivum* L.), potato (*Solanum tuberosum* L.) and other vegetables[c]
Yunnan	0.54	0.13	0.00	0.00	0.54	0.13	6 m × 6 m[a] Peach (*Amygdalus persica* L.) and plum (*Prunus cerasifera* Ehrh.)[b] Geraniums (*Pelargonium graveolens* L'Herit.), maize (*Zea mays* L.), sweet potato (*Ipomoea batatas* (L.) Lam.), pea (*Pisum sativum* L.), soybean (*Glycine max* Linn. Merr.), broad bean (*Vicia faba* L.) and some herbal medicines[c]	–
Sichuan + Chongqing	0.87	1.43	0.00	0.00	0.87	1.43	6 m × 6 m[a] Rapeseed (*Brassica napus* L.), sweet potato (*Ipomoea batatas* (L.) Lam.), peanut (*Arachis hypogaea* Linn.), pea (*Pisum sativum* L.), soybean (*Glycine max* Linn. Merr.) and other vegetables[c] Chicken (*Gallus domesticus*)[d]	–
Sum	3.88 58.43%	2.36 35.54%	0.13 1.96%	0.27 4.07%	4.01 60.39%	2.63 39.60%	–	–

M-(Monoculture) present that only olive trees were grown in the orchard, I-(Intercropping) express that olive trees were intercropped with other crops

[a]The density of olive trees was usually used

[b]Mixture intercropping pattern by the olive-perennial plants (1:1)

[c]Understory intercropping pattern by the olive-annual crops

[d]Feeding pattern by the olive-poultries

national engineering project called "Project for Conversion of Cropland to Forest" (Gutiérrez Rodríguez et al. 2016). In order to improve the benefits of the units of available land for olive groves, olive agroforestry patterns were improved by farmers in China so that extra matters (other crops and poultries) could also be produced in olive orchard.

Although intercropping in olive orchards with other crops has been noticed in many places during field visits in the Yunnan, Gansu and Sichuan provinces, scientific research is still lacking. Previous studies in the Guizhou province of China showed that the intercropping of soybeans and sweet potatoes in olive groves not only improved the land use efficiency, but it also achieved the early economic benefits that were especially good for the areas of low olive fruit production (Long and Lin 1997). The intercropping of bahiagrass (*Paspalum notatum* Flüggé) in Longnan (Gansu) China was shown to effectively improve the microenvironment of olive rhizosphere soil and improve the antioxidant levels, ultimately enhancing the overall drought resistance of the olive (Yang et al. 2016).

Scientific research

Progress in scientific research is necessary to improve the olive industry, and patents are a reflection of innovation ability. In recent years, published patents about olives in China have grown, with 101 intellectual property patents for olives in China by 2015. Among these patents, 63.37% were developed for the processing technology, packaging and sales of olive derivative products by enterprises, and 26.73% of patents were established for product packaging and sales by individuals. Colleges and professional research institutes have not participated extensively in olive research, but they have made certain contributions to some key technologies of the olive industry, and approximately 9.90% of patents come from them. The olive industry's standards are also used to reflect the level of the olive industry, and there are 32 standards consisting of 2 national and 30 industrial standards (26 forestry industry standards and 4 commodity inspection industry standards), with the exception of enterprise standards, for which 75% were implemented by 1990 without replacing new standards. At present, five major regulations of the olive industry have been developed, e.g., olive fruits, food products, olive oil and residual oil, olive seedling quality grades as well as cultivation techniques. Finally, it is worth studying high-output cultivation technologies, effective processing technologies and useful olive derivatives. Approximately 23 scientific investigations on olives were supported in China by 2012, with 14 of them primarily focusing on seedling cultivation, cultivars, cultivation technologies and leaf antioxidant active component studies, etc., and 9 of them were related to plantation base construction and fruit processing (http://cpquery.sipo.gov.cn/). The olive agroforestry is a new topic for developing olive industry, which was very rare to be researched not only in China but also in the Mediterranean, so we suggest that more research olive agroforestry will be a huge benefit on olive industry. The government and olive enterprises have started to pay more attention to scientific research and innovation, and the research achievements of enterprises have been increasing consistently, especially since 2000.

Opportunities

Globally recognized health organizations strongly recommend that people who employ a Mediterranean diet will have good health and longevity, and these organizations have also suggested that olive oil may reduce mortality, with obvious effects on human health (Verberne et al. 2010; Buckland et al. 2012). With the enhanced living standards of the Chinese people, the demand for olive products is also increasing constantly, which shows a positive movement towards market development (Radnic 2011; Ayca 2015). The olive industry in China has accumulated a scientific research and production basis, and this is a critical period of development with many opportunities.

Rapid demand for olive oil

This study found that since 2001, Chinese olive oil import volumes have accounted for more than 90% of total domestic consumption, with an increase of 60–70% each year (Zhang et al. 2008). According to the China General Administration of Customs (Fig. 6) (http://www.haiguan.info/; World Olive Oil Figures 2015), the Chinese olive oil imports from 1999 to 2015 increased on a yearly basis, and this trend is

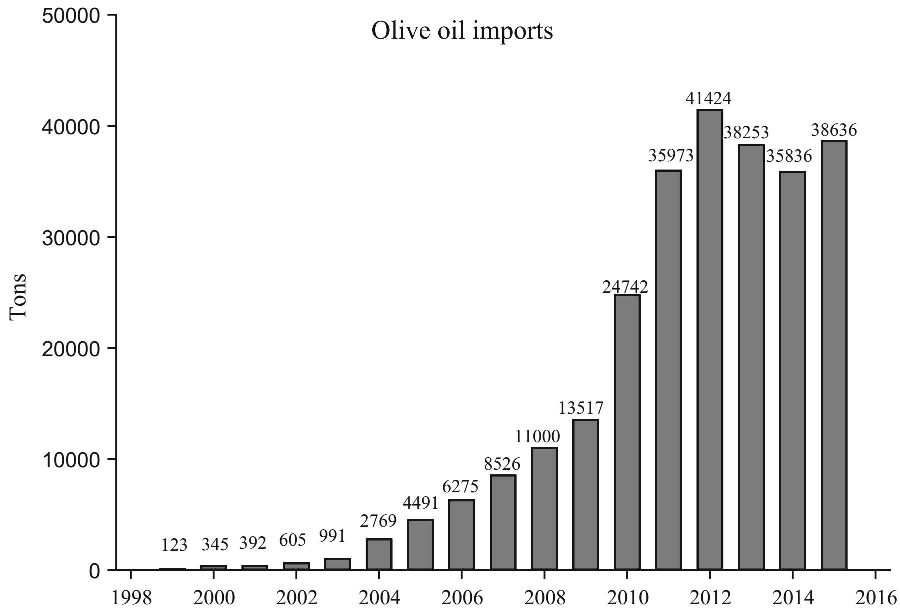

Fig. 6 Trends in olive oil imports in China (Jan. 1st to Dec. 31st). Resource Sharing: China's General Administration of Customs

moving faster each day. A breakthrough in the olive oil import volume occurred in 2008 (11,000 tons), with an increase in 2012 (41,424 tons), showing 276.36% of the mean annual growth and accounting for 93.75% of the total domestic olive oil consumption. Although olive oil imports were highest in 2012 but later showed a declining trend and total import volume for 2014 of approximately 32,451 tons, the domestic oil production for this year was approximately 3123 tons [20, 820 tons of fruits production (Zhang 2014)], which represented approximately 10% of the total import volume. This annual rise in the olive oil import volume has also been reported by the international olive oil council (World Olive Oil Figures 2015). Similarly, 2015 again showed an increasing trend, with a total import volume of 38,636 tons and a mean value of approximately ¥1.15 $\times$ 10^9 (http://www.haiguan.info/). This trend is consistent with the overall consumption reflected by economic indicators (International Monetary Fund 2015). According to preliminary estimates, global olive oil consumption made up approximately 3% of the total edible oil consumption (Peng et al. 2010). Therefore, it is predicted that olive oil imports will continue to increase at their greatest speed, especially in the coming 20 years, which is attracting a large number of domestic as well as international investors to this emerging industry in China.

Increasing demand for olive derivatives

With the gradual application of scientific outputs, olive product categories have continued to increase. We can see more and more derivatives beside olive oil in the Chinese market such as preserved olive fruits, canned olives, olive leaf tea, medicine, and cosmetic products as well as raw industrial materials (McEvoy et al. 1999). To obtain fairly high profits, enterprises are developing more and more new olive products in China, and some research shows that the olive leaf contains antioxidants at 60–90 and 10–40 mg g^{-1} in fresh olive fruits and 0.02–0.5 mg g^{-1} in olive oil. The amounts of flavonoid and oleuropein phenolic compounds in the leaf is clearly higher than they are in the fruit and bark (Koutsaftakis et al. 1999; Bianchi 2003; El and Karakaya 2009; Riachy et al. 2011; Guinda et al. 2015). Therefore, the extraction of polyphenol antioxidants from olive leaves will become a milestone in the development of the olive industry (El and Karakaya 2009; Wang et al. 2009).

At present, the price of Chinese olive products continues to be higher than that of other similar products, and therefore, the olive industry is greatly encouraged by the profitable status of olive products. In 2006, there were three import prices for olive oil in China, i.e., ¥20.40 kg^{-1} (virgin oil), ¥17.00 kg^{-1} (refined olive oil) and ¥14.28 kg^{-1} (olive fruit residue) (Li 2006). The average price of olive import products in 2015 was approximately ¥29.78 kg^{-1} (http://www.haiguan.info/). The price of olive oil on the Chinese market is much higher than that of the international market with an average price of ¥120–220 kg^{-1}, which is approximately 4–7 times higher than its import price and approximately 6–8 times higher than the price of common edible oil (Wang et al. 2012). Market profits for olives are continuing at anomalous levels because the gradual increase in the demand for olive products will be far higher than the imports and domestic production. It will be a great challenge to cater to this situation in which the demands exceed the supplies, especially in the coming 20 years.

Large number of potential consumer groups

The consumer group that purchases olive products is reflected in the rapid growth of olive oil imports. In China, olive products are sold intensively in large cities (Zhang et al. 2008; International Olive Council 2010; Radnic 2011; Ayca 2015). The majority of cities and regions have small sales volumes. China has a population of over 1.3 billion, but at present, only a small number of people have been using olive products, and approximately 80% of urban dwellers do not often consider purchasing or using olive products or have no idea about their advantages. This great potential consumer group will lead to a continued demand for olive products (Radnic 2011).

Consumer market

To obtain a true picture of the market, this study conducted a market survey to get to know the consumer as well as seller responses about olive products, which represent part of the Chinese olive market. Approximately 69.00% of consumers know about olive oil, but only 39.50% of consumers are using or have used olive oil, and only approximately 35.90% of consumers know about other olive products. This finding indicated that just a few groups of people are consuming olive products in China. Some important reasons may reflect this situation, such as the fact that the price of olive oil would not be affordable for 62.30% of the people in China. Approximately 54.70% of the people agreed that the quality of olive oil is better than that of other types of edible oil, with approximately 36.50% of the people feeling that it is not convenient to buy olive oil from the local market; 39.10% could not accept the special flavor of olive oil. However, 73.70% of the people would like to think about olive oil as having a good impact on human health (Fig. 7). This situation clearly indicated that in China, the potential consumers of olive products are the people with wealthy life styles who want to consume good-quality food for better health. However, there is still a considerable lack of awareness about olive products among the Chinese people. These findings are consistent with those of the International Olive Council (2010), Radnic (2011) and Carrasco (2014), who said that most Chinese people do not yet understand the use of olive oil, and they like many other edible oils. The researchers also said that because of the high prices of olive products, the potential consumer group is primarily rich people and highly educated professionals. This might be the reason why olive oil consumption is primarily focused on the large and medium cities in China, especially Beijing, Shanghai, Guangzhou, Shenzhen, Tianjin, Xian, and Chengdu, etc. Although half of the consumers assented with regards to the quality of olive oil and its beneficial impact on human health, the olive products did not always fulfill the demands of consumers. One reason might be the very small domestic olive oil production that was consumed in the local regions that did not enter the mass consumption market (International Olive Council 2010). Another study suggested that it is necessary to expand olive products into cities of the second and third tiers in which the growth forecasts of the average income level of the population is relatively favorable and can have huge potential (Oficina Económica y Comercial de la Embajada de España en Shanghai 2004). Thus, there is good potential for the olive industry in China by enhancing supplies through effective market management as well as taking immediate steps to enhance local production, which could increase the cultivation areas by enhancing scientific and market research that will ultimately lead to the reduction of prices.

Seller market

To explore seller responses, a survey was conducted in Beijing, Shaanxi and Gansu provinces. The results of the study indicated that less than 40% of the workers in supermarkets/shops are selling olive products, out of which approximately 74.50% agree that the supply of olive products is sufficient. However, approximately

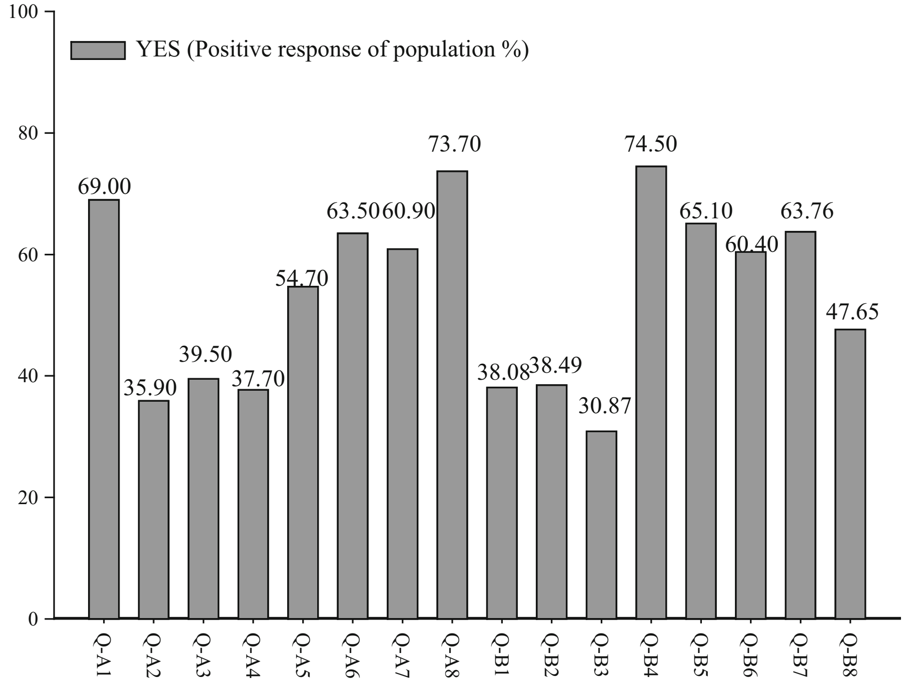

Fig. 7 The answer (YES) of questionaires in Chinese market. *Q-A* is Consumer response, *Q-B* is Seller response

69.13% of the workers think that the olive product demand is not high. Approximately 65.10% of the shops are selling local or domestic olive products whereas 60.40% are selling imported olive products. This might be the reason for the price differences in both types of products in that only 47.65% of workers think that domestic product prices are higher than imported ones. Although the prices of imported olive products are relatively higher than the prices of domestic products, approximately 63.76% of workers agreed that their consumers prefer to buy imported products from their shops (Fig. 6). This situation indicated that future demands for olive products will increase rapidly in the Chinese market because of the large number of potential consumers whose awareness level is gradually increasing. A survey that was performed in the past showed that at Beijing, Shanghai and Guangzhou, a huge quantity of the stores primarily sell imported olive products from Spain, Italy, Greece, Turkey, Tunis, France and a few from China (International Olive Council 2010). This survey stated that a huge group of Chinese consumers are brand-conscious when purchasing olive products and prefer to buy international products rather than domestic ones (Radnic 2011), which ultimately enhances the demand for imported olive products (Radnic 2011; Carrasco 2014).

Olive with tremendous cultivation potential

Olives could blossom and bear fruits normally in 5 Chinese provinces (Yunnan, Sichuan, Gansu, Shaanxi and Hubei) and they were also able to grow normally in 7 other provinces (Guizhou, Guangxi, Hunan, Jiangxi, Fujian, Zhejiang and Jiangsu), but their flowering and fruit-bearing abilities are quite poor (Table 2). The olive planting areas are expanding constantly in levels 1 and 2 of the suitable growing regions in China with good site conditions (Xu 2001; Xu and Wang 2004; Deng and Yu 2011). In land with poor site conditions, we should be committed to developing high-resistance cultivars and improving cultivation techniques, and also might be possible to enhance the olive resistance by introducing some efficient olive agroforestry patterns (Yang et al. 2016). Olives should be maintained as highly resistant dominant trees that can be expanded and cultivated in the large areas of these 12 provinces. In providing full ecological benefits (Erbay and Icier 2010), this tree can not only provide fruits and other renewable products, but it also has fewer impacts on the environment as well as preventing soil and water loss (Cuneo and Leishman 2006).

This study considers that although the absolutely suitable growing regions for olives in China are narrow and the areas for high output are limited, the adaptability of cultivars is relative. However, we can select cultivars with fairly strong resistance through repeated trials. The cultivation areas in China and fruit outputs will increase several times if the olive cultivars would blossom and bear fruit normally in common growth areas, and if olive leaves can be used as raw materials for production (El and Karakaya 2009; Wang et al. 2009; Erbay and Icier 2010). Therefore, the space for developing the olive industry in China is quite large and the development prospects are tremendous.

Potential and benefits in olive agroforestry system

We suggest that China has a great potential for agroforestry practices in olive growing areas, because approximately 39.60% (26,300 ha) of olive cultivation areas practiced intercropping with other crops (Table 6); and, the farmers in China have spontaneously adopted different agroforestry systems through intercropping and poultry feeding in olive orchards. The technology of intercropping should be researched more in order to improve the land use efficiency of limited interspace among olive trees. Even though reports of the introduction of various agroforestry systems in olive orchards have just begun in the Mediterranean countries, scientific research is lacking on olive agroforestry practices, not only in China but also in the world (Abid Karray et al. 2008; Daoui and Fatemi 2014; Rosati 2014; Pantera et al. 2015; Mantzanas et al. 2016; Pantera et al. 2016; Paolotti et al. 2016; Rosati and Mantovani 2016).

Apart from the benefits of olive products other matters from the olive agroforestry system as the additional benefits of intercrops and poultries would be also produced in olive orchard, which is an interesting approach to improve land use efficiency but also other positive aspects, such as soil conservation, landscape service, weed control, moisture preservation and utilization (Abid Karray et al. 2008; Daoui et al. 2012; Rosati 2014; Pantera et al. 2015), but on the other hand due to the complexity of management some disadvantages like olive fruit reduction, higher costs and market risks may also be the issues of great concerns in olive agroforestry (Daoui and Fatemi 2014; Rosati 2014). The previous studies can provide some examples of introducing agroforestry practices in olive orchards: the intercropping of wild asparagus (approximately 5000 trees ha^{-1}) and raising meat chickens (approximately 1000 chicken ha^{-1}) in olive orchards was more efficient for meat production and saved approximately 250 kg ha^{-1} of fertilizer (Douglas et al. 2012; Rosati et al. 2012) Marocoo (i.e. 100 olive trees ha^{-1}) it was estimated that approximately 25% of land was occupied for olive trees and the remaining land (approximately 75%) was used for intercropping between olive rows, but in order to reduce the negative impacts between olive trees and intercrops, all intercrops needed to be kept 0.5–2.0 m away from the trunks of the olive trees (Daoui and Fatemi 2014); legume crops are preferred more than cereals due to their biological nitrogen fixation (Heimstra and Harris 1998; Amassaghrou et al. 2016), which may enhance soil fertility, especially in low olive fruit production areas.

Olive agroforestry is a new topic for developing the olive industry. Therefore, we suggest that the selection of an appropriate pattern of olive agroforestry should be made according to the needs and special conditions of a region (climatic, topographic, water and edaphic factors). Care should be taken according to the current situations of olive growing in China. For example, most olive trees were planted in the hilly areas which resulted in water deficits from winters to springs; Therefore, olive-annual crops (i.e. legume and other drought resistant crops) might be suitable options than olive-perennial plants. Furthermore, the pattern of olive-poultries can be considered if terrains are convenient to it. It is also suggested that more comprehensive scientific research is needed to analyze the best suitable combinations of perennial and annual for olive agroforestry in different areas of China.

Government priorities for olive industry development

In recent years, because of the global energy crisis and edible oil safety issues, China has paid great attention to the development of its woody oil plant industry (International Olive Council 2010; Yang et al. 2013). The government has started focusing on the olive industry (Carrasco 2014) by enhancing policies and supporting the development layout planning of economically advantageous forests in 2014, in which there was a priority to develop olives, especially for the 7 dominant counties of Sichuan and Yunnan provinces (Deng et al. 2015). The Project for Conversion of Cropland to Forest as one of the most important national plan for economic fruit trees has also been applied to olive trees in agroforestry (Xu and Yan 2002; Gutiérrez Rodríguez et al. 2016), so this national project has proven to be useful for expanding the areas of olive agroforestry. From 1987 to 2012, approximately 23 scientific research projects were supported by the Chinese Government. Fourteen projects were intended to enhance production technologies and another 9 were related to industrial aspects (http://cpquery.sipo.gov.cn/). At present, the government has already planned to enhance the olive industry including in that of the agroforestry cultivation efficiency (Zhu et al. 1991; Xu and Yan 2002; Deng and Yu 2011), which will have an enormous influence in the next 10 to 20 years that will be conducive to achieving the development goals of the olive industry (Zhang et al. 2008; Wang et al. 2013). By 2030, the government olive planting areas within the olive-dominant provinces of China are predicted to be approximately 127,000 ha more than the current planted area (Table 5). We also suggest that community should pay more attention on olive agroforestry for industry development in the future.

Challenges

At present, the olive industry in China is developing rapidly. After numerous research tests and practices, the olive industry has just achieved its initial objectives and has improved in many respects. However, on the whole, the development of the Chinese olive industry is generally far behind that of Spain, Italy, Turkey, Australia and other countries. Therefore, there is a dire need to learn from previous lessons and to continue with the development process. It is expected that the future olive industry in China will have to face more severe challenges.

Small suitable growing regions

The successful introduction of olives to China is an achievement on a global level, but the suitable growing regions for flowering and fruit-bearing are few in number (Ma and Wang 2014), which greatly hinders the enlargement of the olive industry. Therefore, ways to domesticate and improve cultivars, to expand the suitable growing regions and to increase production in the relatively limited suitable area has become the focus of the Chinese olive cultivation technology. In addition, to improve the land use efficiency by agroforestry on limited olive cultivation areas is a potential approach to increase income. However, the efficient exploration of the potential values of olives (its oil, branches, leaves and fruits) as well as the effective transfer of the new technology achievements to the market has become the key role of the olive industry in China.

Confusion in olive cultivars

The olive introduction process in China is complicated because the introduced cultivars are numerous and confounded by the different local names of single cultivars within different growing regions (Xu 1981). This phenomenon leads to the reduction of high-efficiency productivity and processing that had been promoted by chaotic olive cultivars. To industrialize olive production, standardized olive planting resources and unified naming standards are critical for guaranteeing the full adoption of cultivars with excellent genetic characteristics. At present, Gansu, Yunnan and Sichuan have strengthened the management of the olive fine cultivars introduction, and many places have begun to establish preservation banks of standardized olive plant resources. They are starting to use RAPD and ISSR-PCR technology to appraise and analyze cultivars (Ma and Collins 2006; Jia 2007; Li et al. 2012; Zhan et al. 2015).

Low level of cultivation techniques in olive orchards

To obtain higher fruit production from one orchard, the enhancement of olive cultivation technology is necessary to develop an olive nursery of fruit-bearing cultivars (Río and Proubi 1999; Ahmad et al. 2014). Most olive-growing regions are centered in the valley areas of China, where the mechanization and cultivation techniques are at a relatively low level. Techniques such as drip irrigation, standardized cultivation, mechanization management and olive agroforestry are generally at a lower level than the world average level (Toplu et al. 2009; Deng 2010; International Olive Council 2010; Daoui and Fatemi 2014; Paolotti et al. 2016). However, the most important tasks are to adopt corresponding cultivation techniques and management measures in orchards, to formulate consistent technical specifications and to implement standardized cultivation. That will be the most important embodiment of efficient cultivation technologies to achieve the standardization of seedlings, land preparation, plantations, fertilization, irrigation, pruning and pest control.

Disorder in market management

The higher oil consumption of all oil crops including olive oil is a large challenge in terms of global food security (Yang et al. 2013). When the limited domestic supply chain of the olive industry is unable to meet the continuously growing business demands, there will ultimately be an increase in olive oil prices (Radnic 2011). Olive oil has become one of China's luxury goods. With normal market circulation, the introduction of foreign olive oil entering into the Chinese market has enhanced competition (Carrasco 2014). This introduction has seriously injured the enthusiasm for the domestic olive oil industry. Therefore, a perfect market management mechanism is highly necessary to guarantee the healthy development of the olive industry.

Poor processing technology

Processing technology is key to industrial transformation and upgrading to develop the potential value of olives. This technology includes new pre-treatment oil extraction, oleuropein extraction, hydroxytyrosol extraction, flavonoid extraction as well as others procedures for processing olives (Bouaziz et al. 2004; Taamalli et al. 2012; Stamatopoulos et al. 2012; Puertolas et al. 2016). Although Chinese enterprises have already developed a series of products such as extra virgin edible olive oil, olive pills, olive wine, olive tea as well as olive cosmetics (Wang et al. 2013), the current olive product research and development program is still insufficient, leading to an inability to transform olive branches, leaves and fruits into all types of new products. Therefore, the efficiency of transferring scientific research into new products is at a low level, especially the investment in research and development in high technologies, such as olive cultivation, olive leaf tea, olive essential oil and high-end cosmetics.

Shortage of personnel training and technology introduction

A large number of professional staff, international scientists, technology cooperation projects, personnel training and scientific technology introduction to work with olives is the strategic choice for the olive industry. To solve these challenges, the Chinese olive industry has developed an expectation to enhance its research collaboration with other countries, and the development of talent training methods should be learned from countries such as Australia, which is also a non-Mediterranean region. Therefore, to enhance its research and development, Australia developed an Australia Olive Association (Beckingham 2006; Zhong et al. 2012; Victoria 2015) after the 2012 China Economic Forestry Association of Olives professional committee was established (Dang 2012). With integrated efforts to boost the olive industry, we must promote a large number of professional talents and continue to optimize the allocation of resources, which will be the key to success. It will be important to strengthen and upgrade China's scientific research ability by collaborating with international olive organizations, with joint talent-training using high technology and seeking new market opportunities from a technical origin.

Conclusions

Olive tree is a basic and dominant component of olive agroforestry, which can provide ecological, social and economic benefits on olive industry in China. From a broader prospective, the Chinese olive industry has been shown to be in its primary stage of rapid development as determined by the huge market demand with low support from domestic production and processing technology. Based on a field survey and summarization of data, this paper analyzes the current status of the Chinese olive industry as well as its opportunities and challenges.

The next 20 years will be a period of strategic opportunity for the Chinese olive industry, and there are many favorable factors: (1) the market has high demand from a potential consumer group; (2) there is a high cultivation potential in China; (3) the government is strengthening its support of the olive industry; (4) there have been a number of achievements in scientific research that have gradually been incorporated into cultivation management, production and processing; (5) the quantity of domestic olive processing and planting enterprises is increasing gradually and (6) the increasingly agroforestry practices in olive plantation areas are being applied, especially for low olive fruit production areas, to maximize the outputs of unit cropland.

However, the olive industry in China will be facing a few great challenges as follows: (1) its suitable growing regions are narrow; (2) the cultivars are chaotic and the potential for excellent cultivars has not been explored yet; (3) poor cultivating technology leads to low fruit output; (4) insufficient research has failed to make full use of the olive branches, leaves and fruit; (5) the processing technology is relatively poor; (6) the professional training and modern technology introduction is still insufficient; and (7) chaotic market management destroys competition in the olive market.

To develop the olive industry, more practical measures should be taken in the future, including the strengthening of efforts to introduce and preserve excellent olive germplasm resources, to accelerate domestication tests on introduced olive cultivars and to select excellent cultivars for suitable regions. It is also necessary to perform research on suitable cultivars with higher outputs of olive oil; study cultivars to expand into cultivation areas in general growing regions; enhance the study of techniques for standardized olive cultivation and processing; more actively promote the appropriate cultivation techniques of olive agroforestry; strengthen research and advertising on related derivatives, such as olive oil branches, leaves and fruit; invest and introduce advanced cultivation; olive agroforestry; processing technologies; optimize the processing flow; and extend the olive industrial processing chain as well as strengthen market management to engage competition.

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