

Sutour et al., 2017). The chemical composition of the twigs oil are listed in Table 3.

Table 3 Chemical Composition of *F. polyandra* Twigs Oil.

No.	Compound	KI (Calc.)	Percentage (%)
Sesquiterpenoids			
1	Hedycrayol	1562	23.5
2	γ -Eudesmol	1643	22.1
3	Elemol	1604	7.8
4	α -Eudesmol	1666	0.3
5	Eudesmol	1642	2.2
6	Amorpha-4,9-dien-2-ol	1771	0.5
7	Oplopanone	1870	2.2
8	Amorpha-4,7(11)-diene	1944	0.8
9	Acetyoxyelemol	1923	0.5
Sesquiterpene hydrocarbons			
11	α -Gurjunene	1494	0.5
11	δ -Elemene	1330	0.3
12	β -Elemene	1386	0.5
13	α -Gurjunene	1660	26.4
14	Sesquisabinene	1460	0.4
15	γ -Amorphene	1488	1.6
16	δ -Amorphene	1512	0.3
17	β -Curcumene	1517	0.4
18	δ -Cadinene	1531	0.3
19	γ -Cadinene	1615	3.5
20	Amorpha-4,7(II)-diene	1630	0.6
Monoterpene hydrocarbon			
21	Limonene	1034	1.9
Total (%)			96.6

CONCLUSION

This study is the first attempt to investigate the chemical composition of essential oils from the peels, leaves, and twigs of *F. polyandra*. The GC and GC-MS analysis of the essential oil showed that the peels oil is rich in monoterpene hydrocarbon (91.4%) with limonene (71.4%) as the most abundance in the oil, whereas sesquiterpenoids comprised as the major content for the leaves oil (75.2%) and twigs oil (59.9%) with α -eudesmol (31.1%) and hedycrayol (23.5%) as the major compound respectively.

ACKNOWLEDGEMENT

The authors are grateful to Research University Grant (GUP) under vote Q.J130000.2526.12H36 for financial support and Faculty of Science, Universiti Teknologi Malaysia for research facilities.

REFERENCES

- R. P. Adams. 2007. Identification of Essential Oil Components by Gas Chromatography/Mass Spectrometry, 4th ed. (Allured Publ., Carol Stream, IL).
- Arch, W. (1958). *Constituent of Cumquats: Flavone Kyoto College of Pharmacy October Kyoto*. Takao Matsuno Hattori, Hasegawa, Shimokoriyama: *Nippon Kagaku Zasshi*, 65, 61 (1944). 126(1936), 1944.
- Çakmakçi, S., Topdaş, E. F., Çakir, Y., & Kalin, P. (2016). Functionality of kumquat (*Fortunella margarita*) in the production of fruity ice cream. *Journal of the Science of Food and Agriculture*, 96(5), 1451–1458. <https://doi.org/10.1002/jsfa.7241>
- Choi, H.-S. (2005). Characteristic Odor Components of Kumquat (*Fortunella japonica* Swingle) Peel Oil. *Journal of Agricultural and Food Chemistry*, 53, 1642–1647.
- Nouri, A., & Shafaghat, A. (2015). Chemical constituents and antioxidant activity of essential oil and organic extract from the peel and kernel parts of *Citrus japonica* Thunb. (kumquat) from Iran. *Natural Product Research*, 1–5.
- Peng, L.-W., Sheu, M.-J., Lin, L.-Y., Wu, C.-T., Chiang, H.-M., Lin, W.-H., Lee, M.-C., & Chen, H.-C. (2013). Effect of heat treatments on the essential oils of kumquat (*Fortunella margarita* Swingle). *Food Chemistry*, 136, 532–537.
- Quijano, C. E., & Pino, J. A. (2009). Volatile Compounds of Kumquat (*Fortunella margarita* (Lour.) Swingle) Leaf Oil. *Journal of Essential Oil Research*, 21(3), 194–196.
- Seidemann, J. (2005). World Spice Plants: Economic Usage, Botany and Taxonomy. In *Journal of Plantation Crops* (Vol. 1). Springer.
- Sicari, V., & Poiana, M. (2017). Comparison of the Volatile Component of the Essential Oil of Kumquat (*Fortunella margarita* swingle) Extracted by Supercritical Carbon Dioxide, Hydrodistillation and Conventional Solvent Extraction. *Journal of Essential Oil Bearing Plants*, 20(1), 87–94.
- Sutour, S., Luro, F., Bradesi, P., Casanova, J., & Tomi, F. (2016). Chemical composition of the fruit oils of five *Fortunella* species grown in the same pedoclimatic conditions in corsica (France). *Natural Product Communications*, 11(2), 259–262.
- Sutour, S., Luro, F., Casanova, J., & Tomi, F. (2017). Integrated Analysis by GC(RI), GC-MS and 1C NMR of *Fortunella japonica* Leaf Volatiles Obtained by Hydrodistillation, Microwave- assisted Hydrodistillation and Hydrolate Extraction. *Natural Product Communications*, 12(3), 431–434.
- Tan, si, Zhao, X., Yang, Y., Ke, Z., & Zhou, Z. (2016). Chemical Profiling Using Uplc Q-Tof/Ms and Antioxidant Activities of *Fortunella* Fruits. *Journal of Food Science*, 81. <https://doi.org/10.1111/1750-3841.13352>
- Wang, Y.-W., Zeng, W.-C., Xu, P.-Y., Lan, Y.-J., Zhu, R.-X., Zhong, K., Huang, Y.-N., & Gao, H. (2012). Chemical Composition and Antimicrobial Activity of the Essential Oil of Kumquat (*Fortunella crassifolia* Swingle) Peel. *International Journal of Molecular Sciences*, 13, 3382–3393.