Characteristics of Tea Seed Oil in Comparison with Sunflower and Olive Oils and Its Effect as a Natural Antioxidant

Mohammad Ali Sahari[a,*], Davood Ataii[a], and Manuchehr Hamedi[b]

[a]Food Technology Department, College of Agriculture, University of Tarbiat Modarres, Tehran, Iran, and
[b]Food Science and Technology Department, College of Agriculture, University of Tehran, Karaj, Iran

ABSTRACT: A comparison of iodine values showed that the degree of saturation of tea seed oil (Lahijan variety) was intermediate between the oils of sunflowerseed (Fars variety) and olive (Gilezeytoon variety), and the saponification values of these three oils were similar. Tea seed oil consisted of 56% oleic acid (C18:1), 22% linoleic acid (C18:2), 0.3% linolenic acid (C18:3), and therefore, on the basis of oleic acid, occupied a place between sunflower and olive oil. In studies at 63°C, the shelf life of tea seed oil was higher than that of sunflower oil and similar to olive oil. Tea seed oil was found to have a natural antioxidant effect, and it enhanced the shelf life of sunflower oil at a 5% level. In this study, tea seed oil was found to be a stable oil, to have suitable nutritional properties (high-oleic, medium-linoleic, and low-linolenic acid contents), and to be useful in human foods.

Paper no. J10693 in *JAOCS 81*, 585–588 (June 2004).

KEY WORDS: Characteristic, functional product, natural antioxidant, olive oil, sunflower oil, tea seed oil.

Like other genera of *Camellia* (from Theaceae family), the tea plant (*C. sinensis*) produces large oily seeds (1). In some countries where tea seed oil is abundantly available, it has been accepted as an edible oil. China, India, Sri Lanka, Java Island (Indonesia), and Japan currently produce thousands of tons of tea seed oil annually (2). Some farmers in China and Japan plant *C. japonica, C. sasanqua,* and *C. oleifera* primarily for the edible oils they yield (2).

Several authors have investigated the edibility and quality of tea seed oil. Sengupta *et al.* (2) determined the composition of TAG in Indian tea seed oil and found that oleic (C18:1), linoleic (C18:2), palmitic (C16:0), and stearic (C18:0) acids were the major FA. Ravichandran and Dhandapani (1) evaluated the composition of three tea seed varieties of southern India and found that they consisted mainly of oleic and linoleic acids; some tea seed oils were found to resemble olive or peanut oils (1). They also reported that the oil in tea seed amounted to 30–32% (when computing the kernel and seed ratio, the value was 20%), remained liquid even at refrigeration temperature, and enjoyed a high organoleptic acceptability.

Tang *et al.* (3) studied the production and properties of Indian tea seed oil and reported that C18:1 was the major constituent FA. They reported that this oil after hydrogenation could be used as a cocoa butter replacer. Tokue *et al.* (4) studied Taiwanese and Japanese tea seeds. The major FA in these varieties were C18:1, C18:2, and C16:0; of the tocopherols, only α-tocopherol was detected.

An extensive research program to assess the commercial feasibility and characteristics of tea seed oil in Iran has been undertaken at the University of Tarbiat Modarres. In Chinese varieties of tea, which constitute the major tea plantations in Iran, 975–1300 kg of seed per hectare could be collected annually (5). In considering that the oil content of tea seed is 20% (1,5), this oil could be important as a raw material and functional product.

EXPERIMENTAL PROCEDURES

The main materials, tea seed (Lahijan variety), sunflowerseed (Fars variety), and olive (Gilezeytoon variety), were obtained from Iranian farms in the Lahijan, Fars, and Gilan regions, respectively. The chemicals used for this study were obtained from Merck (Darmstadt, Germany). Five days after collection on the farm (located in the north of Iran) and transfer to the university laboratory in baskets at ambient conditions, the tea seeds *(C. sinensis)* were oven-dried at 102°C (moisture = 15%). The oil was then extracted in a Soxhlet apparatus with petroleum ether (b.p. range 40–60°C) for 6 h (6). After grinding, tea seed and sunflowerseed oils were extracted by the solvent method; olive oil was extracted by the press method (7). Oils were first clarified by centrifugation at 2500 × *g* and were then filtered through fine cheesecloth.

GC was used to determine the FA profile; this entailed using a fused-silica capillary column (BPX70; SGE, Melbourne, Australia), 100 m × 0.25 mm × 0.39 μm film thickness; a split injector (1.2 μL injection) at 240°C, and an FID at 250°C. Helium was used as carrier gas (pressure of 50 psi). The temperatures of the column, detector, and injection port were 190, 300, and 250°C, respectively (6).

The iodine value (IV) was determined with the Hanus method, and saponification value (SV) with the chemical method (6).

The shelf life was determined by the oven test at 63°C and continued measurement of PV (6). The effect of tea seed oil as a natural antioxidant in enhancing the shelf life of sunflower and olive oils was tested by adding tea seed oil at two levels (5 and 10%) and then performing the oven test again (6).

*To whom correspondence should be addressed at Food Technology Department, College of Agriculture, University of Tarbiat Modarres, P.O. Box 14115-111, Tehran, Iran.
E-mail: masahari@noavar.com or sahari@modares.ac.ir

TABLE 1
ANOVA for Saponification Values (SV) and Iodine Values (IV) in Tea Seed, Sunflowerseed, and Olive Oils

Source of variation	DF	Sum of squares (SS)		Mean square (MS)		Observed *F*		Necessity *F* (5%/1%)	
		SV[a,b]	IV[b,c]	SV	IV	SV	IV	SV	IV
Total value	14	179.7	8921.500			21.045	926.561	3.89/6.93	
Treatments	2	139.6	8864.1	69.8	4422.05				3.89/6.93
Error	12	39.8	57.4	3.317	4.873				

[a]mg KOH/g.
[b]Averages of SV and IV in the three kind of oils were significantly different at $P < 0.10$.
[c]Hanus method: 1 mL of $Na_2S_2O_3$ (N/10) = 0.01269 I_2.

TABLE 2
FA Profiles of Tea Seed, Sunflowerseed, and Olive Oils[a]

Samples	C14:0	C16:0	C16:1	C18:0	C18:1(*cis*)	C18:2(*cis*)	C18:3	C20:0	C20:1
Tea seed oil	—	16.5 ± 1.05	—	3.343 ± 0.75	56.97 ± 0.44	22.17 ± 0.28	0.3 ± 0	0.533 ± 0.207	—
Sunflowerseed oil	0.1 ± 0	6.2 ± 0.1	—	6.367 ± 0.057	24.93 ± 0.057	61.37 ± 0.057	0.29 ± 0.012	0.540 ± 0.051	—
Olive oil	—	10.23 ± 0.05	0.423 ± 0.028	3.233 ± 0.056	76.20 ± 0.2	8.567 ± 0.114	0.1967 ± 0.0056	0.320 ± 0.1133	0.45 ± 0.045

[a]Data are reported as percentages.

TABLE 3
ANOVA for C18:1, C18:2, and C18:3 in Tea Seed, Sunflowerseed, and Olive Oils

Source of variation	DF	Sum of squares (SS)			Mean square (MS)			Observed *F*			Necessity *F* (5%/1%)		
		C18:1[a]	C18:2[a]	C18:3[a]	C18:1	C18:2	C18:3	C18:1	C18:2	C18:3	C18:1	C18:2	C18:3
Total value	8	4025.060		0.077				16463.77	6764.51	0.837	5.14/10.92	5.14/10.92	5.14/10.92
Treatments	2	4024.27	4509.44	0.017	2012.163	2254.72	0.008						
Error	6	0.733	0.200	0.020	0.122	0.033	0.010						

[a]For the three kind of oils, differences were at $P < 0.10$ in C18:1 and C18:2; they were not significant for differences C18:3.

The FA contents of three kinds of oil (tea seed, sunflowerseed, and olive) were analyzed by statistical calculation (MSTATC: a program originated by M.S. Sahari); fat content, IV, and SV were analyzed by a multifactorial ANOVA, and the FA average contents by the Duncan test (8–10).

RESULTS AND DISCUSSION

Averages of the IV and SV in tea seed, sunflowerseed, and olive oils were 85.00, 130.09, 75.10 (± 0.5) (Hanus method: 1 mL of $Na_2S_2O_3$ N/10 = 0.01269 I_2) and averages of SV in tea seed, sunflowerseed, and olive oils were 194.9, 197.7, 190.3 (±1) (mg KOH/g), respectively. The IV and SV ANOVA are presented in Table 1. The difference between IV values in tea seed and sunflowerseed oils and between sunflowerseed and olive oils was significant ($n = 3$; $P < 0.10$); however, IV for tea seed and olive oil values were similar. No significant difference in SV was found. This result confirms that of Weihrauch and Teter (11), who reported that tea seed oil properties could be comparable to olive oil. The FA profile for the three kinds of

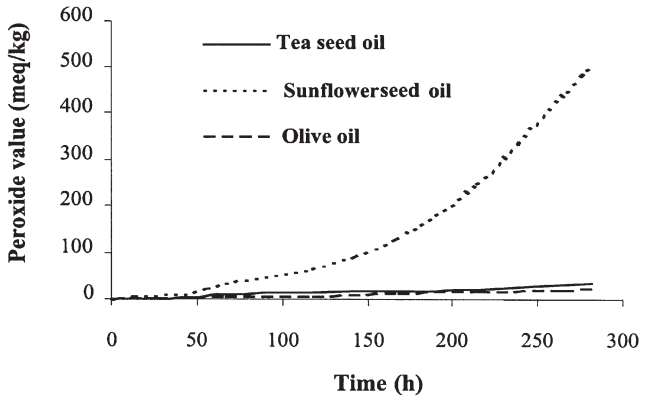

FIG. 1. Comparison of the peroxide values of tea seed, sunflowerseed, and olive oils at 63°C.

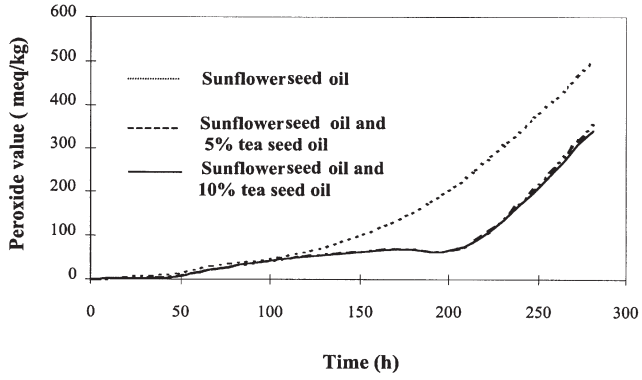

FIG. 2. Comparison of the peroxide values of pure sunflowerseed oil and of that mixed with 5 and 10% tea seed oil.

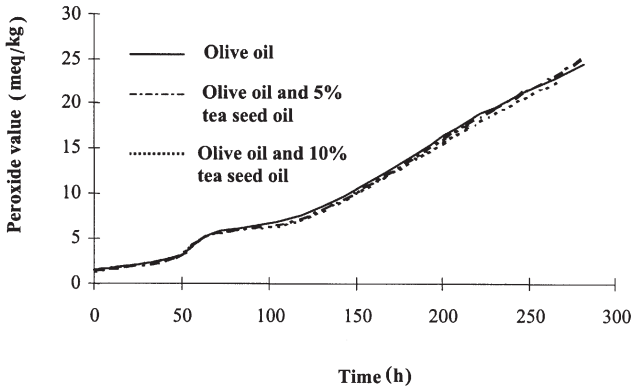

FIG. 3. Comparison of the peroxide value of pure olive oil and of that mixed with 5 and 10% tea seed oil.

oils as determined by GC and the ANOVA for C18:1, C18:2, and C18:3 are presented in Tables 2 and 3, respectively. Comparison of these data showed a similarity between tea seed oil and olive oil with respect to these properties. This result confirms that of Belitz and Grosch (12), who reported that the FA composition of tea seed oil was very similar to that of olive oil. Shelf life as determined by the oven test at 63°C was 14, 9, and 15 d for tea seed, sunflowerseed, and olive oils, respectively; the shelf life of sunflowerseed and olive oils mixed with tea seed oil at two levels of 5 and 10% were 11, 11 (sunflowerseed oil mixed with 5 and 10% tea seed oil, respectively), 15, and 15 d (olive oils mixed with 5 and 10% tea seed oil, respectively).

The storage stability of tea seed oil resembled that of olive oil and was higher than that of sunflowerseed oil. This means that tea seed oil in the amount of 5 and 10% affected the shelf life of only sunflowerseed oil. The high stability of the tea seed oil was probably due to the low content of glycerides of linolenic and linoleic acids and to the presence of polyphenols and vitamin E as antioxidants (13). The change in PV with time in pure and mixed oils is presented in Figures 1–3.

In Table 4 some characteristics of tea seed oil from Iran (present study) and other countries (1,15,16) are compared. The ratio of kernel to seed coat in the tea seed sample from Iran with 15% moisture was 65:35; in five repetitions the oil content was 30.5% (computing the kernel and seed ratio, it was 20%); therefore, it was similar to Indian, Turkish, and Korean tea seeds (1,5, 14–16).

The intensely yellow oil remained clear and liquid during storage even at refrigeration temperatures and after a few days of being stored in the refrigerator. It seems that the presence of carotenoids in the tea seed oil caused this color and antioxidant activity (17,18). Tea seed oil also had acceptable organoleptic characteristics, which make it useful as a salad oil. The same properties were reported by Salunkhe *et al.* (19).

Owing to its high percentage of unsaturated FA, especially C18:1 and C18:2, tea seed oil can be considered as edible oil; this result also was reported by Ravichandran (13) and Ravichandran and Dhandapani (1) for southern Indian tea seed oil. Probably because of the low content of TAG that contain linoleic acid (in comparison with sunflowerseed oil) and linolenic acid and because of the high natural antioxidant content, the Iranian tea seed oil showed a higher degree of stability (18). Tea seed oil had little tendency to dry because of the low C18:2 and C18:3 contents, which cause polymerization, as confirmed by Ravichandran (13) in southern Indian tea seed oil. Since partially

TABLE 4
Comparison of Characteristics of Tea Seed Oil from Iran with Seeds from Other Countries

Characteristic	Iranian tea seed oil oil (present study)	Southern Indian tea seed oil[a] (China variety)	Turkish tea seed oil[b]	Korean tea seed oil[c]
Kernel/seed coat ratio[d] (%)	65:35[e]	65:35	70:30	—
Oil content[f] (%)	30.5	31	32.8	—
IV[g,h]	85	91	90.9	—
SV[h] (mg KOH/g)	194.9	194	192.8	—
Physical appearance	Clear, liquid	Clear, liquid	Clear, liquid	—
FA content (%)				
C16:0	16.5	14.8	16	16.1
C18:0	3.343	3.1	1.67	1.5
C18:1	56.97	57.1	59.4	52.7
C18:2	22.17	22.5	21.8	22.8
C18:3	0.3	1.5	—	1.9
C20:0	0.533	—	1.23	—

[a]Reference 1.
[b]Reference 16.
[c]Reference 15.
[d]Calculated on the basis of wet weights.
[e]100 g seed per replicate; $n = 5$.
[f]SD was ±1%.
[g]Hanus method: 1 mL of $Na_2S_2O_3$ (N/10) = 0.01269 I_2.
[h]After storage for 5 d at refrigerator temperature. SV, saponification value; IV, iodine value.

hydrogenated sunflower oil is accepted for producing potato chips (19), the high C18:1 and low C18:2 levels in tea seed oil (in comparison with sunflower oil) should be useful in cooking and in the food industry.

Iranian tea seed oil had a higher palmitic acid content than sunflower oil (Table 3) and is suitable for margarine production (19), like the tea seed oils in southern India, Turkey, and Korea (13,15,16). According to the results, mixing tea seed oil with other oils, such as sunflowerseed, could increase their stability (Figs. 2,3). Therefore, it could be used directly as a natural antioxidant and functional product for increasing food stability.

REFERENCES

1. Ravichandran, R., and M. Dhandapani, Composition, Characteristics and Potential Uses of South Indian Tea Seeds, *J. Food Sci. Technol. 29*:394–396 (1992).
2. Sengupta, C., A. Sengupta, and A. Ghosh, Triglyceride Composition of Tea Seed Oil, *J. Sci. Food Agric. 27*:1115–1122 (1976).
3. Tang, L., E. Bayer, and R. Zhuang, Production, Properties and Use of Chinese Tea Seed Oil, *Fett Wissenschaft Technol. 95*:23–27 (1993).
4. Tokue, C., E. Kataoka, and W. Tanimura, Characterization of Lipids in Tea Seed Cultivated in Taiwan and Japan, *J. Jpn. Soc. Nutr. Food Sci. 42*:71–77 (1989).
5. Singh, I.D., Tea Variety Development and Management in Iran, Food and Agriculture Organization, Rome, TCP/IRA/6614, 1998, 185 pp.
6. Egan, H., R.S. Kirk, and R. Sawyer, *Pearson's Chemical Analysis of Foods*, 8th edn., Longman, Harlow, Essex, United Kingdom, 1987.
7. Tindale, L.H., and S.R. Hill-Haas, Current Equipment for Mechanical Oil Extraction, *J. Am. Oil Chem. Soc. 53*:265–270 (1976).
8. Hicks, C.R., and K.V. Turner, *Fundamental Concepts in the Design of Experiments*, 5th edn., Oxford University, Oxford, 1999.
9. Steel, R.G.D., J.H. Torrie, and D.A. Dickey, *Principles and Procedure of Statistics*: *A Biometrical Approach*, McGraw Hill, New York, 1997.
10. Yandell, B.S., *Practical Data Analysis for Designed Experiments*, Chapman & Hall, London, 1997.
11. Weihrauch, J.L., and B.B. Teter, Fruit and Vegetable By-products as Sources of Oil, in *Technological Advances in Improved and Alternative Sources of Lipids*, edited by B. Kamel and Y. Kakuda, Chapman & Hall, Glasgow, United Kingdom, 1994, pp. 177–208.
12. Belitz, H.D., and W. Grosch, *Food Chemistry,* 2nd edn. (translated from the 5th German edn. by M.M. Burghagen, D. Hadziyev, P. Hessel, S. Jordan, and C. Sprinz), Springer, Berlin, 1999, pp. 602–630.
13. Ravichandran, R., Fat Stability and Amino Acids in South Indian Tea Seeds, *Int. J. Food Sci. Technol. 28*:639–646 (1993).
14. Owuor, P., A. Chavanji, and R.M. Munavu, Chemical Studies of the Kenyan Tea Seeds. I, Physical and Chemical Characteristics of the Kernel Oil, *Tea 6*:23–28 (1985).
15. Rah, H.H., S.O. Baik, and S.B. Han, Chemical Composition of the Seed of the Korean Green Tea Plant (*Camellia sinensis* L.), *J. Kor. Agric. Chem. Soc. 35*:272–275 (1992).
16. Yazicioglu, T., A. Karaali, and J. Goekcen, Turkish Tea Oil and Tea Saponin, *Fett Seifen Anstrichm. 79*:115–120 (1997).
17. Hodgson, A.S., Refining and Bleaching, in *Bailey's Industrial Oil and Fat Products*, 5th edn., edited by Y.J. Hui, John Wiley & Sons, New York, 1996, Vol. 4, pp. 157–212.
18. Silkeberg, A., and S.P. Kochhar, Refining of Edible Oil Retaining Maximum Antioxidative Potency, U.S. Patent 6,033,706 (2000).
19. Salunke, D.K., J.K. Chavan, R.N. Adsule, and S.S. Kadam, *World Oilseeds*, Van Nostrand Reinhold, New York, 1992, pp. 87–248.

[Received July 10, 2003; accepted January 7, 2004]