Characterizations of Malaysian avocado pulp oil obtained through mechanical press extraction

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ABSTRACT This study aimed to determine the characteristics of pulp oil from Malaysian avocado (*Persea americana*) using mechanical press extraction. The quality of extracted crude oil was assessed for basic physicochemical parameters, and triacylglycerol (TAG) and fatty acid compositions. The extracted oil was in a liquid form at room temperature (25 °C), with dark green in colour. The iodine and free fatty acid values of the oil were 79.48 g I_2/100 g oil and 1.66%, respectively. The oil was found to contain POL (21.37%) as the predominant TAG, followed by POO (14.42%), PLL (12.383%), and PPO (9.764%). The oil had high amounts of total unsaturated fatty acids (68.09%), mainly contributed by oleic acid (34.53%), followed by palmitic (30.08%), linoleic (19.12%), and palmitoleic (11.06%) acids.

KEYWORDS: Avocado pulp oil; Mechanical press; Physicochemical properties; Fatty acids; Triacylglycerols
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INTRODUCTION

Avocado (*Persea americana* Mill.) is a tree with edible fruit, belonging to the Lauraceae family. The fleshy fruit is borne yearly, and the green fruit ripens only after being harvested. It is native to the Western Hemisphere from Mexico south to the Andean region, but is also widely distributed in tropical and subtropical countries. According to the data from Food and Agriculture Organization of the United Nations (2022), the largest avocado-producing countries in the world in 2021 are Mexico, Columbia, Peru, Indonesia, Dominican Republic, Kenya, Brazil, Haiti, Vietnam, and Chile, contributing to 80% of the world's avocado production with Mexico alone accounting for 28% of the world production (2.44 million metric tons). Most of the produce is grown for fresh consumption, while in Southeast Asia countries, avocados are also widely used in the preparation of milkshakes. Although avocado is primarily consumed fresh, a substantial increase in the use of avocado-based products and oil for cosmetics and culinary purposes also suggests further market growth (Costagli & Betti, 2015).

Avocado is a rich source of oil that is primarily derived from the flesh of the fruit, whereby its lipid content has been reported as the highest among all known fruit and vegetable varieties (Flores *et al*., 2019). The main fatty acids of the avocado pulp oil are oleic acid (59.46–67.69 %), followed by palmitic (12.79–17.50 %), and linoleic (10.50–15.15 %) acids (da Silva Moura *et al*., 2023). Avocado pulp oil has been proposed as a new functional food ingredient because of its high contents of oleic acid

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and bioactive compounds. Nowadays, avocado pulp oil has been acknowledged for its high nutritional value and potential benefits to human health, including the management of hypercholesterolemia, hypertension, diabetes, and fatty liver disease. Avocado pulp oil which contains predominantly monounsaturated fatty acid (MUFA) or oleic acid has also been known for its thermal-oxidative stability and excellent characteristics, making it suitable for sizzling, sautéing, or even deep fat frying to maintain product quality and enhance palatability (Flores *et al*., 2019).

Due to the numerous valuable compounds and the significant benefits of avocado pulp oil, many studies have been conducted to maximize oil yields using different extraction methods, including solvent extraction, supercritical fluid extraction, aqueous enzymatic extraction, and mechanical extraction (Costagli & Betti, 2015). However, the use of chemical solvents and potential contamination of oil products raise environmental and food safety concerns. Among the various extraction methods, mechanical extraction gained attention for its simple setup, low investment, low operation costs, absence of toxic solvents, and ability to achieve high oil yields (Muangrat *et al*., 2018). Extractions of avocado pulp oil using the mechanical press method have been studied extensively in the past (Chaiyasut *et al*., 2019; Krumreich *et al*., 2018; Chimsook & Assawarachan, 2017). However, reports on the characteristics of oil obtained from Malaysian avocado cultivars using mechanical press extraction are still limited. Therefore, this study aimed to determine the physicochemical characteristics of the oil extracted from a local avocado cultivar using mechanical press extraction.

METHODOLOGY

Sample Collection

Mature avocado fruit was obtained from a local market located in Kota Kinabalu, Sabah. The fruit was stored in dry and dark conditions until reaching full ripeness. This was indicated by the change in skin colour from green to brown, and uniform flesh softness felt upon touch, as suggested by Tripathi *et al*. (2024). The fully ripe fruit was manually washed, cut, and de-stoned, before being mashed into smooth paste. The mashed mesocarp was dried in a cabinet tray dryer (TD-78T-SD, Thermoline, Australia) for 24 h at 60 °C and subsequently ground into powder using a Waring blender (Model HGBTWTS3, Dynamic Corporation of America, New Hartford, USA). All chemicals used in this study were of analytical grades, unless otherwise specified.

Oil Extraction

Oil extraction from a finely ground sample of dried avocado fruit was carried out by mechanical pressing method. The dried powder was placed into a filter cloth, and the jack of the machine was pumped to squeeze out the oil. The pressure of the machine was 5 Pa and the extraction was done at room temperature (25 °C). The extracted oil was collected in a sealed glass bottle and stored at -20 °C until it was used. Prior to analysis, the oil sample was removed from frozen storage, thawed at room temperature for 1 h, and incubated at 60 °C until completely melted.

Determination of Iodine Value and Free Fatty Acid Value

The iodine value and free fatty acid value of the oil were determined according to the AOAC (2023) standard analytical methods.

Determination of Fatty Acid Composition

Fatty acid methyl esters (FAME) were prepared by dissolving 50 mg of the oil sample in 0.8 mL of hexane and adding 0.2 mL of 1M sodium methoxide (PORIM, 1995). Fatty acid composition was determined using a headspace autosampler (Model G1888, Agilent Technologies, Palo Alto, CA, USA) according to Fadzillah *et al*. (2019) with slight modifications. The transfer line from the headspace sampler was directly connected to the injector of the gas chromatograph (GC) unit. The oven was set at 110 °C. The extraction conditions in the headspace autosampler were programmed as follows: 20 min for vial equilibration, 0.2 min for vial pressurisation, 0.2 min for filling the injection loop, 0.05 min for loop equilibration and 1 min for sample injection. Helium with a purity of 99.99% was used for vial pressurization and as the carrier gas. Volatile compounds were analysed using a GC-MS (Model 7890, Agilent Technologies, Palo Alto, CA, USA) equipped with a non-polar column (J&W Scientific DB-5; 30 m, ID 0.25 mm, film thickness 0.25µm). The column temperature was kept at 40°C for 10 min, increased at 6 °C/min to 240 °C and then maintained isothermally for 20 min. The mass selective detector (Model MSD59556, Agilent Technologies, Palo Alto, CA, USA) was used in electron ionisation mode. A mass range between 30 and 550 m/z was scanned. The mass spectra obtained were compared to those of the National Institute of Standards and Technology (NIST) Mass Spectral Search Program for compound identification. Thirty-seven FAME standards (Sigma St. Louis, MO) were used as authentic samples to calculate the percentage of fatty acids based on peak area. The quantification of FAME was performed using a normalisation internal technique.

Determination of Triacylglycerol Composition

The triacylglycerol profile of the oil was determined by non-aqueous reverse-phase HPLC, according to Yanty *et al*. (2018). The HPLC (G1213B, Agilent Technologies, California, USA) was equipped with a C-18 column (250 mm × 4.6 mm, Kromasil 100-5-C18), and a refractive index detector (Model RID-6A). The mobile phase used was a mixture of acetone: acetonitrile (63.5:36.5, v/v), with a flow rate of 1 mL/min. The column temperature was isothermal at 30 °C, and the total run time was 40 min. Auto-injection was set at 10 µL of 5% (w/w) oil in chloroform. The individual peaks were identified using a set of TAG standards, and quantified based on relative percentages using the peak areas produced (Manaf *et al*., 2018).

Statistical Analysis

In all analyses, three sample replicates were used and the results were expressed as mean values ± standard deviations. The data obtained were statistically analysed using IBM SPSS Statistics version 29.0.0.0. Differences were considered significant at a 0.05 probability level.

RESULT AND DISCUSSION

Visual observation revealed that the crude oil sample was dark-green in colour, which is a common feature of avocado pulp oil, indicating the presence of pigments such as chlorophyll, carotene etc (Ashton *et al*., 2006). The oil extracted in this study remained entirely in liquid form at room temperature (25 °C). In the contrary, Yanty *et al*. (2011) found that local avocado cultivars extracted using Soxhlet yielded fats that were semi-solid at room temperature. The iodine and free fatty acid values of the oil determined in this study were compared with those of other avocado cultivars obtained using mechanical press from previous studies (Table 1).

The iodine value indicates the degree of unsaturation of oils and fats. The iodine value (79.48 g I_2/100 g) in this study was found to be lower than that of the Brazilian avocado (90.1 – 91.4 g I_2/100 g) (Krumreich *et al*., 2018) and higher than that of the avocado grown in Dhankuta, Nepal (70.60 g I_2/100 g) (Shrestha, 2022). The results of the iodine value obtained in this study were found to be consistent with several reports stating that the iodine values for avocado pulp oils were in the range of 65 to 95 (AOCS, 1998).

Table 1. Iodine value and free fatty acid value of avocado pulp oils obtained from mechanical press extraction.

Sample	Iodine value (g I_2/100g)	Free fatty acid (%)
Malaysian avocado[a]	79.48 ± 0.43	1.66 ± 0.03
Thai avocado[1)]	-	0.43 – 0.63
Nepali avocado[2)]	70.60	1.23
Brazilian avocado[3)]	90.1 – 91.4	-

[a]Each value in the table represents the mean ± standard deviation of three replicates.
[1)]Chimsook & Assawarachan (2017); [2)]Shrestha (2022); [2)]Krumreich *et al*. (2018).

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Free fatty acid is related to the degree of hydrolysis and is used as an indicator of oil quality in the food industry. Generally, the lower the free fatty acid value, the better the quality of the oil. The free fatty acid value of avocado pulp oil in this study was 1.66% (Table 1). This value was higher compared to those reported by Chimsook & Assawarachan (2017), which ranged from 0.43% to 0.63% of oil extracted from Thai avocado cultivars. Currently, the proposed avocado pulp oil standards by Codex Alimentarius (2019) state that the maximum free fatty acid level for crude avocado pulp oil and refined avocado pulp oil is at 5% and 0.1% (expressed as oleic acid), respectively. Therefore, the level of hydrolysis of the extracted oil in this study complies with the Codex Alimentarius (2019) limits. Nevertheless, the free fatty acid value is expected to decrease following refining processes.

Table 2 shows the fatty acid composition of the extracted avocado pulp oil in comparison with previous findings. A total of six fatty acids were found in the avocado pulp oil in this study, with oleic acid being the major component (34.53%), followed by palmitic acid (30.08%), linoleic acid (19.12%), and palmitoleic acid (11.06%). Linolenic acid (3.38%) and stearic acid (0.09%) were found in small amounts. A similar distribution of major fatty acids in avocado oils from other countries has also been report (Krumreich *et al*. (2018); Chimsook & Assawarachan, 2017). Tan *et al*. (2017) demonstrated in their study that the proportional distributions of saturated, monounsaturated, and polyunsaturated fatty acids in avocado pulp oils were influenced by their geographical origins.

Table 2. Fatty acid composition of avocado pulp oils obtained from mechanical press extraction.

Fatty acid	Relative percentage (%)		
	Malaysian[a)]	Thai[1)]	Brazilian[2)]
Palmitic acid (C16:0)	30.08 ± 0.54	28.88 – 29.69	19.90 – 21.20
Palmitoleic acid (C16:1)	11.06 ± 1.28	7.21 – 7.82	2.70 – 6.50
Stearic acid (C18:0)	0.09 ± 0.00	0.51 – 0.56	-
Oleic acid (C18:1)	34.53 ± 0.25	33.12 – 36.66	58.60 – 64.50
Linoleic acid (C18:2)	19.12 ± 1.71	15.55 – 16.22	10.60 – 10.70
Linolenic acid (C18:3)	3.38 ± 0.25	-	0.40 – 0.60

[a]Each value in the table represents the mean ± standard deviation of three replicates.
[1)]Chimsook & Assawarachan (2017); [2)]Krumreich *et al*. (2018).

Table 3 shows the triacylglycerol distributional profile of the oil in the present study, compared to those of other avocado varieties from previous studies. Fourteen triacylglycerol components were identified in the extracted avocado pulp oil in this study, with the most prominent being POL (21.370%), POO (14.420%), PLL (12.383%), and PPO (9.764%) (Table 3). In this study, the triacylglycerol components of the extracted avocado pulp oil primarily consisted of di-unsaturated triacylglycerols (49.247%) and tri-unsaturated triacylglycerols (29.514%). Due to the scarcity of data on the triacylglycerol profile of avocado pulp oil extracted using the mechanical press method, the influence of the extraction method on the triacylglycerol composition of avocado pulp oil has not yet been determined.

Table 3. Triacylglycerol (TAG) composition of avocado pulp oil.

Triacylglycerol	Percentage (%)
LLLn	5.22 ± 0.05
LLL	2.09 ± 0.06
OLL	8.29 ± 0.07
PLL	12.38 ± 0.06
OOL	7.64 ± 0.09
POL	21.37 ± 0.10
PPL	8.21 ± 0.07
OOO	6.276 ± 0.16
POO	14.42 ± 0.21
PPO	9.76 ± 0.04
PPP	2.05 ± 0.02
OOS	1.08± 0.09
POS	0.86 ± 0.04
PPS	0.36 ± 0.02

[a]Each value in the table represents the mean ± standard deviation of three replicates.
Abbreviations: O: Oleic; P: Palmitic; S: Stearic; L: Linoleic, Ln: Linolenic.

CONCLUSION

This study showed that the crude oil extracted from a Malaysian avocado using mechanical press extraction was in liquid form at room temperature, making it suitable for cooking applications. The low free fatty acid value is an important parameter in evaluating the quality of edible oil; hence, the low value obtained in this study was a highly appreciated property. The data on the fatty acid and TAG compositions showed that this oil was primarily mainly composed of unsaturated components. This avocado pulp oil contained a fair proportion of monounsaturated and polyunsaturated fatty acids, similar to olive oil. Further studies on the properties and extraction of avocado pulp oils are essential to produce avocado pulp oil that meets the expectations of both consumers and the food industry.

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