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SHORT COMMUNICATION

Fatty acid composition and tocopherol, sitosterol, squalene components of *Camellia reticulata* oil

Yongqing Cao[1] · Yin Xie[2] · Huadong Ren[1]

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Abstract

Camellia reticulata is a typical *Camellia* species used for the production of edible oil in Southwest China. Here we analyzed the fatty acid composition and bio-active compounds including tocopherol, sitosterol and squalene in *C. reticulata* oil. The oil mainly comprises 72.78–75.52% oleic acid, 11.40–12.58% palmitic acid, 6.91–8.01% linoleic acid, 2.29–2.98% stearic acid, 0.33–0.52% linolenic acid. The average content of α-tocopherol, β-sitosterol and squalene in solvent extracted *C. reticulata* oils from six sites are 27.19 mg per 100 g, 289.47 mg kg^{-1} and 138.28 mg kg^{-1}, respectively. We also evaluated the effect of elevation, an important environment factor influencing seed oil content, on fatty acid composition and bio-active compounds of *C. reticulata* oil. The results indicated that only β-sitosterol content showed significant difference at the different elevations.

Keywords *Camellia reticulata* · Fatty acid · Bio-active compounds · Elevation

1 Introduction

Camellia oil is used widely in Southern China and Southeast Asia, and because of its similar chemical composition to olive oil, is often referred to as *Eastern Olive Oil* (Ma et al. 2011; Wang et al. 1994). Indeed, the camellia oil contains a high content of unsaturated fatty acids, comprising 60–80% oleic acid and 5–10% linoleic acid (Ma et al. 2011) and the ratio of monounsaturated fatty acids to saturated fatty acids in the camellia oil is close to the optimal ratio following the Simopoulos' "Omega Diet" (Simopoulos and Robinson 1999). Besides the main constituents of fatty acids, the camellia oil still has some other bio-active components such as tocopherols, squalenes and so on (Lee and Yen 2006; Robards et al. 2009). These features are considered having balanced and healthy effects in reducing the risk of obesity, cancer, and heart disease.

Camellia reticulata, one of the most famous plants in the family Theaceae, is an evergreen flowering tree or shrub naturally distributed in Southwest China (Huang et al. 2013a, b) (Fig. 1). Besides ornamental cultivation, it also has been cultivated as an important oil plant in its indigenous region for at least 150 years (Yu and Bruce 1980; Huang et al. 2012). The wild population of *C. reticulata* mainly scattered in Tengchong County of Yunnan province, where the elevation is from 1700 to 2300 m (Ming et al. 2000). It is reported that the oil content in seeds of *C. reticulata* achieved values of 34% and is strongly influenced by elevation and soil type (Huang et al. 2013a, b). However, there is little available data about the fatty acids composition and bio-active compounds in *C. reticulata* oils from different wild populations and their correlations with elevation.

In the present study, the fatty acid composition and bio-active compounds including tocopherol, sitosterol and squalene in *C. reticulata* oils from wild populations in Tengchong County were analyzed and the results will help to develop further support for consumption and production of *C. reticulata* oil.

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✉ Yongqing Cao
caoyq1981@163.com

[1] Research Institute of Subtropical Forestry, Chinese Academy of Forestry, Hangzhou 311400, Zhejiang, People's Republic of China

[2] Experimental Station of Camellia reticulata, National Center for Oil-tea Camellia Science and Technology, Tengchong 679100, Yunnan, People's Republic of China

Fig. 1 *Camellia reticulata*

2 Results and discussion

2.1 Fatty acid composition of *C. reticulata* oil

Levels in percentage of palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1), linoleic acid (C18:2) and linolenic acid (C18:3) in *C. reticulata* oil from 6 sites are shown in Table 1 (Chinese standard GB/T 22223-2008; Rui et al. 2007). The principal fatty acid found was oleic acid, ranging between 72.78 and 75.52%. It was followed by palmitic acid (11.40–12.58%), linoleic (6.91–8.01%), stearic acid (2.29–2.98%) and linolenic acid (0.33–0.52%). The fatty acid composition is quite similar to that of olive. And the ratio of oleic acid is much higher than that in oils originated from other plants such as walnut, peanut, rapeseed, palm, soybean, sunflower seed and corn (Bailey 1979). The *C. reticulata* oil had lower oleic acid (73.92%) than *C. oleifera*, *C. meiocarpa* and *C. chekiangoleosa* oil in which the oleic acid percentage could be over 80%. Furthermore, the fatty acid composition of *C. reticulata* oil is almost the same as that of *C. yuhsienensis* oil (Cao et al. 2017; Yang et al. 2016).

Besides, no significant difference was found among 6 sites with different elevations from 1702 to 2266 m.a.s.l. (metres above sea level) in terms of fatty acid composition. It can be seen that the elevation is not the influencing factor of fatty acid composition though it affects seed oil content of *C. reticulata* significantly (Huang et al. 2013a, b). The fatty acid composition may depend on fruit development and genotypes (Cao et al. 2013; Li et al. 2014; Yang et al. 2016).

2.2 Tocopherol, β-sitosterol and squalene content in *C. reticulata* oil

The content of tocopherol, β-sitosterol and squalene in solvent extracted oil of *C. reticulata* were determined (Bao et al. 2002; Mao et al. 2007; Rastrelli et al. 2002) (Table 2). Like many oils that are dominated by one or two

Table 1 Fatty acid composition of *C. reticulata* oil from six sites

Location	Fatty acid%				
	C16:0	C18:0	C18:1	C18:2	C18:3
Qushi	11.54 ± 1.22a	2.87 ± 1.03a	75.07 ± 2.25a	7.22 ± 1.21a	0.33 ± 0.18a
Tengyue	11.59 ± 1.48a	2.87 ± 0.89a	73.34 ± 3.25a	7.87 ± 1.22a	0.37 ± 0.15a
Beihai	11.78 ± 1.31a	2.75 ± 0.79a	75.52 ± 2.42a	7.39 ± 1.27a	0.41 ± 0.16a
Mazhan	11.40 ± 1.37a	2.98 ± 1.05a	73.33 ± 3.53a	6.91 ± 1.37a	0.52 ± 0.27a
Mingguang	12.58 ± 1.22a	2.29 ± 0.82a	73.98 ± 2.18a	8.01 ± 1.46a	0.46 ± 0.33a
Zhonghe	12.31 ± 1.57a	2.50 ± 0.79a	72.78 ± 3.34a	7.98 ± 1.50a	0.51 ± 0.22a
Mean	11.87	2.71	73.92	7.56	0.43

Each result represents the mean ± SE of 10 determinations. In each column different letters mean significant differences ($p < 0.05$)

Table 2 Tocopherol, *β*-sitosterol and squalene content in *C. reticulata* oil from six sites

Sites	α-Tocopherol (mg per 100 g)	*β*-Sitosterol (mg kg^{-1})	Squalene (mg kg^{-1})
Qushi	27.82 ± 3.04ab	293.46 ± 14.59a	151.54 ± 21.13a
Tengyue	25.97 ± 2.15ab	267.67 ± 12.20b	160.54 ± 29.73a
Beihai	29.88 ± 1.96ab	279.82 ± 10.60b	118.50 ± 19.42ab
Mazhan	30.78 ± 2.18a	276.61 ± 10.23b	167.63 ± 27.18a
Mingguang	24.38 ± 1.20b	294.69 ± 7.90ab	87.27 ± 11.19b
Zhonghe	24.29 ± 2.28b	324.57 ± 13.41a	144.21 ± 21.74ab
Mean	27.19	289.47	138.28

Each result represents the mean ± SE of 10 determinations. In each column different letters mean significant differences ($p < 0.05$)

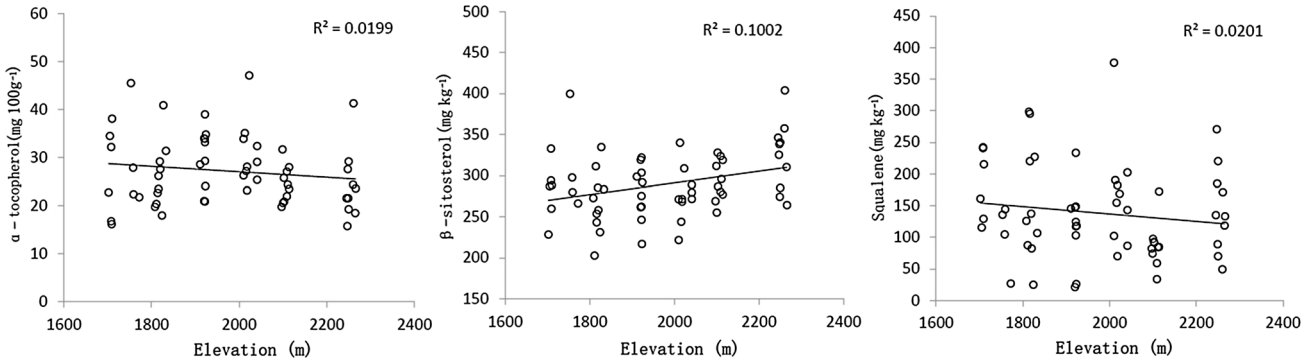

Fig. 2 The influence of elevation on bio-active compounds content in oils of *C. reticulata* ($n = 60$) grown in Tengchong County, Yunnan Province, China

tocopherols (Robards et al. 2009), only α-tocopherol was detectable in our experiment and the average content of α-tocopherol was 27.19 mg per 100 g in oils from six sites. The α-tocopherol levels are higher than that in *C. oleifera* oil (Li et al. 2014) and place *C. reticulata* near the top of the list of tocopherol-rich oils, between sunflower oil (56 mg per 100 g) and hazelnut oil (26 mg per 100 g) according to Bauernfeind (1980).

It was reported that the sitosterol levels in camellia oil were low compared to many other vegetable oils such as rapeseed, soybean and so on (Phillips et al. 2002). Here the average content of *β*-sitosterol in *C. reticulata* oils from 6 sites was 289.47 mg kg^{-1} which is quite similar to *C. oleifera* oil (Li et al. 2014). While the content of squalene (138.28 mg kg^{-1}) in *C. reticulata* oils was much higher than that in rapeseed and soybean oil (Liao et al. 2008).

Besides, the content of α-tocopherol, *β*-sitosterol and squalene showed significant differences among samples collected from six sites (Table 2). For instance, the α-tocopherol content in oils sampled from Zhonghe and Mingguang were significantly lower than that sampled from Qushi, Tengyue, Beihai and Mazhan. And the *β*-sitosterol content in oils sampled from Tengyue, Beihai and Mazhan were significantly lower than that sampled from Qushi and Zhonghe. In order to clarify whether the elevation factor influences the bio-active compounds content in *C. reticulata* oils, we analyzed the correlations between bio-active compounds content and elevations. It was found that only the *β*-sitosterol content in oils seemed to be significantly influenced by elevation ($p < 0.05$) and the α-tocopherol and *β*-sitosterol content had no significant correlations with elevation (Fig. 2). The correlation coefficient between *β*-sitosterol content and elevation was not high ($R = 0.317$) which indicates that the elevation was not the sole environmental factor responsible for *β*-sitosterol content in *C. reticulata* oil though their relationship is statistically significant. For instance, seeds oil content of *C. reticulata* was strongly influenced by two environmental factors, elevation and soil types (Huang et al. 2013a, b). Further studies are needed to investigate which environmental factors influence the bio-active compounds content in *C. reticulata* oil and how does it happen.

2.3 Conclusions

The *C. reticulata* oil is quite similar to olive oil in terms of fatty acid composition even though its oleic acid ratio (72.78–75.52%) is a little lower than that of *C. oleifera*, *C. meiocarpa* and *C. chekiangoleosa* oils. And the *C. reticulata* oil is also rich in α-tocopherol (27.19 mg per 100 g) and squalene (138.28 mg kg^{-1}). While the content of *β*-sitosterol (289.47 mg kg^{-1}) is relatively low and it seems to be strongly influenced by elevation. Overall, the *C. reticulata* oil should be a healthy edible oil peculiar to Southwest China.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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