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CHEMICAL COMPOSITIONS OF *PASSIFLORA EDULIS* SEED OIL CULTIVATED IN VIET NAM

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Abstract. The present research was aimed to study the chemical compositions of *Passiflora edulis* Sims seed oil, including the fatty acid, sterols, triglycerides, and tocopherols. The oil content of the seeds was 24.88 % (w/w) by using the Soxhlet method and mainly consisted of linoleic acid (ω-6, 66.94 %) and oleic acid (ω-9, 18.86 %). Sterols (2935.35 mg/kg), triglycerides (monomer TAG, 74.11 %) and tocopherols (18.04 mg/kg) were also determined by using IOC and ISO methods. The findings demonstrate that *P. edulis* seed oil could be used in the food and cosmetic industries.

Keywords: *Passiflora edulis,* Passifloraceae, seed oil, fatty acid, sterol, triglyceride, tocopherol.

Classification numbers: 1.3.1, 1.4.1.

1. INTRODUCTION

Passiflora edulis Sims (Passifloraceae), a popular tropical fruit throughout the world is usually used for juice production [1]. In Viet Nam, *P. edulis* is popularly cultivated in Tay Nguyen, Nghe An and Son La with areas of over ten thousand hectares. The *P. edulis* extracts were found to possess biological activities, including antioxidant [2], antifungal [3] and compounds from the seeds of *P. edulis* were found to inhibit melanogenesis and promote collagen synthesis [4]. Previous studies on chemical constituents of *P. edulis* seeds showed the presence of stilbenoids [4, 5], oil and tocopherols [6].

P. edulis seeds accounted for 6-12 % of fruit weight and they were used for the treatment of constipation and hemorrhoids [7]. *P. edulis* seed oil belonged to the polyunsaturated oil class, containing greater linoleic acid (65-70 %) and oleic acid (15-20 %) [8] similar to most of the commercial edible oils, *i.e*., sunflower, soybean, and corn oil [9]. Linoleic acid and oleic acid are important in human food because of its prevention of certain cardiovascular diseases [10]. They also find application in the food, perfume and aroma industries [11]. In spite of the number of

studies that have been performed [7, 12], there has been no investigation of chemical compositions and antioxidant activity of *P. edulis* seed oil cultivated in Viet Nam. Therefore, this paper describes the fatty acid, sterols, triglycerides and tocopherols profiles from *P. edulis* seed oil.

2. MATERIALS AND METHODS

2.1. Plant materials

The seeds of *Passiflora edulis* Sims were provided by Nafoods Group JSC (Nghe An Province, North Viet Nam) in 2016 and identified by botanist Dr. Nguyen Quoc Binh, Viet Nam National Museum of Nature, VAST, Ha Noi, Viet Nam. A voucher specimen (C-573) was deposited in the Herbarium of the Institute of Natural Products Chemistry, VAST.

2.2. Oil extraction

The oil was obtained from *P. edulis* seeds by Soxhlet extraction according to the International Organization for Standardization (ISO) method [13]. Briefly, 10 g of dry seeds was grinded in a ball mill and extracted with 200 mL of hexane by the Soxhlet apparatus at 60 -70 ºC for 6 h. After extraction, the solvent was removed to obtain 2.488 g of oil (24.88 %).

2.3. Analysis of fatty acid, sterol, triacylglycerol and tocopherol profiles

2.3.1. Fatty acid composition

Fatty acid was determined by gas chromatography followed by the ISO standard method with some modifications [14].

2.3.2. Sterol profile

Sterol was determined according to the International Olive Oil Council (IOOC) method [15]. To identify the individual peaks of sterols, the determination of relative retention times (RRT) for sterols was carried out according to the majority compound of sterols (*β*-sitosterol), knowing that RRT (*β*-sitosterol) equal to 1 as described by COI [16].

2.3.3. Triglyceride profile

Triglyceride (TG) molecular species profile was elucidated according to the International Olive Council (IOC) method of analysis [17], using the RP-HPLC instrument (Agilent technology, 1200 series).

2.3.4. Tocopherol profile

Tocopherol was determined by HPLC analysis as described previously in [18].

3. RESULTS AND DISCUSSION

3.1. Fatty acid composition

The *P. edulis* seed oil was obtained using the Soxhlet extraction system. It was found that the kernel of *P. edulis* seeds contains 24.88 % (w/w) of oil (Table 1). The oil yield of *P. edulis* seeds cultivated in Viet Nam was higher than that of *P. edulis* seed in China (23.40 %) [19], Kenya (18.4 %) [6], and lower than that of *P. edulis* f. *flavicarpa* seeds (30.39 %) in Brazil [20].

The fatty acid compositions were analyzed by gas chromatography and summarized in Table 1. It exhibited a great variation of the composition. The *P. edulis* seed oil contained common fatty acids in different proportions, such as the saturated fatty acids (SFA) like palmitic acid (8.56 %) and the unsaturated fatty acids (UFA) like oleic acid (18.86 %) or linoleic acid (66.94 %). In the *P. edulis* seed oil, the UFA content was relatively high (89.25 %). The fatty acid profile of *P. edulis* seed oil, having a higher UFA content and a low percentage of SFA is considered ideal for edible oil, indicating that *P. edulis* seed oil can be employed in cooking, potentially used as salad oil and used in the preparation of margarine and mayonnaise. The content of linoleic acid was also high in the studied sample (66.94 %). Oleic acid (C18:1 n-9) is the most common dietary monounsaturated fatty acid, found in most animal fats, including poultry, beef and lamb, as well as olives, nuts, seed, and corn. *P. edulis* seed oil displayed relatively low content of oleic acid at 18.86 %. In addition, other monounsaturated fatty acids found in *P. edulis* seed oil including C16:1 (n-7), C18:3 (n-3), C20:1 (n-11) and C20:2 (n-6) were only in very low quantities (< 1 % of total fatty acids).

Table 1. Fatty acid composition (%) of *Passiflora edulis* seed oil.

N_o	Retention time (min)	Fatty acid	Values (%)
1	10.321	Miristic (C14:0)	0.06
2	14.228	Palmitic (C16:0)	8.56
3	15.243	Palmitoleic (C16:1)	0.19
4	16.731	Magaric (C17:0)	0.09
5	19.621	*cis*-Vaccenic (C18:1)	2.51
6	19.765	Stearic (C18:0)	0.03
7	20.705	Oleic (C18:1)	18.86
8	22.758	Linoleic (C18:2)	66.94
9	25.045	Linolenic (C18:3)	0.44
10	26.062	Araquidic (C20:0)	0.13
11	27.228	Eicosenoic (C20:1)	0.12
12	29.413	Eicosadienoic (C20:2)	0.03
13	33.059	Behenic (C22:0)	0.06
14	37.763	Squalene	0.08
		Saturated fatty acid (SFA)	8.93
		Unsaturated fatty acid (UFA)	89.25
		Other	1.82

The linoleic acid content (66.94 %) from *P. edulis* seed oil cultivated in Viet Nam was lower than that of *P. edulis* Sims (72.69 %) in China [18], *P. edulis* Sims var. *edulis* (74.39 %) in Uganda [21], *P. edulis* f. *flavicarpa* (73.14 %) in Brazil [20] and was similar to that of *P. edulis* Sims var. *flavicarpa* (67.89 %) in Uganda [21].

3.2. Physical and chemical properties of *P. edulis* seed oil

The physical and chemical properties of the oil obtained from the seed of *P. edulis* are shown in Table 2.

Table 2. Physical and chemical properties of *P. edulis* seed oil.

Property	Values
Specific gravity (d^{25})	0.892
Refractive index (n_D^{25})	1.472
Acid value (mg KOH/g oil)	2.160
Peroxide value (mmol/kg)	3.602
Saponification value (mg KOH/g oil)	174.96
Iodine value (g I_2/100 g oil)	125.77

The acid value is the measure of the quantity of fatty acids in the oil. A higher fatty acid value (2.160) was observed in *P. edulis* oil. This reflects the high fatty acid content of the oil. Iodine value measures the unsaturation of fats and oils. The iodine value of *P. edulis* seed oil was found to be 125.77. *P. edulis* seed oil shows a low saponification value (174.96). The refractive index (1.472) of the oil is in the range with the values obtained for some conventional oils such as soybean oil (1.466-1.470) [22] and is similar to that of *P. edulis* Sims (1.4731) in China [19]. This property suggests that oil can be used in studies relating to optics [23].

3.3. Sterol composition

Total phytosterols are present in amounts from 0.1 to 0.3% of total oil. These values are in agreement with those already described for walnuts and are in the same range of those found in olive, peanut, and hazelnut oils but lower than those found in the majority of other oils [24]. The identified compounds are listed in Table 3. Results showed that the phytosterols (2935.35 mg/kg) of *P. edulis* seed oil were higher than that of *P. edulis* Sims (2090 mg/kg) in Kenya [6]. Several typical sterols were predominant in the studied sample, including campesterol, stigmasterol, *β*-sitosterol, $\Delta^{5,23}$-stigmastadienol, and Δ^5-avenasterol (Table 3). *β*-sitosterol (1112.68 mg/kg), the major sterol in *P. edulis* seed oil was also higher than that of *P. edulis* Sims (870.2 mg/kg) in Kenya [6]. *β*-sitosterol was reported to have anti-hypercholesterolemic, anti-inflammatory, anti-bacterial, anti-fungal, anti-hyperlipoproteinemic activities and inhibited carcinogenesis [25].

The contents of campesterol (353.49 mg/kg), stigmasterol (910.70 mg/kg) and Δ^5-avenasterol (146.53 mg/kg) in the seed oil of *P. edulis* were also higher than that of *P. edulis* Sims in Kenya (282 mg/kg for campesterol, 871 mg/kg for stigmasterol and 69 mg/kg for Δ^5-avenasterol) [6].

Table 3. Sterol compositions (%) of *P. edulis* seed oil.

N_o	Retention time (min)	Sterol	Content (mg/kg)
1	36.257	Cholesterol	8.18
2	36.727	Cholestanol	-
3	38.277	Brassicasterol	72.76
4	41.240	24-Methylencholesterol	3.65
5	41.567	Campesterol	353.49
6	41.937	Campestanol	53.55
7	43.023	Stigmasterol	910.70
8	44.133	Δ^7-Campesterol	22.37
9	45.050	$\Delta^{5,23}$-Stigmastadienol	12.95
10	45.480	Clerosterol	11.54
11	45.907	β-Sitosterol	1112.68
12	46.213	Sitostanol	57.39
13	46.573	Δ^5-Avenasterol	146.53
14	47.573	$\Delta^{5,24}$-Stigmastadienol	17.09
15	48.290	Δ^7-Stigmastenol	75.26
16	48.950	Δ^7-Avenasterol	77.20
		Total	2935.35

(-): not detected.

3.4. Triglyceride (TG) composition

The qualitative and quantitative of TG contents can be used as markers for the detection of oil adulteration [26]. The percentage content of TG in *P. edulis* seed oil is shown in Table 4. The most frequent TG is monomer triacylglycerol (TAG, 74.31 %), diglyceride (11.49 %) and free fatty acids (FFA, 8.85 %). These results suggested that *P. edulis* seed oil contains a high amount of monomer TAG (74.31 %).

Table 4. Triglyceride compositions (%) of oil extract from *P. edulis* seed.

N_o	Retention time (min)	Triglyceride type	Values (%)
1	24.550	Monomer TAG	74.31
2	25.367	Diglyceride	11.49
3	26.717	Monoglyceride	1.47
4	28.867	FFA	8.85
5	29.533	Glycerin	0.85
		Other	3.03
		Total	100

3.5. Tocopherol composition of *P. edulis* seed oil

A further important criterion for the assessment of seed oil was the content of tocopherol. The major tocopherols in the *P. edulis* seed oil were found to be γ-T (5.55 mg/kg) and δ-T (9.37 mg/kg) (Table 5). The total tocopherol (18.04 mg/kg) in *P. edulis* oil was lower than that of *P. edulis* Sims (465 mg/kg) in China [19] and *P. edulis* f. *flavicarpa* (499.30 mg/kg) in Brazil [20]. The δ-T (9.37 mg/kg) in *P. edulis* oil was higher than that of sunflower (9.2 mg/kg), canola (6.1 mg/kg) oils [27] and lower than that of *P. edulis* Sims (243 mg/kg) in China [18] and *P. edulis* f. *flavicarpa* (278.70 mg/kg) in Brazil [20].

Table 5. Tocopherol compositions of *P. edulis* seed oil.

N_o	Retention time (min)	Compounds	Values (mg/kg)
1	12.532	α-T	0.34
2	16.849	α-T3	0.29
3	24.605	β-T	2.49
4	26.163	γ-T	5.55
5	39.793	δ-T	9.37
		Total tocopherols	18.04

The quantity and nature of tocopherols naturally present in such unsaturated oils is of crucial importance regarding their oxidative stability. Tocopherols are natural antioxidants and depending on their nature, they can differ in their antioxidant capacity. Indeed, γ-tocopherols and δ-tocopherols are believed to be better antioxidant than α-and β-tocopherols [28]. Therefore, one can expect *P. edulis* seed oil to be protected against oxidation because of high amounts of γ-and δ-tocopherols.

4. CONCLUSION

In this work, the fatty acid, sterol, triglyceride and tocopherol compositions from the *P. edulis* seed oil cultivated in Viet Nam were investigated for the first time. The *P. edulis* seeds contained a high amount of oil (24.88 %, w/w). The major monounsaturated and saturated fatty acids were linoleic acid (66.94 %) and oleic acid (18.86 %). Steroids were predominant in the *P. edulis* seed oil, including several typical sterols such as campesterol, stigmasterol, *β*-sitosterol, $\Delta^{5,23}$-stigmastadienol, and Δ^{5}-avenasterol. *β*-sitosterol was the major sterol (1112.68 mg/kg) in *P. edulis* seed oil. The most frequent TG is monomer TAG (74.31 %), diglyceride (11.49 %), and free fatty acids (FFA, 8.85 %). The total of tocopherols in *P. edulis* seed oil was 18.04 mg/kg and the major tocopherols were found to be γ-T (5.55 mg/kg) and δ-T (9.37 mg/kg).

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REFERENCES

1. Fraife Filho G. A., Leite J. B. V, Ramos J. V. - Passion fruit. Available from: http://www.ceplac.gov.br/radar/maracuja.htm. (Accessed in Apr 25, 2012).
2. Lourith N., Kanlayavattanakul, M. – Antioxidant activities and Phenolics of *Passiflora edulis* seed recovered from juice production residue, J. Oleo Sci. **64** (2013) 235–240.
3. Pelegrini P. B., Noronha E. F., Muniz M. A., Vasconcelos I. M., Chiarello M. D., Oliveira J. T., Franco O.L. - An antifungal peptide from passion fruit (*Passiflora edulis*) seed with similarities to 2*S* albumin proteins, Biochim. Biophys. Acta **1764** (2006) 1141–1146.
4. Matsui Y., Sugiyama K., Kamei M., Takahashi T., Suzuki T., Katagata Y., Ito T. - Extract of Passion Fruit (*Passiflora edulis*) Seed Containing High Amounts of Piceatannol Inhibits Melanogenesis and Promotes Collagen Synthesis, J. Agric. Food Chem. **58** (2010) 11112–11118.
5. Sano, S., Sugiyama, K., Ito, T., Katano, Y., Ishihata, A. - Identification of the strong vasorelaxing substance scirpusin B, a dimer of piceatannol, from passion fruit (*Passiflora edulis*) seed, J. Agric. Food Chem. **59** (2011) 6209–6213.
6. Piombo G., Barouh N., Barea B., Boulanger R., Brat P., Pina M., Villeneuve P. - Characterization of the seed oils from kiwi (*Actinidia chinensis*), passion fruit (*Passiflora eulis*) and guava (*Psidium guajava*), Ocl Ol Corps Gras Li. **13** (2006) 195–199.
7. Chau, C., Huang, Y. - Characterization of passion fruit seed fibers - a potential fiber source, Food Chem. **85** (2004) 189–194.
8. Regis S. A., de Resende E. D., Antoniassi R. - Oil quality of passion fruit seed subjected to a pulp-waste purification process, Ciência Rural **45** (2015) 977–984.
9. Dubois V., Breton S., Linder M., Fanni J., Parmentier M. - Fatty acid profiles of 80 vegetable oils with regard to their nutritional potential, Eur. J. Lipid Sci. Technol. **109** (2007) 710–732.
10. Gupta S., Shrivastava S. K., Shrivastava M. - Fatty acid composition of new hybrid varieties of minor millets seed, IIOAB J. **5** (2014) 15–18.
11. Lopez A S. - Lipids from the seed of passion fruit (*Passiflora edulis*), Rev. Theobroma **10** (1980) 47–50.
12. Liu S. C., Yang F., Li J. L. Zhang C. H., Ji H. W., Hong P. J. - Physical and chemical analysis of *Passiflora* seed and seed oil from China, Int. J. Food Sci. Nutr. **59** (2008) 706–715.
13. International Organization for Standardization. Oil seed - Determination of oil content, ISO Geneva, Switzerland, Standard No. 659, 1988.
14. International Organization for Standardization. Animal and vegetable fats and oils-preparation of methyl esters of fatty acids, ISO, Geneva, Switzerland, Standard No. 5509, 1988.
15. International Olive Council. Determination of the composition and content of sterols by capillary-column gas chromatography, Spain; Madrid, COI/T, 20/Doc. No. 10 Rev. 2001.
16. International Olive Council. Determination of the composition and content of sterols and triterpene dialcohols by capillary column gas chromatography, Spain; Madrid, COI/T, 20/Doc. No. 30/Rev. 2013.

17. International Olive Council. Determination of the difference between actual and theoretical content of triacylglycerols with ECN 42, International Olive Council, COI/T.20/Doc. no. 20 /Rev. 2, 2008.
18. International Organization for Standardization. Animal and vegetable fats and oils-Determination of tocopherol and tocotrienol contents by high-performance liquid chromatography, ISO, Geneva, Switzerland, Standard No. 9936, 2006.
19. Liu S. C., Yang F., Li J. L., Zhang C. H., Ji, H. W., Hong P. Z. - Physical and chemical analysis of *Passiflora* seeds and seed oil from China, Int. J. Food Sci. Nutr. **59** (2008) 706–715.
20. Malacrida C. R., Jorge N. - Yellow Passion Fruit Seed Oil (*Passiflora edulis* f. *flavicarpa*): Physical and Chemical Characteristics, Braz. Arch. Biol. Technol. **55** (2012) 127–134.
21. Nyanzi S., Carstensen B., Schwack W. - A comparative study of fatty acid profiles of *Passiflora* seed oils from Uganda, J. Am. Oil. Chem. Soc. **82** (2005) 41–44.
22. Codex Alimentarius Commission. Codex-Stan 210: codex standard for named vegetable oils. Rome, 2008.
23. Ju Y., Chen T. - High-purity γ-linolenic acid from borage oil fatty acids, J. Am. Oil. Chem. Soc. **79** (2002) 29–32.
24. Kamm W., Dionisi F., Hischenhuber C., Engel K. - Authenticity assessment of fats and oils, Food ReV. Int. **17** (2001) 249–290.
25. Yasukawa K., Takido M., Matsumoto T., Takeuchi M., Nakagawa S. - Sterol and triterpene derivatives from plants inhibit the effects of a tumor promoter, and sitosterol and betulinic acid inhibit tumor formation in mouse skin two-stage carcinogenesis, Oncology. **41** (1991) 72–78.
26. Harrabi S., Boukh S., Kallel H., Mayer P. M. - An electrospray-ionization mass spectrometry analysis of triacylglycerol in developing corn kernels, Can. J. Anal. Sci. Spectr. **53** (2008) 22–27.
27. Tuberoso C. I. G., Kowalczyk A., Sarritzu E., Cabras P. - Determination of antioxidant compounds and antioxidant activity in commercial oilseed for food use, Food Chem. **103** (2007) 1494–501.
28. Rossignol-Castera A., Bosque F. - Nouvelle Approche des Antioxydants, OCL **1** (1994) 10–15.