The physicochemical properties and fatty acid composition of two new woody oil resources: Camellia hainanica seed oil and Camellia sinensis seed oil

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\textbf{ABSTRACT}

Woody plants are important source of edible oil, and \textit{Camellia hainanica} and \textit{Camellia sinensis} are two new option. The physicochemical properties and fatty acid composition were determined in both species. The oil content of \textit{C. hainanica} was 37.60–41.60\%, and that of \textit{C. sinensis} was 31.04–33.20\%. There were no significant differences in saponification value, refractive index or relative density \((P > 0.05)\). The types of fatty acids were the same in both species, but the composition was significantly different \((P < 0.01)\). Among the nine fatty acids measured, only the concentration of oleic acid was higher in \textit{C. hainanica} oil than that of \textit{C. sinensis} oil. The contents of vitamin E and total phenols in \textit{C. hainanica} oil were significantly higher than those in \textit{C. sinensis} oil \((P < 0.01)\). The higher unsaturated fatty acids, vitamin E, and total phenols, in \textit{C. hainanica} give it a greater advantage.

\textbf{1. Introduction}

Woody plants are an important source of edible oils. \textit{Camellia oleifera}, \textit{Canarium album}, \textit{Cocos nucifera}, and \textit{Trachycarpus fortunei} are proposed as four woody oils globally. Apart from the above trees, there other woody plants harvested for their oils, such as \textit{Juglans regia} (Labuckas et al., 2014), \textit{Paeonia suffruticosa} (Han et al., 2016). Woody oil plants not only protect limited cultivated land, but also have ecological effects, one of the most important of which being that they have high nutritional value. Olive oil, which has high levels of mono-ununsaturated fatty acids, polyphenolic compounds, squalene, and \(\alpha\)-tocopherol, is considered as a functional food and that reduces the risk of coronary heart disease and several varieties of cancers (Stark & Madar, 2002). \textit{Camellia} seed oil can also enhance antioxidant activity and protect cardiovascular tissues (Chou et al., 2018). Based on the many advantages of woody oil, the history of human consumption is long-standing; in some regions, woody oil is a component ingredient of the diet.

\textit{Camellia} seed oil (or tea oil) has been used in China as a unique woody oil, and has started to be exported to other countries in recent years (Li et al., 2010). It is extracted from \textit{C. oleifera} seeds, and can be confused with oils from other \textit{Camellia} plants (Yongzhong et al., 2020). The fatty acids contained in \textit{Camellia} seed oil are mainly those of oleic acid, linoleic acid, and a small amount of saturated fat; the content of oleic acid reaches 74\% – 89\%, similar to that of olive oil (Li et al., 2010). Due to the health benefits of \textit{Camellia} seeds, other \textit{Camellia} resources have received extensive attention in recent years.

The oil from \textit{C. hainanica} and \textit{C. sinensis} are new woody oil resources. The custom of consuming tea oil in Hainan, China, for its pleasurable flavor is an enduring one, and in relation to the high demand, this oil is very expensive in Hainan (Duo-Jun et al., 2015). However, there is little research exploring which ingredients make it so appealing. Recently, the woody plant \textit{C. hainanica} was confirmed as a new species belonging to \textit{Camellia} sect. \textit{Oleifera} (Xu et al., 2020). Oil
from *C. sinensis* has been used throughout history, but its bitter taste has hindered it from being widely promoted as an edible oil. In recent years, with the development of extraction technology, the flavor of *C. sinensis* oil has been enhanced, and this new version has been gradually introduced to the market (Guoyan et al., 2013; Dong et al., 2014; Xingqiu et al., 2013). Until now, research on the above two new woody oil resources focused on the extraction process (Bingbing et al., 2015), but in order to explore the nutritional properties of the new tea oil, the physiochemical properties and fatty acid composition need to be determined. This study aimed to help us more effectively understand the nutritional value of the two new tea oil resources.

2. Materials and methods

2.1. Sample collection

The fruits of *C. hainanica* and *C. sinensis* were collected from Chengmai, China (19°38’ 25.56” N, 110°0’ 56.02” E, 80 m) and Jinhua, China (29°0’ 03.38” N, 119°38’ 28.24” E, 70 m), respectively (Table 1). Five trees were randomly selected from each collection site, and at least 5 kg of fruit was collected from each. The collected fruits were then peeled from the shell and the impurities were removed. The pressing method was employed to extract the oil (Ao et al., 2020), the oil content of tea seeds was calculated and the appearance of the oil was observed (Yichang et al., 2020).

2.2. Determination of physicochemical properties and composition

Acid value, iodine value, saponification value, relative density, refractive index, and peroxide value were determined. The above physicochemical indicators were detected in accordance with standard methods (Hong et al., 2006). At the same time, fatty acid composition was tested using gas chromatography (GC) equipment (Agilent Technologies, Folsom, CA, USA) according to the standard method (Wang et al., 2011). Based on the above fatty acid composition, saturated fatty acid (SFA), monounsaturated fatty acid (MUFA) and poly-unsaturated fatty acid (PUFA) were calculated. In order to better evaluate the nutritional value of two new tea oil, the contents of vitamin E and total phenols were assessed using the methodology described by (Malheiro et al., 2012). The chemical reagents used in the experiment were all analytically pure.

3. Results and analysis

3.1. Oil content of nuts and appearance of the tea oil

The oil content of *C. hainanica* was 37.60% – 41.60%, which was higher than that of *C. sinensis* (31.04% – 33.20%). The appearance of both seed oil were transparent, and both had a specific fragrance. However, the oil of *C. hainanica* was golden, whereas the oil of *C. sinensis* was orange (Table 1).

3.2. The physicochemical properties of the tea oil

The saponification value, refractive index, and relative density of *C. hainanica* oil were 191.68 ± 1.30 mg KOH/g, 1.47 ± 0.01, and 0.92 ± 0.02, respectively (Table 2). The above indices for both tea oils were similar, and there were no significant differences for either tea oils (P > 0.05). The acid and iodine values of *C. hainanica* were 0.68 ± 0.02 mg/g and 83.00 ± 1.00 gl2/100 g, respectively, which were significantly lower than that of *C. sinensis* oil (P < 0.05). The peroxide values of *C. hainanica* and *C. sinensis* were 3.05 ± 0.13 mmol/kg and 0.32 ± 0.07 mmol/kg, respectively. The peroxide value of *C. hainanica* was significantly higher than that of *C. sinensis*, by approximately 10 times (P < 0.01).

3.3. Fatty acid composition

The types of fatty acids contained in *C. hainanica* tea seed oil were the same as those in *C. sinensis* tea seed oil, but the compositions were significantly different (P < 0.01, Figure 1). Among all fatty acids, the content of oleic acid (C18:1n9c) was the highest. The content of oleic acid for *C. hainanica* tea seed oil and *C. sinensis* tea seed oil were 79.62% and 59.21%, respectively. Among the nine fatty acids measured, only the content of oleic acid in *C. hainanica* tea seed oil was higher than that of *C. sinensis* tea seed oil. The saturated fatty acid content of *C. hainanica* tea seed oil was 12.14%, which is lower than that of *C. sinensis* tea seed oil (16.83%). The PUFA (poly-unsaturated fatty acid) content in *C. hainanica* tea seed oil was also less than *C. sinensis* tea seed oil. *C. hainanica* had a higher content of MUFA.

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### Table 1. Oil content of nuts and appearance of tea oil

| Collection site         | Oil content (%) | Appearance         |
|-------------------------|-----------------|--------------------|
| *C. hainanica* Chengma | 37.60% ± 0.02   | Transparent, clear, golden, fragrant |
| *C. sinensis* Jinhua   | 31.04% ± 0.02   | Transparent, clear, orange, fragrant |

### Table 2. The physicochemical properties of the tea oil

|                  | Acid value (KOH)/mg/g | Iodine value (gl2/g) | Saponification value (mgKOH/g) | Refractive index | Relative density | Peroxide value (mmol/kg) |
|------------------|-----------------------|----------------------|-------------------------------|------------------|-----------------|------------------------|
| *C. hainanica*   | 0.68 ± 0.02           | 83.00 ± 1.00**       | 191.68 ± 1.30                 | 1.4678 ± 0.01    | 0.92 ± 0.02     | 3.05 ± 0.13**          |
| *C. sinensis*    | 0.82 ± 0.03           | 89.17 ± 0.75         | 190.09 ± 0.93                 | 1.4637 ± 0.01    | 0.90 ± 0.02     | 0.32 ± 0.07            |

*P < 0.05, significant correlation; **P < 0.01, very significant correlation.
Figure 1. The fatty acids composition of two tea oil. Note: SFA (saturated fatty acid) included myristic acid (C14:0), palmitic acid (C16:0), margaric acid (C17:0) and stearic acid (C18:0); MUFA (monounsaturated fatty acid) included palmitoleic acid (C16:1), oleic acid (C18:1n9c) and eicosanoic acid (C20:1); PUFA (polyunsaturated fatty acid) included linoleic acid (C18:2n6c) and α-linoleic acid (C18:3n3).  

Figura 1. Composición de ácidos grasos de dos aceites de té. Nota: El SFA (ácido graso saturado) incluye el ácido mirístico (C14:0), el ácido palmitico (C16:0), el ácido margárico (C17:0) y el ácido estéarico (C18:0); el MUFA (ácido graso monoinsaturado) incluye el ácido palmitoleico (C16:1), el ácido oleico (C18:1n9c) y el ácido eicosanoico (C20:1); los PUFA (ácidos grasos poliinsaturados) incluyen el ácido linoleico (C18:2n6c) y el α-ácido linoleico (C18:3n3).  

(monounsaturated fatty acid) than that of C. hainanica tea seed oil, similar to the oleic acid results.

3.4. Vitamin E and total phenols

Vitamin E and total phenols are important nutrients in edible oils. The content of total phenol was higher than that of vitamin E for both C. hainanica and C. sinensis tea seed oil (Figure 2). The content of vitamin E in C. hainanica was 194.43 μg/g, and the total phenols content in C. hainanica was 345.73 μg/g. The contents of vitamin E and total phenols in C. hainanica tea seed oil were significantly higher than those in C. sinensis tea seed oil (P < 0.01)

Figure 2. The content of vitamin E and total phenols in both tea seed oil. 

Figura 2. Contenido de vitamina E y fenoles totales en ambos aceites de semillas de té.

4. Discussion and conclusion

Woody oils are favored because they contain a high content of unsaturated fatty acids, which can prevent cardiovascular diseases and provide other medical and health benefits. The tea seed oil of C. oleifera is a traditional edible oil which has recently become more widely recognized (Meng et al., 2018). SFA, which is an unfavorable fatty acid for health, was between 9.88% – 10.40% in C. oleifera tea seed oil (Wang et al., 2011; Yinghui, 2019). The measurement results show that the content of SFA in C. hainanica and C. sinensis tea seed oil was higher than that in C. oleifera, and C. sinensis had the highest value of the three, excluding heptanoic acid (C7:0). C. hainanica and C. oleifera tea seed oil contained similar MUFAs and PUFAs. The content of these unsaturated fatty acids in C. sinensis tea seed oil was much lower than that in C. oleifera. The content of vitamin E and total phenols in different varieties of C. oleifera tea seed oil was quite varied, 3.00–17.42 μg/g for vitamin E and 5.92–28.75 μg/g for total phenols. The present study investigated whether C. hainanica or C. sinensis tea seed oil had further potential to be exploited, and their vitamin E and total phenol content are significantly higher than those of C. oleifera tea oil.

The two new woody oil resources, C. hainanica and C. sinensis have strong development potentials. The seed oil has good physical and chemical properties and reasonable fatty acid composition. In particular, C. hainanica tea seed oil has a fatty acid composition similar to that of C. oleifera tea seed oil and higher vitamin E and total phenol content. Processing technology plays an important role in Camellia oil. In follow-up research, it is necessary to further strengthen these finding in order to develop these resources more effectively.
Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Disclosure statement

The authors declare that they have no conflict of interest.

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Author contribution

Xu Zhenggang and Yang Guiyan wrote the manuscript. Xu Zhenggang and Li Chaoyang performed the experiments. Cao Zhiru and Yao Haoran analyzed the data. Xu Zhenggang and Zhao Yunlin designed the study. Xu Zhenggang and Yuan Deji revised the manuscript.

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