Research Article

doi: 10.25081/jpc.2020.v48.i3.6633
Journal of Plantation Crops, 2020, 48(3): 247-251

Tea seed oil: Physicochemical profiling

Pradeep Kumar Patel*, Rupak Sarma, Buddhadeb Das[1], Shobhit Kumar Singh and Anoop Kumar Barooah

Tocklai Tea Research Institute, Tea Research Association, Jorhat-785 008, Assam, India
[1]North Bengal Regional R & D Centre, Tea Research Association, Jalpaiguri-735 225, West Bengal, India

(Manuscript Received: 20-08-2020, Revised: 08-10-2020, Accepted: 12-10-2020)

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 (^oC), 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 cm^3), 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

Table 1. TRA released bi-clonal hybrid tea seed stocks

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)

**Corresponding Author: pradeepk.bhu@gmail.com*

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 ^{o}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 cm^3 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 cm^3 (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 I_2 per 100 g in TSS 1, and the lowest was found 82.74 g of I_2 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^{j}	20.8 ± 0.07^{j}	21.9 ± 0.05^{j}
Oil colour (Y+5R)	4.45 ± 0.01^{lm}	4.63 ± 0.01^{lmn}	4.47 ± 0.01^{kl}
Oil pH	4.62 ± 0.02^{lm}	4.64 ± 0.03^{lmn}	4.64 ± 0.01^{kl}
Oil density (g cm^{-3}) 36 ^{0}C	0.94 ± 0.02^{no}	0.92 ± 0.002^{no}	0.93 ± 0.006^{lm}
Viscosity (cP)	264.9 ± 0.05^{c}	261.3 ± 0.07^{c}	261.9 ± 0.03^{b}
Calorific value (J 100g^{-1})	6870.5 ± 0.91^{a}	6891.1 ± 0.49^{a}	6822.5 ± 0.26^{a}
Smoke point (^{0}C)	251.53 ± 0.92^{d}	247.33 ± 0.61^{d}	247.29 ± 0.25^{c}
Iodine value (g of I_2 100 g^{-1})	82.74 ± 0.04^{f}	83.41 ± 0.24^{f}	85.65 ± 0.03^{f}
Saponification value (mg KOH g^{-1})	185.49 ± 0.43^{e}	185.72 ± 0.58^{e}	185.33 ± 0.04^{d}
Refractive index (40 ^{0}C)	1.461 ± 0.01^{no}	1.46 ± 0.000^{no}	1.46 ± 0.000^{lm}
Peroxide value (meq kg^{-1})	2.63 ± 0.03^{mno}	2.57 ± 0.01^{mno}	1.17 ± 0.01^{lm}
Antioxidant activity (DPPH free radical scavenging activity) (%)	6.30 ± 0.27^{l}	6.48 ± 0.01^{klm}	7.14 ± 0.03^{k}
β-carotene (mg kg^{-1})	12.93 ± 0.01^{k}	9.60 ± 0.08^{k}	4.62 ± 0.26^{kl}
α-tocopherol(mg kg^{-1})	366.52 ± 0.47^{b}	343.16 ± 1.60^{b}	90.49 ± 0.47^{e}
γ-tocopherol (mg kg^{-1})	4.35 ± 0.01^{m}	7.9 ± 0.07^{kl}	45.62 ± 0.50^{h}
Fatty acids (%)			
C14:0 (Myristic acid)	0.11± 0.01^{o}	0.18 ± 0.01^{o}	0.10 ± 0.00^{m}
C16:0 (Palmitic acid)	21.22 ± 0.21^{j}	20.15 ± 0.01^{j}	20.52 ± 0.04^{j}
C16:1 (Palmitoleic acid)	0.16 ± 0.01^{o}	0.12 ± 0.01^{o}	0.15 ± 0.02^{m}
C18:0 (Stearic acid)	3.23 ± 0.02^{mn}	4.28 ± 0.02^{lmno}	5.34 ± 0.03^{k}
C18:1 (Oleic acid)	2.15 ± 0.01^{mno}	41.53 ± 0.03^{g}	50.80 ± 0.07^{g}
C18:2 (Linoleic acid)	ND	31.91 ± 0.04^{h}	21.21 ± 0.03^{j}
C18:3 (Linolenic acid)	0.37 ± 0.01^{o}	0.50 ± 0.05^{no}	0.27 ± 0.0^{1m}
C20:0 (Arachidic acid)	ND	0.13 ± 0.01^{o}	0.12 ± 0.0^{1m}
C20:1 (Paulinic acid)	ND	0.72 ± 0.01^{no}	ND
SFA (Saturated fatty acid)	24.73 ± 0.04^{i}	24.83 ± 0.18^{i}	26.13 ± 0.01^{i}
MUFA (Mono unsaturated fatty acid)	43.05 ± 0.04^{g}	42.59 ± 0.48^{g}	51.20 ± 0.13^{g}
PUFA (Poly unsaturated farry acid)	30.02 ± 0.02^{h}	32.47 ± 0.06^{h}	21.48 ± 0.01^{j}
P/S (PUFA/SFA) index	1.21 ± 0.01^{no}	1.31 ± 0.01^{no}	0.82 ± 0.00^{lm}

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^{o}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.

Acknowledgements

Authors gratefully acknowledge the receipt of research grant from Science and Engineering Research Board (SERB), Department of Science and Technology (DST), Government of India, New Delhi (Sanction no.ECR/2016/000002) for the work reported herein.

References

AOAC. 1984. Vitamins and other nutrient. Official Methods of Analysis Association of Official Analytical Chemists. Inc. Arlington, Virginia, 884-847.

AOAC. 2000. *Official Methods* 981.11, 17th Ed. Oils and Fats Preparation of test sample.

AOAC. 2005 *Official Methods* 996.06 revised AOAC International Gaithersburg, MD.

AOCS. 1997. *Official and Recommended Practices of the AOCS*, 5th Ed. American Oil Chemist's Society Press, Champaign, USA.

Ataii, D., Sahari, M.A. and Hamedi, M. 2003. Some physico-chemical characteristics of tea seed oil. *Journal of Science and Technology of Agriculture and Natural Resources* **7:** 173-183.

Das, S.C. and Konowor, B.K. 2002. Tea seed production. In; *Notes on Field Management*. Tea Research Association, Tocklai Experimentation Station, Jorhat, pp. 19-26.

Deng, P.J., Zhang, Y.H. and Huang, J.X. 1993. A study of the effect of tea seed oil on serum lipid in normal adults. *Acta Nutrimenta Sinica* **3**: 289-292.

Diaz, M.F., Hernandez, R., Martinez, G., Vidal, G., Gomez, M., Fernandez, H. and Garces, R. 2006. Comparative study of ozonized olive oil and ozonized sunflower oil. *Journal of Brazilian Chemical Society* **17:** 403-407.

Duh, P.D., Yen, G.C., Yen, W.J. and Chang, L.W. 2001. Anti-oxidant effects of water extracts from barley (*Hordeum vulgare* L.) prepared under different roasting temperatures. *Journal of Agricultural and Food Chemistry* **49:** 1455-1463.

George, K.O., Kinyanjui, T., Wanyoko, J., Moseti, O.K. and Wachira, F. 2013. Extraction and analysis of tea (*Camellia sinensis*) seed oil from different clones in Kenya. *African Journal of Biotechnology* **12**: 841-846.

Gimeno, E., Calero, E., Castellote, A., Lamuela-Raventos, R.M., de la Torre, M.C. and Lopez-Sabater, M.C. 2000. Simultaneous determination of alpha-tocopherol and beta-carotene in olive oil by reversed-phase high-performance liquid chromatography. *Journal of Chromatography A* **88**: 255-259.

Hui-Chen, Y. 2007. Physiochemical properties and bio-activities of tea seed (*Camellia oleifera*) oil. *M. Sc. Thesis*, Graduate School of Clemson University, USA.

Kang, M.J., Shin, M.S., Park, J.N. and Lee, S.S. 2005. The effects of polyunsaturated:saturated fatty acids ratios and peroxidisability index values of dietary fats on serum lipid levels and hepatic antioxidant enzyme activities in rats. *Korean Journal of Nutrition* **36**: 245-254.

Lee, C.P. and Yen, G.C. 2006. Antioxidant activity and bioactive compounds of tea seed (*Camellia oleifera* Abel.) oil. *Journal of Agricultural and Food Chemistry* **54**: 779-784.

Lee, D.S., Noh, B.S., Bae, S.Y. and Kim, K. 1998. Characterization of fatty acids composition in vegetable oils by chromatography and chemometrics, *Analitica Chimica Acta* **358**: 163-175.

Lin, C.Y. and Fan, C.L. 2011. Fuel properties of biodiesel produced from *Camellia oleifera* Abel oil through supercritical-methanol transesterification. *Fuel* **90**: 2240–2244.

Liu, G., Xu, S., Wang, X., Xu, G. and Zhang, H. 2016. Analysis of the volatile components of tea seed oil (*Camellia sinensis* O. Ktze) from China using HS-SPME-GC/MS. *International Journal of Food Science and Technology* **51**(12): 2591-2602.

Nyam, K.L., Tan, C.P., Lai, O.M., Long, K. and Che Man, Y.B. 2009. Physicochemical properties and bioactive compounds of selected seed oils. *LWT - Food Science and Technology* **42**: 1396-1403.

Rajaei, A., Barzegar, M. and Yamini, Y. 2005. Supercritical fluid extraction of tea seed oil and its comparison with solvent extraction. *European Food Research and Technology* **220:** 401-405.

Ravichandran, R. 1993. Fat stability and amino acids in south Indian tea seeds. *International Journal of Food Science and Technology* **28**: 639-646.

Rho, T., Choi, S.J., Kil, H.W., Ko, J. and Yoon, K.D. 2019 Separation of nine novel triterpene saponins from *Camellia japonica* seeds using high-performance counter current chromatography and reversed-phase high-performance liquid chromatography. *Phytochemical Analysis* **30**(2)**:** 226-236.

Sahari, M.A., Ataii, D.A. and Hamedi, M. 2004. Characteristics of tea seed oil in comparison with sunflower and olive oils and its effect as a natural antioxidant. *Journal of the Ammerican Oil Chemists' Society* **81**: 585-588.

Sarmah, K. and Das, P. 2018. Biochemical characteristics, fatty acid profiles and antioxidant activities of tea seed oil. *Current Science* **114**(12): 25.

Sarmah, K., Das, P., Saikia, G.K. and Sarmah, T.C. 2018 Biochemical characterization of tea (*Camellia* spp.) seed oil cake. *Bulletin of Environmental, Pharmceutical and Life Sciences* **7**(8): 98-102.

Sengupta, C., Sengupta, A. and Ghosh, A. 1976. Triglyceride composition of tea seed oil. *Journal of the Science of the Food Agriculture* **27**: 1115-1122.

Singh, I.D. and Bhattacharjee, H. 1992. Tea seed oil. *Two and a Bud* **39**(2): 7-11.

Tokue, C., Kataokam E. and Tanimura, W. 1989. Characterization of lipids in tea (*Camellia sinensis*) seeds cultivated in Taiwan and Japan. *Journal of Japan Society of Nutrition and Food Sciences* **42**: 71-77.

Wang, Y., Sun, D., Chen, H., Qian, L. and Xu, P. 2011. Fatty acid composition and antioxidant activity of tea (*Camellia sinensis* L.) seed oil extracted by optimized supercritical carbon dioxide. *International Journal of Molecular Sciences* **12**: 7708-7719.

WHO, 2003. Diet, Nutrition and the prevention of chronic diseases. WHO Technical Report Series 916.

Wrolstad, R.E. 2003. Analysis of tocopherols and tocotrienols. In: *Current Protocols in Food Analytical Chemistry***,** (Ed.) Wrolstad, R.E., John Willey & Sons, U.K.

Yahaya, L.E., Adebowale, K.O., Olu-Owolabi, B.I. and Menon, A.R.R. 2011. Compositional analysis of tea (*Camellia sinensis*) seed oil and its application. *International Journal of Research in Chemistry and Environment* **1**: 153-158.

Zeb, A. 2012. Triacylglycerols composition, oxidation and oxidation compounds in *Camellia* oil using liquid chromatography-mass spectrometry. *Chemistry and Physics of Lipids* **165**(5)**:** 608-614.

Zeng, W., and Endo, Y. 2019. Effects of cultivars and geography in China on the lipid characteristics of *Camellia oleifera* seeds. *Journal of Oleo Science* **68**(11): 1051-1061.

Zhou, L.X. 1995. Study on development and utilization of tea seed from Yunnan big leaf tea. *Yunnan Journal of Animal Science and Veterinary Medicine* **17**: 24-26.