Tea seed oil: Physicochemical profiling

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Abstract

A study was undertaken to evaluate the quality characteristic of tea (Camellia sinensis L.) seed oil. The oil content ranged between 20.84 and 21.90 per cent. Smoke point, iodine value, saponification value, calorific value, refractive index, oil density, oil colour and oil pH were in the range of 247.29 - 251.53 (°C), 82.74 - 85.65 (g I 100-1 g), 185.33 - 185.72 (mg KOH g-1), 6822.53 - 6891.05 (J per 100 g), 1.46 (at 40 0C), 0.92 - 0.94 (g per cm3), 4.45 - 4.47 (Y+5R) and 4.62 - 4.64, respectively. The oxidation parameters, i.e., peroxide value, ranged from 1.17 - 2.63 meq kg-1. The tea seed oil has PUFA/SFA ratio 0.82 - 1.31 closer to WHO recommended value. Besides, antioxidant activity in term of DPPH free radical scavenging activity ranged between 6.30 - 7.14 per cent, β-carotene 4.62 - 12.93 mg kg-1 and α-tocopherol 90.49 - 366.52 mg kg-1. Highest oleic acid content was found in TSS 1, whereas highest α-tocopherol was found in TS 557. The results open up the possibilities of extracting oil from these bi-clonal seed stocks, which will diversify the use of tea.

Keywords: Antioxidant, bi-clonal, fatty acid, oil, seed stock, tea seed

Introduction

Camellia seeds are born in capsules having oleaginous nature. The kernels, which constitute about 70 per cent of the weight of seed, are rich in oil content ranging from 20 to 23 per cent (Singh and Bhattacharjee, 1992). Seeds of different species viz., C. reticulata, C. oleifera, and C. japonica, have been used as a source of cooking oil, raw materials for cosmetics, soaps and medicines. Hence, it has unique and proved significant nutritional and health benefits (Rho et al., 2019; Liu et al., 2016; Zeb, 2012; Lin and Fan, 2011).

Assam tea is widely grown for its leaves and is commercialized as black tea. It has been reported that tea seeds are produced only for the production of planting material (Sarmah et al., 2018). After planting, seeds can be freshly harvested from third year onwards. Seed yield is maximum of 6.42 qtls ha-1, under triangular planting system with 3 x 3 m spacing under normal growing conditions (Das and Konowor, 2002). This is the first comprehensive report on physico-chemical properties of these three Tea Research Association (TRA) released seed stock to ascertain its potential applications.

Materials and methods

The present research work was carried using oils from three bi-clonal hybrid seed stocks namely TS 557, TS 589 and TSS 1 of Camellia sinensis L. samples obtained from Tocklai Tea Research Institute, TRA Jorhat, Assam released to the tea

| Stock no. | Year of release | Parents /generative clones |
|-----------|-----------------|---------------------------|
| TS 557    | 1996            | (TRA/AV 2 x TA 17/1/54)   |
| TS 589    | 1996            | (TV 20 x TRA /HK 22/14)   |
| TSS 1     | 2015            | (TV 13 x TV 17)           |

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industry in different decades. The detailed information of the seed stocks is shown in Table 1.

**Tea seed oil extraction**

The oil was extracted from the freshly harvested dried cotyledons of matured tea seeds of three different bi-clonal tea seed stocks, commercially maintained for propagation purposes. Oil extraction was carried out using the method followed by Lee and Yen (2006). Extracted oil kept at -20 °C for further analysis.

**Physical and chemical evaluation of tea seed oils**

Per cent oil in the seed was quantified by the official method (AOAC, 2000). The extracted oils were analyzed for density, refractive index, colour, pH, calorific value, smoke point, iodine value, peroxide value, saponification following standard methods of AOCS (1997).

**Fatty acid composition**

All the standards for fatty acid profiling (standard mixture), β-carotene and tocopherols were purchased from Sigma-Aldrich (USA). Methanol, ethanol, potassium hydroxide, sodium chloride and other chemicals used were of analytical reagent grade.

Fatty acids were determined using gas chromatography/mass spectrometry (GC/MS) by AOAC (2005) official method 996.06.

**Anti-oxidant activity**

The anti-oxidant activity was estimated using 2, 2-diphenly-1-picrylhydrazyl (DPPH) assay Duh et al. (2001).

**Vitamins**

β-carotene was determined by AOAC (1984) official method, and tocopherol was quantified, according to Wrolstad (2003).

**Statistical analysis**

All results of physicochemical particular of oil were analyzed from INDOSTAT-EXE statistical software. Analysis of variance (ANOVA) followed by Duncan’s multiple range tests (DMRT) was used for the analysis of the results. The means of each treatment (as mentioned in respective experiments) and their interactions were compared and found statistically significant (P<0.05).

**Results and discussion**

Physico-chemical profiling of bi-clonal seed stocks oil is presented in Table 2. The oil content of bi-clonal hybrid seed stocks ranged between 20.8 - 21.9 per cent. The maximum seed oil was found in TSS 1 (21.9 per cent). Oil content from 15 to 27 per cent was reported earlier in tea seed (Wang et al., 2011; Yahaya et al., 2011, Sarmah and Das, 2018) and 17.5 to 25.2 per cent in Kenyan tea seed stocks (George et al., 2013).

In the present study, the highest oil density was found to be 0.94 g per cm³ in TS 557, and the lowest was 0.92 g cm⁻³ in TS 589. However, *Camellia oleifera* seed oil was reported to have a density of 0.904 g per cm³ (Hui-Chen, 2007). Oil colour and oil pH were in the ideal range of 4.45 to 4.47 and 4.62 to 4.64, respectively. The highest iodine value was recorded as 85.65 g of I₂ per 100 g in TSS 1, and the lowest was found 82.74 g of I₂ per 100 g in TS 557. The saponification value (SV) was found to be highest in TS 589 (185.7 mg KOH g⁻¹) followed by TS 557 (185.5 mg KOH g⁻¹). The tea seed oil exhibited a good oxidative state as indicated by low peroxide values from 1.17 to 2.63 meq kg⁻¹ of oil. The values lower than sunflower oil (7.9 meq kg⁻¹) and olive oil (10 meq kg⁻¹) were reported by Diaz et al. (2006). The highest antioxidant activity was displayed by the oil obtained from seed stock TSS 1 (7.14%), followed by TS 589 (6.48%). The order of effectiveness of oils in inhibiting free radicals was TSS 1>TS 589> TS 557. Oleic acid (C18:1) is the major fatty acid followed by linoleic acid (C18:2), palmitic acid (C16:0) and stearic acid (C18:0) (Zeb, 2012; Wang et al., 2011, Yahaya et al., 2011, Sengupta et al., 1976, Tokue et al., 1989 and Ravichandran, 1993). Highest oleic acid was reported in the TSS 1 (50.80%) followed by TS 589 (41.53%). It was reported that the oleic acid was the major fatty acid in the *Camellia* spp (Das and Knowor, 2002; Sahari et al., 2004; Hui-Chen, 2007; Zhou, 1995; Rajaei, 2005; Deng et al. 1993; Ataii et al. 2003; Sarmah and Das, 2018). Lipid characteristics of the *Camellia* seeds significantly affected by the planting region and the cultivar type (Zeng and Endo, 2019).
Table 2. Physico-chemical profiling of tea seed oils.

| Parameters                      | TS 557        | TS 589        | TSS1         |
|---------------------------------|---------------|---------------|--------------|
| Seed oil (%)                    | 20.8 ± 0.01   | 20.8 ± 0.07   | 21.9 ± 0.05  |
| Oil colour (Y+5R)               | 4.45 ± 0.01   | 4.63 ± 0.01   | 4.47 ± 0.01  |
| Oil pH                           | 4.62 ± 0.02   | 4.64 ± 0.03   | 4.64 ± 0.01  |
| Oil density (g cm⁻³) 36 °C      | 0.94 ± 0.02   | 0.92 ± 0.002  | 0.93 ± 0.006 |
| Viscosity (cP)                   | 264.9 ± 0.05  | 261.3 ± 0.07  | 261.9 ± 0.03 |
| Calorific value (J 100g⁻¹)      | 6870.5 ± 0.91 | 6891.1 ± 0.49 | 6822.5 ± 0.26 |
| Smoke point (°C)                | 251.53 ± 0.92 | 247.33 ± 0.61 | 247.29 ± 0.25 |
| Iodine value (g of I₂ 100g⁻¹)   | 82.74 ± 0.04  | 83.41 ± 0.24  | 85.65 ± 0.03 |
| Saponification value (mg KOH g⁻¹)| 185.49 ± 0.43| 185.72 ± 0.58 | 185.33 ± 0.04 |
| Refractive index (40 °C)        | 1.461 ± 0.01  | 1.46 ± 0.000  | 1.46 ± 0.000 |
| Peroxide value (meq kg⁻¹)       | 2.63 ± 0.03   | 2.57 ± 0.01   | 1.17 ± 0.01  |
| Antioxidant activity (DPPH free radical scavenging activity) (%) | 6.30 ± 0.27 | 6.48 ± 0.01 | 7.14 ± 0.03 |
| β-carotene (mg kg⁻¹)            | 12.93 ± 0.01  | 9.60 ± 0.08   | 4.62 ± 0.26  |
| α-tocopherol (mg kg⁻¹)          | 366.52 ± 0.47 | 343.16 ± 1.60 | 90.49 ± 0.47 |
| γ-tocopherol (mg kg⁻¹)          | 4.35 ± 0.01   | 7.9 ± 0.07    | 45.6 ± 0.50  |
| Fatty acids (%)                 |               |               |              |
| C14:0 (Myristic acid)           | 0.11 ± 0.01   | 0.18 ± 0.01   | 0.10 ± 0.00  |
| C16:0 (Palmitic acid)           | 21.22 ± 0.21  | 20.15 ± 0.01  | 20.52 ± 0.04 |
| C16:1 (Palmitoleic acid)        | 0.16 ± 0.01   | 0.12 ± 0.01   | 0.15 ± 0.02  |
| C18:0 (Stearic acid)            | 3.23 ± 0.02   | 4.28 ± 0.02   | 5.34 ± 0.03  |
| C18:1 (Oleic acid)              | 2.15 ± 0.00   | 41.53 ± 0.03  | 50.80 ± 0.07 |
| C18:2 (Linoleic acid)           | ND            | 31.91 ± 0.04  | 21.21 ± 0.03 |
| C18:3 (Linolenic acid)          | 0.37 ± 0.01   | 0.50 ± 0.05   | 0.27 ± 0.00  |
| C20:0 (Arachidic acid)          | ND            | 0.13 ± 0.01   | 0.12 ± 0.00  |
| C20:1 (Palmitic acid)           | ND            | 0.72 ± 0.01   | ND           |
| SFA (Saturated fatty acid)       | 24.73 ± 0.04  | 24.83 ± 0.18  | 26.13 ± 0.01 |
| MUFA (Mono unsaturated fatty acid)| 43.05 ± 0.04| 42.59 ± 0.48 | 51.20 ± 0.13 |
| PUFA (Poly unsaturated fatty acid) | 30.02 ± 0.02| 32.47 ± 0.06 | 21.48 ± 0.01 |
| P/S (PUFA/SFA) index            | 1.21 ± 0.01   | 1.31 ± 0.01   | 0.82 ± 0.00  |

Each value is a mean of three replicate, Mean ± Standard Deviation. Different parameters were analysed using ANOVA to detect significant difference between means. Means were compared using Duncan’s Multiple Range Test (DMRT) at P<0.05. Mean with the same alphabets in columns are not significant. ND=not detected.

In the present study, the highest polyunsaturated fatty acids (PUFA) was found in TS 589 (32.47%), whereas the lowest PUFA was found in TSS 1 (21.48%). Earlier, in the seed oil, PUFA was reported to be 64.33 and 26.63 per cent (Sarmah and Das, 2018). The saturated fatty acids (SFA) ranging between 24.83 per cent and 26.13 per cent were also found in the bi-clonal seed stocks studied. The saturated fatty acid in the tea seed oil was reported to be 2.21 to 20.3 per cent (Sarmah and Das, 2018).

The abundance of oleic acid (50.80%) and substantial-high smoke point (247.29°C) in TSS 1 make it suitable as cooking oil, which is similar to olive oil (Lee et al., 1998). Low-abundance fatty acids were also found in oil samples viz., C14:0, C16:1, C18:3, C20:0, and C20:1. Such trace fatty acids have hardly ever been reported in tea seed oils. The relative PUFA/SFA (P/S) index of bi-clonal tea seed oil varied between 0.82-1.31. Their favourable ranges from 0.8 to 1.0 (WHO, 2003) help
to reduce the risk of cardio-vascular diseases (Kang et al., 2005).

The b-carotene and a-tocopherol showed significant differences among the seed stocks. Highest b-carotene was observed in TS 557 (12.93 mg kg⁻¹) followed by TS 589 (9.60 mg kg⁻¹). The bi-clonal seed stock TS 557 recorded the highest content of a-tocopherol (366.52 mg kg⁻¹), followed by TS 589 (343.16 mg kg⁻¹) which indicated tea seed oil is a good source of a-tocopherol. b-carotene and a-tocopherol are used for malignancy deterrence and heart diseases (Gimeno et al., 2000; Noromura, 1987; Nyam et al., 2009).

Conclusion

TSS 1 contents high oleic acid with considerable low SFA level, high smoke point and having ideal oil colour, oil pH and P:S index closer to WHO recommended value which makes the oil nutritionally valuable, whereas TS 557 is a good source of vitamin E due to highest a-tocopherol. These physicochemical qualities indicate possible uses of oil for product diversification.

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