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Supercritical fluid extraction of avocado oil

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ABSTRACT

Avocado oil, extracted using supercritical carbon dioxide, was compared to oil obtained using hexane for extraction. The chemical composition, as well as the resulting yield, was used to compare oils obtained using the two methods. The influence of temperature and pressure on the supercritical extraction process of avocado oil was evaluated. It was found that 94% of the oil had been extracted within 2 hr at 350 atm. All indications are that supercritical fluid extraction (SFE) of avocado oil is economically feasible. However, the economic viability must be confirmed together with role players from the avocado industry.

INTRODUCTION

The aim of this project is to evaluate supercritical fluid extraction (SFE) as an alternative technique for the extraction of oil from avocado fruit. To achieve this aim, the extraction of avocado material on a laboratory scale SFE system and the comparison of this extract with oil obtained by hexane extraction was investigated.

MATERIALS AND METHODS

Liquid carbon dioxide, purity 99.995% from Air Products SA, was used without any further purification as the extraction fluid. An in-house built apparatus was constructed for the extraction. It consisted of a high-pressure pump (ISCO 100 DX), a 10 ml extraction cell and a 10 ml pre-heating column (Keystone Scientific, Bellefonte, PA, USA) placed in a Carlo Erba Fractovap (Model 2700) gas chromatograph oven.

Avocado fruit, variety Fuerte and of unknown origin, was purchased from a local market. The fruit was allowed to ripen before processing. The material was prepared by oven drying destoned, unpeeled, fresh fruit at 80°C for 24 hr. The dried avocado was ground to less than 2 mm by means of a Kenwood food processor (Model PFP 32) and stored in a freezer at 4°C until analysis.

Extractions were performed at 37°C / 350 atm, 37°C / 540 atm and at 81°C / 350 atm, 81°C / 540 atm. Prior to any analysis the extracted oil was subjected to vacuum evaporation for 30 min in order to remove any water and dissolved carbon dioxide. The fluid flow rate was kept constant at 4.5 ml/min, measured at the pump head and controlled by a heated needle valve. All extractions were performed on 4.000 g ripe oven dried avocado mesocarp samples and the extracted oil was collected in a glass collection vessel without any solvent to assist collection.

Solvent extractions were performed on a 10.00 g dried sample using hexane (Merck – AR) and a Soxhlet extractor for 8 hr. Solvent was removed by vacuum evaporation and exposure to heat in a drying oven at 100°C until constant mass.

RESULTS AND DISCUSSION

The influence of temperature and pressure on the SF extraction of avocado oil was evaluated and results are presented in Figure 1.

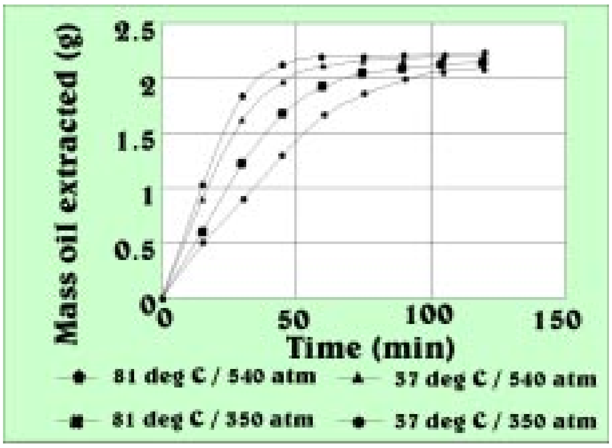

Figure 1. Yield of avocado oil obtained under different temperatures and pressures.

At both 37°C and 81°C the yield of the avocado triglycerides in unmodified carbon dioxide increased with increased pressure. As may be seen in Figure 1, after 120 min there was only a difference of about 0.1 g between the highest and lowest yields. At 37°C after 50 min, however, the increased pressure (from 350 to 540 atm) resulted in an increase of about 50% in yield. The percentage increase (29%) was less for the higher temperature (81°C).

High pressures will result in higher yields of triglycerides using supercritical carbon dioxide, but they should also be beneficial to the extraction of avocado oil because of the physical effect that pressure will have on the oil-bearing cells in the mesocarp. The oil in avocado is carried in idioblast cells with strong lignified walls. Increasing pressure will assist in breaking the walls of the cells, so that the oil is more readily available.

An important feature to note regarding the results as presented in Figure 1, is that at 37°C and 350 atm, 94% of the total extractable avocado oil was obtained within 120 min, when taking the maximum yield to be obtained at 81°C and 540 atm. This was the maximum that could be extracted with available instrumentation. The obtained yield at 350 atm is of great economical importance because of the capital investment associated with an industrial system operating at 350 atm instead of at 540 atm.

Solvent extractions by means of a Soxhlet extractor were optimised and it was determined that all extractable material was removed after 8 hr. It was assumed that the oil extracted by means of the Soxhlet extractor represented 100% of the extractable oil from the avocado material. The optimisation results of a typical Soxhlet extraction of avocado oil are represented in Figure 2.

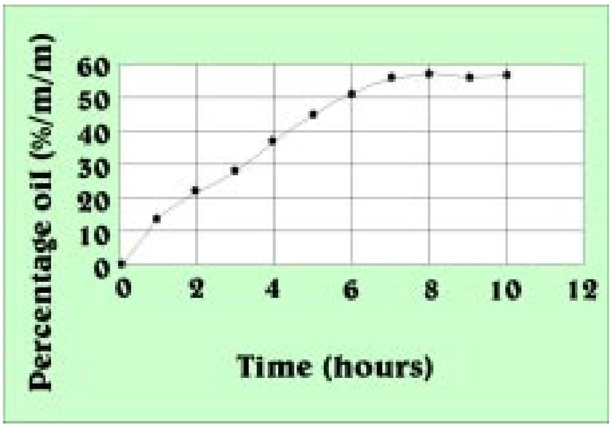

Figure 2. Optimisation of Soxhlet extraction of avocado oil from dried avocado material with hexane as a solvent.

The optimum extraction conditions for supercritical carbon dioxide extractions were found to be 532 atm and 81°C. Experimental data obtained under these conditions of temperature and pressure was used in the statistical comparison between SFE and Soxhlet extractions.

Statistical comparison of the results showed that there was no significant difference between the precisions of the two methods ($F_{calc} < F_{int}$). The two-sided t-test, $t_{calc} > t_{crit}$, indicated a significant difference in the yield of the two methods (55.7% m/m hexane / 56.5% m/m SFE). The high yields in the case of the hexane extrac-

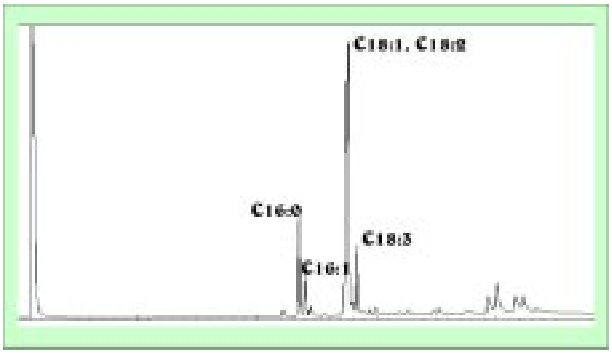

Figure 3. GC analysis of fatty acid methyl esters content of avocado oil as extracted by hexane. (C16:0- Methyl Hexadecanoate, C16:1- Methyl 9(Z)-Hexadecanoate, C18:0- Methyl Octadecanoate, C18:1- Methyl 9(Z)-Octadecanoate, C18:2- Methyl 9,12(Z,Z)-Octadecadienoate, C18:3- Methyl 9,12,15(Z,Z,Z)-Octadecatrienoate).

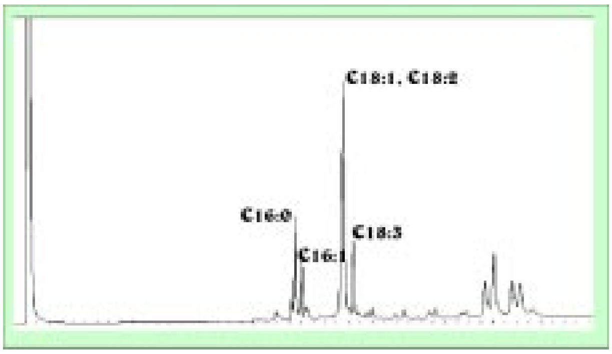

Figure 4. GC analysis of fatty acid methyl esters content of avocado oil as extracted by SFE at 37°C/350 atm. (C16:0- Methyl Hexadecanoate, C16:1- Methyl 9(Z)-Hexadecanoate, C18:0- Methyl Octadecanoate, C18:1- Methyl 9(Z)-Octadecanoate, C18:2- Methyl 9,12(Z,Z)-Octadecadienoate, C18:3- Methyl 9,12,15(Z,Z,Z)-Octadecatrienoate).

tion may be ascribed to the presence of chlorophyll and possible other components that were extracted during solvent extraction and not with SFE.

The fatty acid methyl ester (FAME) composition of the oils, extracted by hexane and SFE (37°C/350 atm), was determined in order to evaluate if there was any difference in composition of the products of the two methods. Compounds were identified by comparing their retention times to that of the standards, RM-5, RM-6 and rapeseed oil (Matreya). The C18:1 and C18:2 FAME could not be separated with the available instrumentation, and was regarded as a single entity in the calculation of the results. The comparison between the different extractions was made by expressing the results for C16:0, C16:1, C18:1 and C18: 2 (as a single entity) and C18:3 relative to the peak area of C16:0. Figure 3 and Figure 4 are examples of gas chromatographic results of the FAMEs in avocado oil extracted by hexane and SFE at 37°C/350 atm.

The average of the relative peak areas for the avocado oils, extracted with different supercritical extraction conditions and those of the oils extracted by hexane, differed less than 10%. The FAME profiles, obtained from the oils extracted under different supercritical conditions, indicated that no fractional extraction of the triglycerides was obtained.

CONCLUSION

It has been shown that supercritical carbon dioxide can successfully extract high quality avocado oil. The optimum extraction pressure was determined to be at 540 atm yielding an extraction that was 95% complete within 1 hr. Reduction of the pressure to 350 atm resulted in the extraction being 94% complete within 2 hr. Although the extraction time was doubled, there would be a substantial decrease in capital investment when operating at a lower pressure. This project has indicated that the supercritical fluid extraction of avocado oil may be economically feasible. This justifies further investigation with regard to industrialization of this process.

ACKNOWLEDGEMENT

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