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Organoleptic and physicochemical properties of 'Hass' avocado (*Persea americana* Mill) oil extract obtained using cold press technology

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Abstract

Largely grown in tropical and subtropical regions of the world, avocado (*Persea americana* Mill) contains 3 – 30% of oil in its pulp, depending on the variety. This study profiled the quality attributes of oil obtained from 'Hass' avocado cultivar using the cold press method of extraction. Physicochemical properties of saponification value (SV), acid value (AV), percentage free fatty acid (FFA) and colour were determined for the extracted oil samples. Sensory analysis was conducted to determine consumer acceptability of the 'Hass' avocado oil extract. Results of the analysis showed a significant difference ($p<0.05$) in the SV, AV and FFA of the avocado oil extract. A significant difference was also found to exist in the L^* and a^* colour properties of the extracted oil. On the determination of the organoleptic properties, it was observed that consumers displayed a higher preference for commercial pure avocado oil than the extracted oil used in this study, although extracted 'Hass' avocado oil exhibited higher physicochemical properties when compared to commercial pure avocado oil.

1. Introduction

The oil obtained from plant origin is increasingly becoming more popular for use in the human diet than oil derived from animal sources. This is due majorly to the health benefits associated with oil obtained from plant sources. Avocado (*Persea americana* Mill) contains high content of mostly unsaturated oils amounting to approximately 79% of fatty acids in the fruits' mesocarp (Ariza *et al.*, 2011; Donetti and Terry, 2014; Ferreyra *et al.*, 2016). Oil extracted from avocado is found in the mesocarp tissue (Somogyi *et al.*, 1996), with the mesocarp composed of 72 g 100/g water, 15.4 g 100/g total lipids, 1.96 g 100/g protein, 6.8 g 100/g fibre, 0.3 g 100/g total sugars, 8.64 g 100/g carbohydrates, 1.66 g 100/g ash, vitamins as well as large parenchyma and idioblast cells (Dreher and Davenport, 2013; Pedreschi *et al.*, 2016).

The high lipid content of the edible portion of the fruit is composed of a great amount of fatty acids (oleic, palmitic, palmitoleic, linoleic, linolenic) especially of the unsaturated type: monounsaturated and polyunsaturated fatty acids (Daguet, 2000; Villa-Rodriguez *et al.*, 2011; Dreher and Davenport, 2013). The oil content in avocado fruit mesocarp is used as a maturity index and indicates the quality of the fruit as well as its degree of firmness (Hofman *et al.*, 2002; Galvao *et al.*, 2014). Avocado oil is cholesterol-free and contains non-essential unsaturated omega 3, 6 and 9 fatty acids as well as natural antioxidants such as vitamin E and phytosterols (Table 1) that lowers the cholesterol level in the blood (Rodríguez-Carpena *et al.*, 2012).

Different oil extraction methods have been studied and reported in the literature on the physicochemical properties of avocado oil. Ikeyi (2013) reported that plant-derived oil produced by the cold press technology exhibited better quality regarding peroxide value, smoking point and percentage of free fatty acids. Ortiz-Moreno *et al.* (2003, 2004) studied the extraction of avocado oil by heating the fruit pulp up to 95°C using

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microwaves, followed by either Soxhlet extraction with hexane or pressing. The authors in their study reported that the combined microwave-hexane method gave the greatest oil yield. A similar study was done by dos Santos *et al.* (2014) on the effects of pulp freezing and oven-drying on the oil yield of avocado fruits, which showed that the cell walls were damaged during freezing, hence making extraction easier and thereby increasing oil yields. Mostert *et al.* (2007) also studied the method of fruit drying on the extractability of avocado oil with hexane and supercritical CO_2. Results of the study showed that Hexane produced high oil yields.

Table 1. Tocopherols, total phenolics, total chlorophyll and fatty acid profile[a] of plant derived oil.

Nutrients	Avocado oil	Sunflower oil	Olive oil
γ-tocopherol[b]	1.78	2.03	0.88
α-tocopherol[b]	9.04	51.90	17.07
Total phenolics[c]	12.75	7.13	167.81
Total chlorophyll[d]	65.49	0.00	13.76
C14:0	0.06	0.06	0.00
C16:0	12.87	6.48	9.62
C16:1 (n-7)	3.86	0.11	0.66
C17:0	0.03	0.04	0.06
C17:1 (n-7)	0.07	0.03	0.10
C18:0	1.45	3.62	2.95
C18:1 (n-9)	57.44	24.70	76.83
C18:1 (n-7)	3.43	0.99	2.61
C18:2 (n-6)	18.70	61.99	5.38
C18:3 (n-3)	0.92	0.28	0.60
C20:0	0.31	0.42	0.56
C20:1 (n-9)	0.31	0.24	0.38
C20:2 (n-6)	0.10	0.14	0.03
C21:0	0.04	0.00	0.00
C20:4 (n-6)	0.09	0.00	0.00
C22:0	0.16	0.67	0.15
C22:1 (n-9)	0.04	0.08	0.00
C24:0	0.11	0.14	0.04

Source: Rodriguez-Carpena *et al.* (2012).

[a]Data expressed as percentage.

[b]Data expressed as mg tocopherol 100/g fat oil^{-1}.

[c]Data expressed as mg caffeic acid equivalent (CAE) kg fat^{-1} oil^{-1}.

[d]Data expressed as mg chlorophyll kg fat^{-1} oil^{-1}.

The physicochemical properties of the oil are very important as they indicate the functional use of the oil and its quality. These properties vary from the type of fruit, method of extraction as well as post-extraction processes (Gomez-Lopez, 2000). This study, therefore, sought to determine the physicochemical characteristics and consumer acceptability of 'Hass' avocado oil extracted from the pulp of avocado using the cold press method of extraction.

2. Materials and methods

In the characterization of avocado oil, the avocado oil extract was the experimental sample while commercial pure avocado oil was used as control. The samples were analysed for physicochemical characteristics such as colour, acid value (AV), saponification value (SV) and percentage free fatty acid (FFA) with all analyses conducted in triplicates.

2.1 Sample preparation and oil extraction

Avocado fruit cultivar 'Hass' used in the conduct of this research was purchased from Shoprite, Thohoyandou, South Africa while the commercial pure avocado oil used as a control was obtained from Woolworth Makhado, South Africa. Matured ripe avocado fruits were washed, peeled, deseeded and cut into wedges. Extraction of oil from the dried avocado pulp was conducted using the cold press method of oil extraction according to the methods stated in the work of Woolf *et al.* (2009) with modifications. The avocado wedges were pulverised using a domestic food blender (Binatone model BLG-555, England) at 4000 rpm for 2 min. Pulverised pulp was then spread in aluminium trays and fed in the oven dryer. Fruit pulp was dried in the oven (Gallenkamp, model OV 880, England) at 50°C for 24 hrs. The extracted oil was centrifuged at 3500 rpm for 10 mins, packaged and stored in a dark cupboard for onward physicochemical analysis.

2.2 Colour analysis

Approximately 6 g of oil was weighed and analysed for colour using a LabScan XE Spectrophotometer with a D65 light source (Hunter Associates Laboratory, Inc, Reston, VA). The CIELAB colour scale with the parameters *L*a*b** were used in the determination of the colour values of extracted oil. The *L** value indicates lightness, 0 - 100 with 0 representing black and 100 representing white. Coordinate *a** corresponds to red (+) and green (-) while *b** corresponds to yellow (+) and blue (-) colours respectively (Wrolstad and Smith, 2010).

2.3 Saponification value

After 48 hrs of extraction of 'Hass' avocado oil, the obtained oil extract was analysed for SV. Approximately 2 g of avocado oil extract and control sample (pure avocado oil) were transferred to Erlenmeyer flasks. A total of 25 mL of KOH solution was poured into each flask and a blank sample prepared. The flask containing the blank, control and Hass avocado extracted oil samples were connected with air condensers and boiled in a water bath for 1 hr. The flasks containing all samples were cooled after which 1.0 mL of phenolphthalein indicator was added. Saponification value was

determined according to the method of AOAC (2000) after titration of KOH with 0.5 N HCl using Equation (1).

$$\text{Saponification value} = \frac{56.1(B - S)N}{W} \quad (1)$$

Where N = Normality of HCl used, B = Volume of HCl used in test, S = Volume of HCl used in blank and W = Weight of oil used

2.4 Acid value

After 48 hrs of extraction of 'Hass' avocado oil, 2 g of oil from both extracted and control samples were weighed and poured in 250 mL conical flasks and 80 mL of hot ethyl alcohol was mixed with the oil. Approximately 1.0 mL of phenolphthalein indicator solution was mixed with the solution, boiled for 5 min and titrated with standard NaOH while being shaken vigorously until a pink colour change was observed. All analyses were done in triplicates with AV determined using Equation (2).

$$\text{Acid value} = \frac{56.1VN}{W} \quad (2)$$

Where N = Normality of NaOH used, V = Volume (mL) of NaOH used and W = Weight of sample used

2.5 Free fatty acid

Percentage FFA was determined from the AV by multiplying with the factor 0.503 according to the methods of Eyres *et al.* (2006) using Equation (3).

$$\%\ \text{Free fatty acid} = 0.503 \times \text{acid value} \quad (3)$$

2.6 Sensory evaluation

Descriptive testing of 'Hass' avocado oil extract and the control sample was done using 10 trained panellists. The sensory evaluation of the avocado oil samples was conducted in the sensory evaluation laboratory of the Department of Food Science and Technology, University of Venda. Trained panellists was used in rating the samples for colour, aroma, viscosity and general appearance. Each panellist was asked to rate the samples using a 5-point hedonic scale where 1 represent poor and 5 represent very good respectively (Gulla and Waghray, 2011).

2.7 Statistical analysis

Values obtained from experimental analysis were statistically analysed using SAS version 9.3. Grouping of means for avocado oil samples was done with the analysis of variance using the T-test at significant levels of $p<0.05$.

3. Results and discussion

3.1 Colour properties of extracted avocado oil

A significant difference was observed in the colour properties of both the 'Hass' avocado oil extract and the control sample. The *L** value of the avocado oil extract was significantly higher ($p < 0.05$) at a value of 5.5 when compared to the *L** value of 3.1 that was obtained for the control sample. A significant difference was also observed in the *a** values of both the extracted oil sample and the control (Table 2). 'Hass' avocado oil extract showed an *a** value of -0.6 with the negative value indicating the presence of dark green colouration compared to 0.6 obtained for the control sample, with the positive value indicating the absence of the green colouration. The absence of green colouration has been attributed to the mode of processing the control sample, as the dark green pigment in the control sample might have been removed during the bleaching process of production (Wong *et al.*, 2011). Requejo-Tapia (1999) and Wong *et al*. (2011), showed that chlorophyll *a* and *b,* *α*- and *β*-carotene, antheraxanthin, neoxanthin, violaxanthin, zeaxanthin as well as pheophytin *a* and *b* have been implicated as the cause of the intense green pigment in oil obtained from avocado. These pigment causing compounds can be lost as a result of the mode of extraction, processing method and type of cultivar used. Hence the higher *a** value (0.6) of the control sample can be attributed to the process of refining used during the production of the control sample prior to bottling (Woolf *et al.*, 2009).

Table 2. Physicochemical properties of avocado oil

Properties	Avocado oil extract	Control
*L**	5.5±0.16^{b}	3.1±0.22^{a}
*a**	-0.6±0.13^{b}	0.6±0.03^{a}
*b**	2.8±0.13^{a}	3.4±0.38^{a}
SV	125±7.19^{b}	104.7±2.8^{a}
FFA (%)	1.8±0.21^{b}	1.3±0.16^{a}
AV	3.6±0.32^{b}	2.6±0.16^{a}

SV = saponification value, FFA = free fatty acid, AV = acid value. Values are expressed as mean±SD, n = 3. Values with different superscripts within the same row are significantly different at $p<0.05$.

There was no significant difference in the *b** values of the avocado oil extract (2.8) and the control sample (3.4) used in this study. However, positive *b** values in both extract and control samples indicated the presence of yellow pigmentation in both samples. In a study conducted by Salesa-Fetu *et al.* (2010) from solvent extracted avocado oil, the *L**, *a** and *b** values obtained were 30.22, -0.37 and 19.01 respectively, with differences in colour values obtained in this study attributed to the extraction method used.

3.2 Acid value of avocado oil extract

From the results of analysed data, there was observed significant difference ($p < 0.05$) in the AV of the commercial avocado oil (2.6) and the 'Hass' avocado oil extract (3.6), with the avocado oil extract recording a significantly higher AV than the control sample. The acid value measures the amount of carboxylic acid groups in organic compounds. The AV also signifies the degree of refining of the extracted oil. A low AV indicates a more refined oil while a high AV indicates a less refined oil.

In this study, the commercial control sample had a lower AV of 2.6, hence indicating a more refined oil when compared to a higher avocado oil extract of 3.6. Salesa-Fetu *et al.* (2010) reported that the AV of solvent extracted and centrifuged avocado oil was found to be 3.5 and 1.18. Ikeyi (2013) in a similar study, showed that the AV of avocado oil was between 0.2 - 2.0. However, the results of AV obtained in this study was higher than the values of 0.49, 0.51 and 0.54 obtained from the works of Galvao *et al.* (2014) who determined the influence of different cultivars on oil quality and chemical characteristics of avocado fruit.

3.3 Saponification value of avocado oil extract

The avocado oil extract had a significantly higher ($p < 0.05$) SV of 125 when compared to the control sample of 104.7. A significant difference was recorded in the SV of the extracted oil and the control sample. Saponification value measures the molecular weight of fat present in the oil, a parameter useful in determining the functional use of the oil. The saponification value of oil decreases with an increase in molecular weight as SV is inversely proportional to the mean molecular weight of the glycerides in the oil (Ikhuoria and Maliki, 2007). Furthermore, an increase in SV results in a decrease in the heat content of an oil. The SV obtained from avocado oil extract used in this study were similar to those of Galvao *et al.* (2014) who reported values of 119.5 – 175 in the pulp of three avocado cultivars examined. Although a higher SV of 246.84 was observed in the study conducted by Ikhuoria and Maliki (2007).

3.4 Free fatty acid (%) of avocado oil extract

The percentage FFA measures the degree of unsaturation of fatty acids in the oil. The percentage FFA is also important in determining the suitability of the oil as edible oil as the lower the FFA content, the higher its use as an edible oil (Ikhuoria and Maliki, 2007). There was a significant difference in the FFA value of the avocado oil extract (1.8%) and the control sample (1.3%), with the FFA, obtained from the avocado oil extract significantly higher than that in the control sample. The result, therefore, implies that the higher FFA of 1.8% obtained in the avocado oil extract contains more unsaturated fatty acids when compared to the commercial pure avocado oil of 1.3%.

Results of FFA obtained from this study was similar to that of Alozie *et al.* (2010), who showed an FFA value of 1.6% for avocado oil but higher than that reported by Ikhuoria and Maliki (2007) who reported a low FFA value of 0.37% in avocado pear. Woolf *et al.* (2009) stated that the standard FFA value of avocado oil should range between 0.1-1.0%. Though avocado oil with higher FFA values contains more unsaturated fatty acid: a useful indication of the high smoking point of the oil required for deep-fried foods, the oil becomes more susceptible to oxidation, hence exhibiting low oxidative stability (Salesa-Fetu *et al.*, 2010). Wong *et al.* (2010) however, observed that a higher percentage of FFA (> 0.5%) in avocado oil can be attributed to poor fruit quality, manufacturing practices or long delays in processing ripened fruits. Quality degradation as a result of flesh bruising, flesh greying, postharvest rots and long -term storage of fruit for durations well above 4 weeks (instead of 1 – 2 weeks prior to ripening and extraction) all contributes to a reduction in oil quality as determined by percentage FFA (Woolf *et al.*, 2009).

3.5 Sensory evaluation of avocado oil extract

Sensory evaluation was assessed for colour, aroma, viscosity and appearance with ten trained panellists used in assessing the sensory attributes of both the control and the avocado oil extract. Paired t-test was conducted for both the control and avocado oil extract used in the study. Significant differences among samples are indicated by different data labels (alphabets a and b) on error bars of the chart (Figure 1). Results of the sensory analysis show that there was no significant difference ($p<0.05$) in the viscosity of both the avocado oil extract and the control sample. The viscosity of both oil extract and control samples were rated fairly at 3.6 and 3.9 respectively.

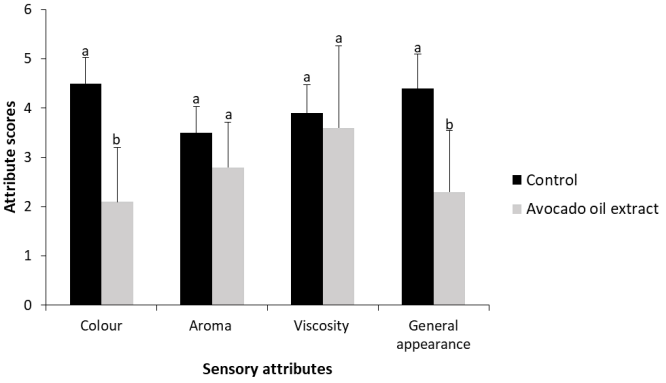

Figure 1. Sensory evaluation of avocado oil samples. Error bars are standard deviation of the mean values (n = 3). Different alphabet notations on the same attribute are significantly different at $p<0.05$.

There was also no significant difference between the avocado oil extract (2.8) and the control sample (4.5) in terms of aroma, thereby indicating that most of the panellist rated fair on the aroma. However, a significant difference was recorded in the general appearance of both the extracted and control sample with the panellist showing a preference for the control sample (4.4) than the avocado oil extract sample (2.3). Preference for colour by the panellist was seen to exist more for the control sample (4.5) than the avocado oil extract (2.1), with a significant difference ($p<0.05$) found to exist among the samples.

The mean values for all sensory attributes of the avocado oil extract were below the average rating of 3 except for viscosity which had a mean rating of 3.6. Conversely, the control sample recorded a rating of > 3.5 with the highest rating of 4.5 obtained for the colour of the control sample. Generally, there was a preference by the panellists for the control sample as the avocado oil extract sample was rated low on all the sensory attributes when compared to the control sample.

4. Conclusion

Extracted avocado oil exhibited better physicochemical properties when compared to refined commercial avocado oil. It was observed that the method of processing and oil extraction had a positive effect on the physicochemical properties of the extracted oil. However, the sensory evaluation conducted on the extracted cold-pressed and refined commercial oil, showed that consumers were more inclined towards the refined, bleached and deodorised commercial oil than the cold press extracted oil. It can therefore be implied that avocado oil obtained through the cold press method of extraction possess good functional properties.

Conflict of interest

The authors declare no conflict of interest.

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References

Alozie, Y.E., Udofia, U.S. and Ogo, A.O. (2010). Physicochemical Properties of Avocado Pear (*Persea Americana*) Oil and its Suitability for Domestic and Industries Uses. *Nigerian Journal of Nutritional Sciences*, 31(2), 16-19. https://doi.org/10.4314/njns.v31i2.63909

AOAC. (2000). Official methods of analysis. Association of Official Analytical Chemists, 17th ed. Virginia, USA: AOAC.

Ariza, J., López, F., Coyot, J., Ramos, M., Díaz, J. and Martínez, A. (2011). Effect of different extraction methods on the profile of fatty acids in avocado oil (Persea americana Mill. Var. Hass). *Revista Venezolana de Ciencia y Tecnologia de Alimentos*, 2 (2), 263–276.

Daguet, D. (2000). Phytosterol: highly promising. *Lipid Technology*, 12(4), 77-80. https://doi.org/10.1016/S1350-4789(00)89115-1

Donetti, M. and Terry, L. (2014). Biochemical markers defining growing area and ripening stage of imported avocado fruit cv. Hass. *Journal of Food Composition and Analysis*, 34(1), 90–98. https://doi.org/10.1016/j.jfca.2013.11.011

dos Santos, M.A.Z., Alicieo, T.V.R., Pereira, C.M.P., Ramis-Ramos, G. and Mendonca, C.R.B. (2014). Profile of Bioactive Compounds in Avocado Pulp Oil: Influence of the Drying Processes and Extraction Methods. *Journal of the American Oil Chemists Society*, 91(1), 19–27. https://doi.org/10.1007/s11746-013-2289-x

Dreher, M. and Davenport, A. (2013). Hass avocado composition and potential health effects. *Critical Reviews in Food Science and Nutrition*, 53(7), 738–750. https://doi.org/10.1080/10408398.2011.556759

Eyres, L., Sherpa, N. and Hendriks, G. (2006). Avocado oil: a new edible oil from Australasia. *Lipid Technology*, 13(4), 84-88.

Ferreyra, R., Sellés, G., Saavedra, J., Ortiz, J., Zúñiga, C., Troncoso, C., Rivera, S.A., González-Agüero, M. and Defilippi, B.G. (2016). Identification of pre-harvest factors that affect fatty acid profiles of avocado fruit (*Persea americana* Mill) cv. 'Hass' at harvest. *South African Journal of Botany*, 104, 15–20. https://doi.org/10.1016/j.sajb.2015.10.006

Galvao, M., Narain, D.S.N. and Nigam, N. (2014). Influence of different cultivars on oil quality and chemical characteristics of avocado fruit. *Food Science and Technology-Brazil*, 34(3), 539-546. https://doi.org/10.1590/1678-457x.6388

Gomez-Lopez, V.M. (2000). Fruit characterization of Venezuelan avocado varieties of medium oil content. *Scientia Agricola*, 57(4), 791-794. https://doi.org/10.1590/S0103-90162000000400031

Gulla, S. and Waghray, K.A. (2011). A Freedom of choice-sensory profiling and consumer acceptability of oil blends. *Studies on Home and Community Science*, 5(1), 1-6. https://

doi.org/10.1080/09737189.2011.11885322

Hofman, P., Fuch, Y. and Milne, D. (2002). Harvesting, packing, postharvest technology, transport and processing. In Whiley, A.B., Schaffer and Wolstenholme, B. (Ed). The avocado: botany, production and uses, p. 363–391. Wallingford, United Kingdom: CABI Publishing. https://doi.org/10.1079/9780851993577.0363

Ikeyi, A.P. (2013). Assessment of fatty acid profile of avocado pear (*Persea americana*) obtained from Nsukka area of Enugu state, Nigeria. *The Experiment*, 12(2), 762-767.

Ikhuoria, E.U. and Maliki, M. (2007). Characterization of avocado pear (*Persea americana*) and African pear (*Dacryodes edulis*) extracts. *African Journal of Biotechnology*, 6(7), 950-952.

Mostert, M.E., Botha, B.M., Du Plessis, L.M. and Duodu, K.G. (2007). Effect of fruit ripeness and method of fruit drying on the extractability of avocado oil with hexane and supercritical carbon dioxide. *Journal of the Science of Food and Agriculture*, 87(15), 2880–2885. https://doi.org/10.1002/jsfa.3051

Ortiz-Moreno, A., Dorantes, A.L., Galindez M.J. and Cardenas, S.E. (2004). Effect of novel oil extraction method on avocado (*Persea americana* Mill) pulp microstructure. *Plant Foods for Human Nutrition*, 59 (1), 11–14. https://doi.org/10.1007/s11130-004-0032-3

Ortiz-Moreno, A., Dorantes, A.L., Galindez, M.J. and Guzman, G.R. (2003). Effect of different extraction methods on fatty acids, volatile compounds, physical and chemical properties of avocado (*Persea americana* Mill) oil. *Journal of Agricultural and Food Chemistry*, 51(8), 2216–2221. https://doi.org/10.1021/jf0207934

Pedreschi, R., Hollak, S., Harkema, H., Otma, E., Robledo, P., Westra, E., Somhorst, D., Ferreyra, R. and Defilippi, B.G. (2016). Impact of postharvest ripening strategies on 'Hass' avocado fatty acid profiles. *South African Journal of Botany*, 103, 32–35. https://doi.org/10.1016/j.sajb.2015.09.012

Requejo-Tapia, L.C. (1999). International trends in fresh avocado and avocado oil production and seasonal variation of fatty acids in New Zealand-grown cv. Hass. New Zealand: Massey University, MSc.

Rodríguez-Carpena, J.G., Morcuende, D. and Estévez, M. (2012). Avocado, sunflower and olive oils as replacers of pork back-fat in burger patties: Effect on lipid composition, oxidative stability and quality traits. *Meat Science*, 90(1), 106–115. https://doi.org/10.1016/j.meatsci.2011.06.007

Salesa-Fetu, G., Faumuina, N. and Maiava, L.F. (2010). Samoa Avocado oils: Processing into exports products and commercialization opportunities, p. 25. Samoa: Scientific Research Organization of Samoa Report.

Somogyi, L.P., Ramasway, H.S. and Hui, Y.H. (1996). Processing Fruits: Science and Technology, Volume 2: Major processed products, p. 545. Pennsylvania, USA: Technomic Publishing.

Villa-Rodriguez, J., Molina-Corral, J., Ayala-Zavala, F., Olivas, G. and Gonzalez-Aguilar, G. (2011). Effect of maturity stage on the content of fatty acids and antioxidant activity of 'Hass' avocado. *Food Research International*, 44(5), 1231–1237. https://doi.org/10.1016/j.foodres.2010.11.012

Wong, M., Ashton, O.B.O., McGhie, T.K., Requejo-Jackman, C., Wang, Y. and Woolf, A.B. (2011). Influence of proportion of skin present during malaxing on pigment composition of cold pressed avocado oil. *Journal of the American Oil Chemists' Society*, 88(9), 1373–1378. https://doi.org/10.1007/s11746-011-1790-3

Wong, M., Requejo-Jackman, C. and Woolf, A.B. (2010). What is unrefined, extra virgin cold-pressed avocado oil? *Inform AOCS*, 21(4), 189-260.

Woolf, A., Wong, M., Eyres, L., McGhie, T., Lund, C., Olsson, S., Wang, Y., Bulley, C., Wang, M., Friel, E. and Requejo-Jackman, C. (2009). Avocado oil. In Moreau, R. and Kamal-Eldin, A. (Eds), Gourmet and Health-Promoting Specialty Oils, p. 73-125. Urbana, Illinois: AOCS Press. https://doi.org/10.1016/B978-1-893997-97-4.50008-5

Wrolstad, R.E. and Smith. D.E. (2010). Color analysis. In Nielsen, S.S. (Ed). Food analysis, p. 573-586. New York: Springer Science+Business Media. https://doi.org/10.1007/978-1-4419-1478-1_32

