A comparison between avocado peel var. Hass and var Lorena to obtain polyphenolic compounds

Daissy Lorena Restrepo Serna IQ, MSc, PhD Candidate
Carlos Ariel Cardona Alzate IQ, MSc, PhD

Research group in Chemical, Catalytic and Biotechnological processes
Instituto de Biotecnología y Agroindustria
Universidad Nacional de Colombia sede Manizales
Facultad de Ingeniería y Arquitectura, Departamento de Ingeniería Química
Manizales, Colombia
2023

Content

Introduction

World production in 2021: 8,685.67 thousand tonnes

1. Mexico: 2,442.94 thousand tonnes
2. Colombia: 979.62 thousand tonnes

After its consumption two wastes are generated

Avocado peel

Avocado seed

Polyphenolic compounds

Phenolic acids	Flavonoids	Tanins
Gallic acid Vanillic acid Syringic acid	**Catechin** **Epicatechin** Apigenin	

Antioxidants, antimicrobial, anti-inflammatory, anti-diabetic properties.

Introduction

Conventional technology

Non-conventional technology

<u>Solid:Liquid extraction (SE)</u>

Principle: combining the solid with a **solvent** in which the metabolite is soluble.

<u>Ultrasound Assisted Extraction (UAE)</u>

Principle: combining the solid with a **solvent** in which the metabolite is soluble in the presence of ultrasonic waves.

<u>Supercritical Fluid Extraction (SFE)</u>

Principle: combining the solid with a **solvent (supercritical fluid)** in which the metabolite is soluble. The metabolite solubility in the solvent is modify by the addition of a **co-solvent**.

The metabolite (catechin and epicatechin) yield extraction is influenced for:

1. **Solvent** – Water, Ethanol, Ethanol solutions
2. **Technology** – Ultrasonic waves, supercritical fluid extraction
3. **Raw material** – the variety of the fruit
4. **Raw material** – cultivation zone

Objetives:

- To identify the technology that improve the catechins extraction
- To analyze the influence of the variety avocado in the catechins extraction

Methodology: Experimental

Avocado peel (Persea americana var. Hass) (APH)

Avocado peel (Persea americana var. Lorena) (APL)

1 Pretreatment

1. Collection
2. Pulping
3. Drying
4. Cutting
5. Sieving

2 Raw material characterization

1. Moisture
2. Extractives
3. Holocellulose
4. Cellulose
5. Lignin
6. Ash

3 Experimental extractions

Solid concentration: 0.2 g/mL

Solvents: Ethanol, Water, Ethanol 50%.

Time: 60 min. Temperature: 60°C

3.1 SE

Agitation: 200 rpm

3.2 UAE

100 % amplitude, power of 50W, 20 kWh energy consumption, and 30 kHz frequency.

3.3 SFE

Pressure: 120 bar and 240 bar

Ethylene glycol as refrigerant

Supercritical fluid: CO_2

Operation: dynamic mode (CO_2 feed continuously) in a ratio 1:18

4 Quantification of extractives

TPC: Folin-Ciocalteu

Antioxidant activity: DPPH and ABTS methods

Reducing sugars: DNS method

HPLC: Catechin and Epicatechin

Raw material characterization

Extractives (NREL/TP – 510 – 42619)

Holocellulose (ASTM D1104)

Cellulose (T203 os–74 ASTM 1695–77)

Lignin (NREL/TP – 510 – 42618)

Ash (NREL/TP – 510 – 42622)

Moisture (NREL/TP - 510-42621)

Methodology: Simulation

Software: Aspen Plus v.9
- **Mass flow:** 19 kg/h
- **Thermodynamic models:** The Predictive Soave-Redlich-Kwong (PSRK) for the SFE process and the Non-Random Two-Liquid (NRTL) for the SE process
- **Solid properties:** Database of National Renewables Energy Laboratory (NREL)
- **Dead time:** 15 min for the SE, and 10 min for the SFE.
- **All the process considered the solvent recirculation and the extract concentration using evaporation.**

Technical evaluation

1. Yield
2. Process Mass Intensity Index
3. Mass Loss Index
4. Renewability Material Index
5. Solvent Intensity Index

Economic evaluation

1. Production cost (USD/kg)
2. Profit margin (%)
3. CapEx (USD)
4. OpEx (USD)
5. Payback period (years)
6. Net Present Value (USD)
7. Minimum selling Price (USD/kg)
8. Minimum Processing Scale for Economic Feasibility (MPSEF)

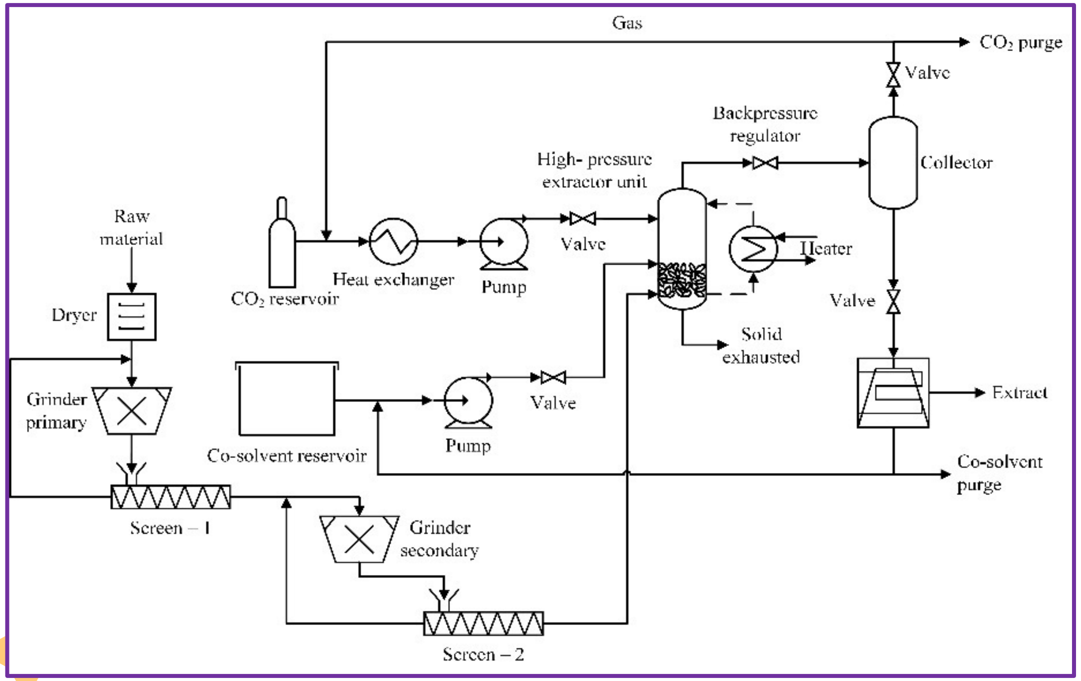


Figure 1. Simulation flowsheet for the SE and UAE

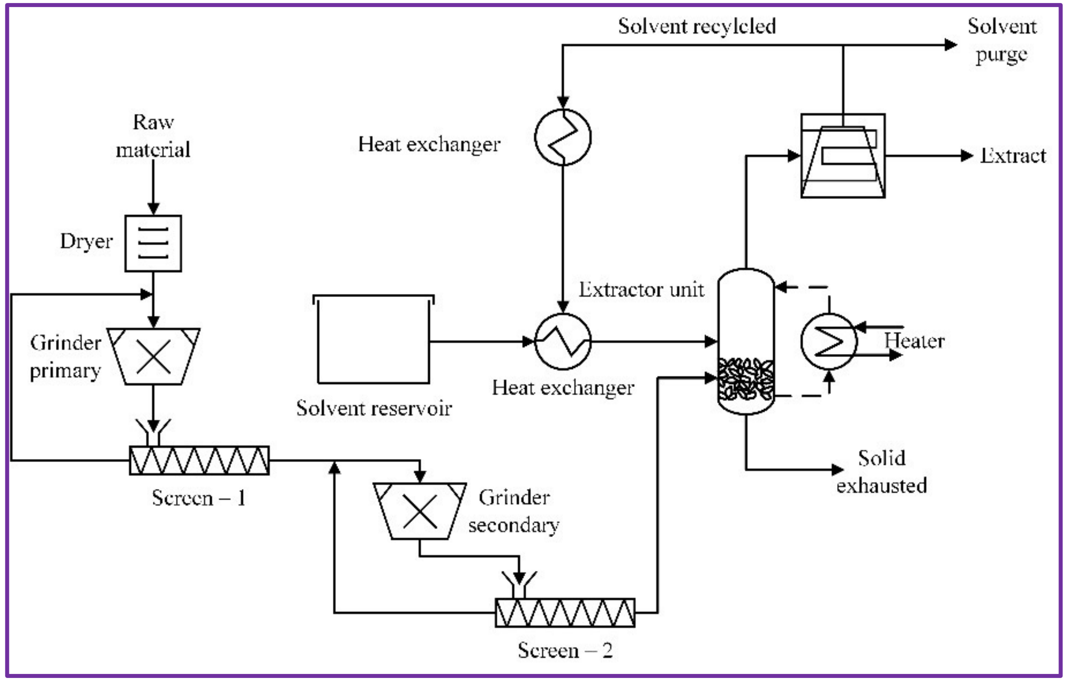
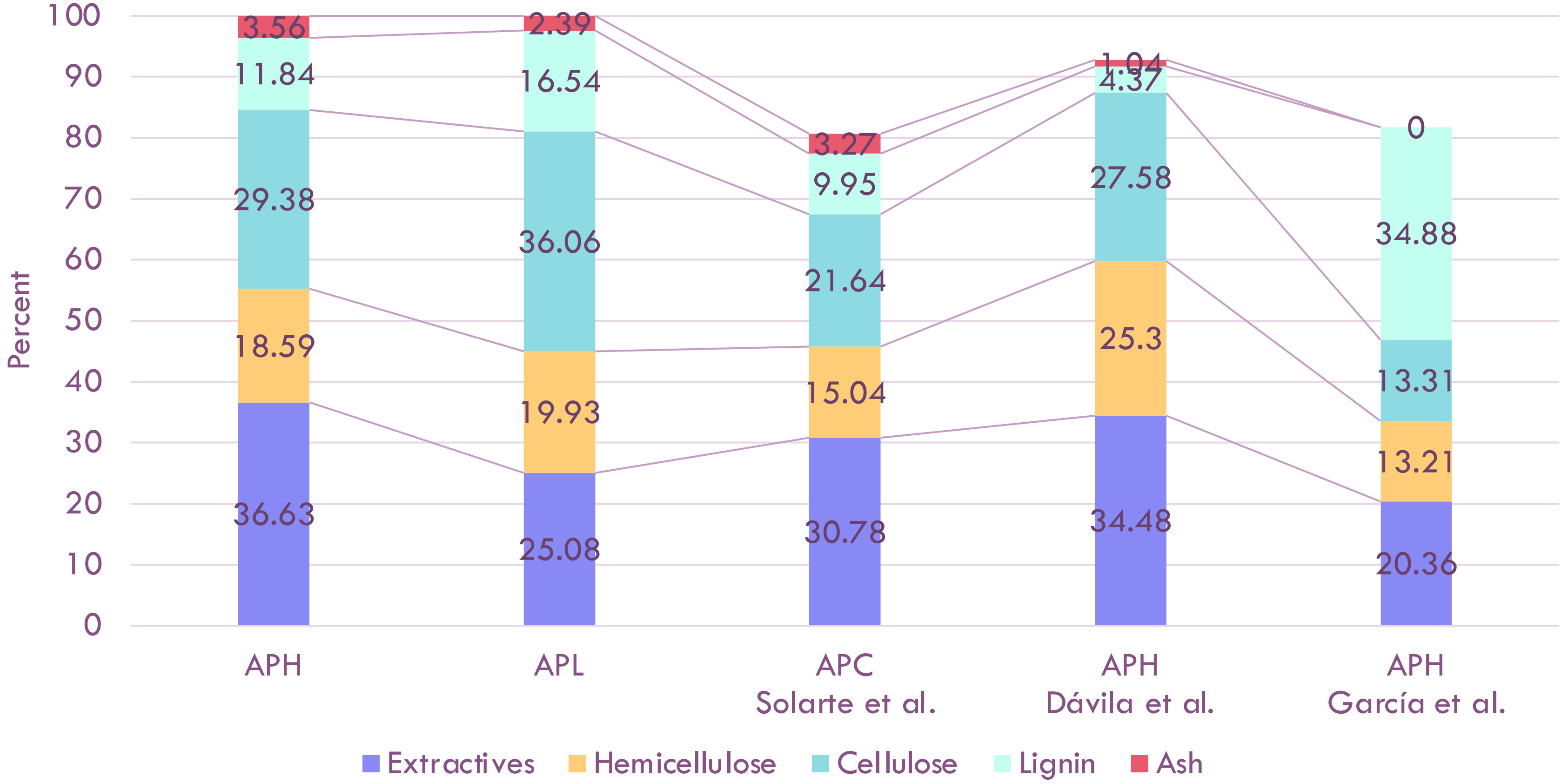


Figure 2. Simulation flowsheet for the SFE process.

Results: Characterization



High extractives content

Figure 3. Physic-chemical characterization of APH and APL and results reported in the literature.

Results: Extractions

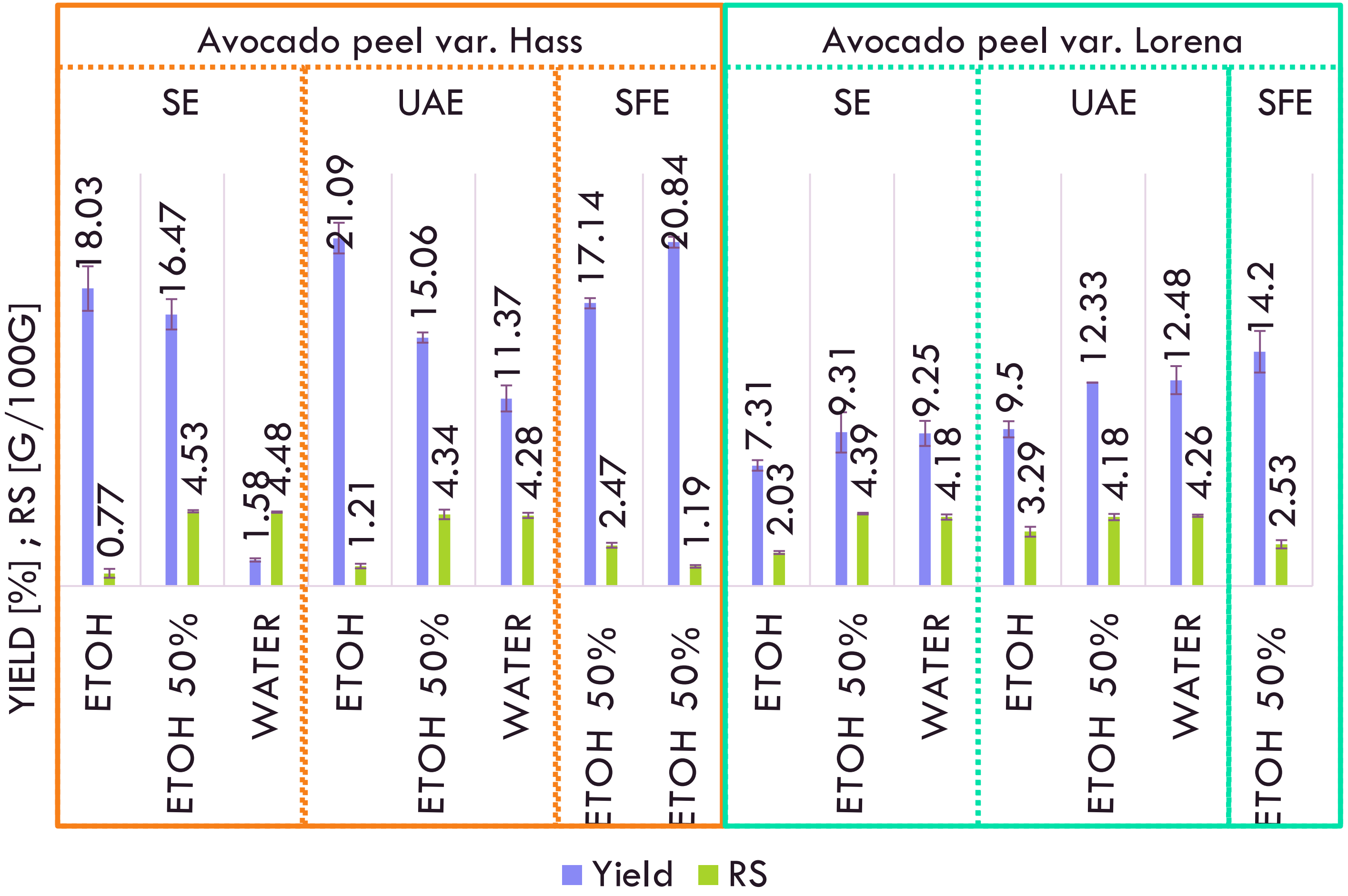


Figure 6. Yield [kg/100 kg AP and Reducing Sugars (RS) [mg/100 g AP content in the extracts from Avocado Peel

- ✓ The use of UAE to extract bioactive compounds from APH results in an increase in yield of 3.15% over that obtained with SE. A similar situation is evident when employing SFE for APL, where the yield increase corresponded to 4.95%.
- ✓ Studies such as Trujillo-Mayol et al. report maximum extraction yields of 25.3% for APH using a combination of ultrasound with maceration [52].
- ✓ Grisales-Mejia et al. report a yield of 9.3% using UAE and ethanol as solvent, a value that increases to 12.4% with a 70% ethanol solution [51].

Results: Extractions

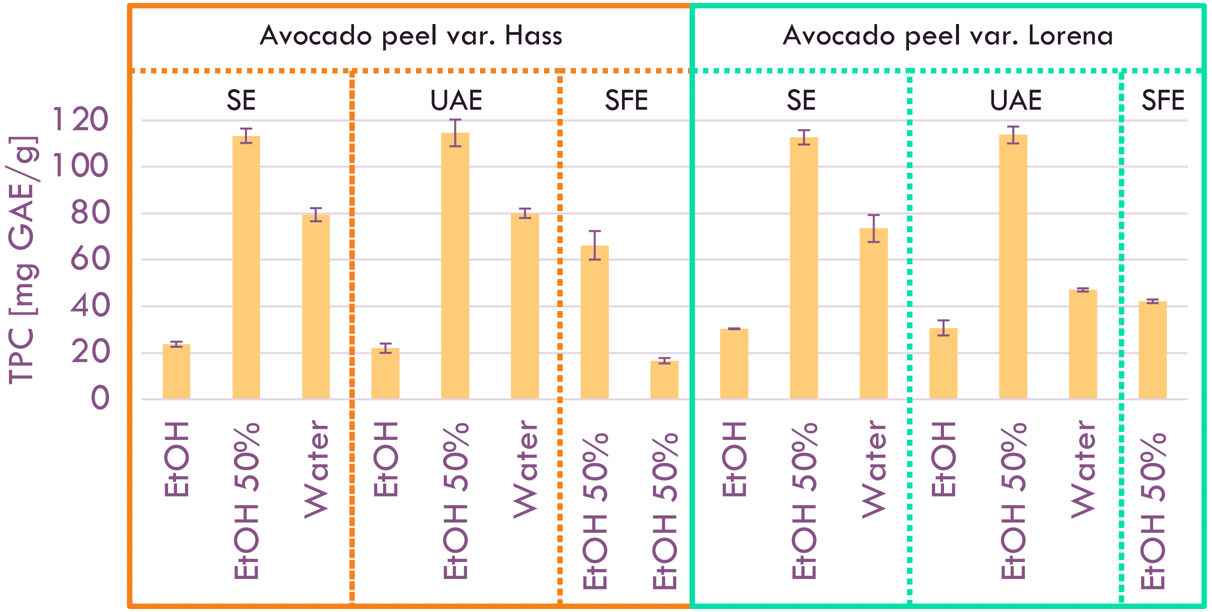


Figure 4. Total Polyphenolic Content (TPC) in the extracts from Avocado Peel

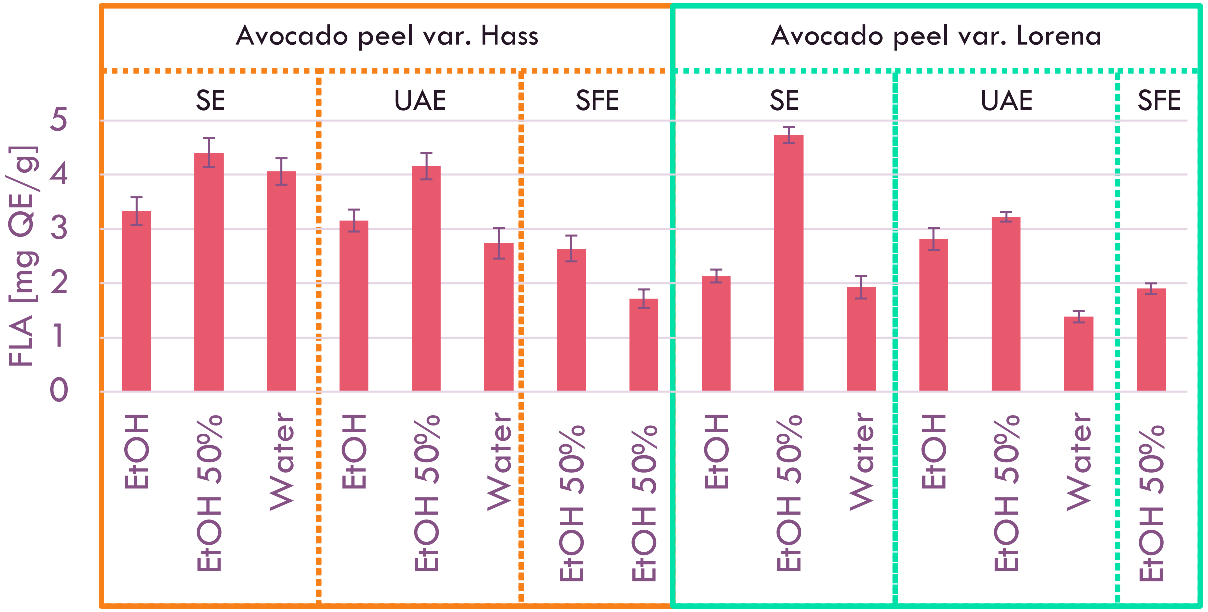


Figure 5. Flavonoid Content (FLA) in the extracts from Avocado Peel

Wang et al. performed the extraction of phytochemicals present in different varieties APs using as solvent a solution of acetone - water - acetic acid in ratios of 70:29.7:0.3 v/v/v/v via vortex and sonication. When quantifying the TPC of the Loretta and Hass varieties, they found values of 7.60 and 12.60 mg GAE/g, respectively.

Results: Extractions

- ✓ The use of water as a solvent allowed the extraction of compounds with higher antioxidant capacity than ethanol-soluble compounds in the APH (SE and UAE) and APL (SE).
- ✓ The use of UAE in the extraction of APL showed an antioxidant capacity independent of the solvent used.
- ✓ The two varieties analyzed have similar antioxidant capacities.

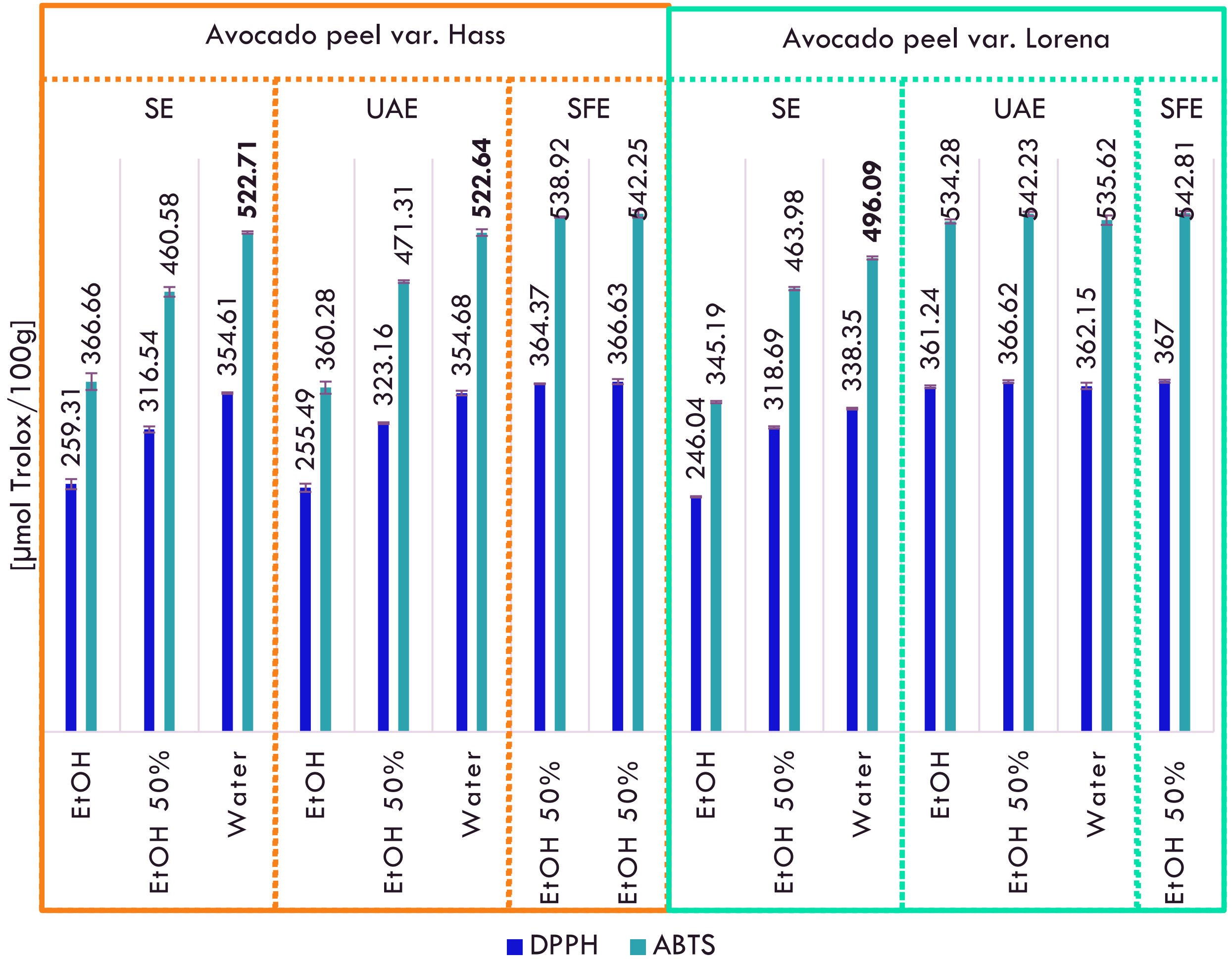
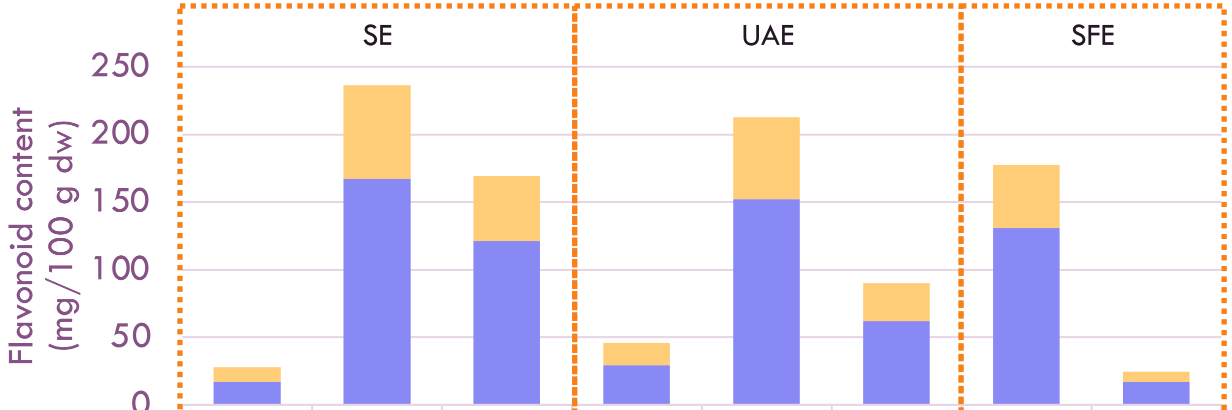


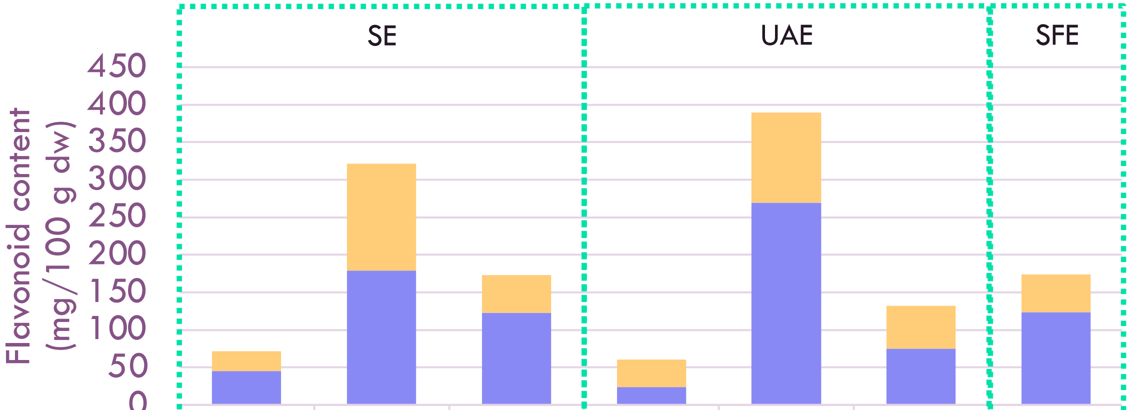
Figure 7. Antioxidant activity in the extracts from Avocado Peel using the DPPH and ABTS methods

Results: Extractions



	SE			UAE			SFE	
	EtOH	EtOH 50%	Water	EtOH	EtOH 50%	Water	EtOH 50%	EtOH 50%
Catechin	10.61	69.26	48.05	16.6	60.77	28.02	46.48	7.26
Epicatechin	17.19	167.27	121.13	29.19	151.96	62.07	130.88	17.05

Figure 8. Catechin and Epicatechin content in the Avocado Peel Extracts from var. Hass

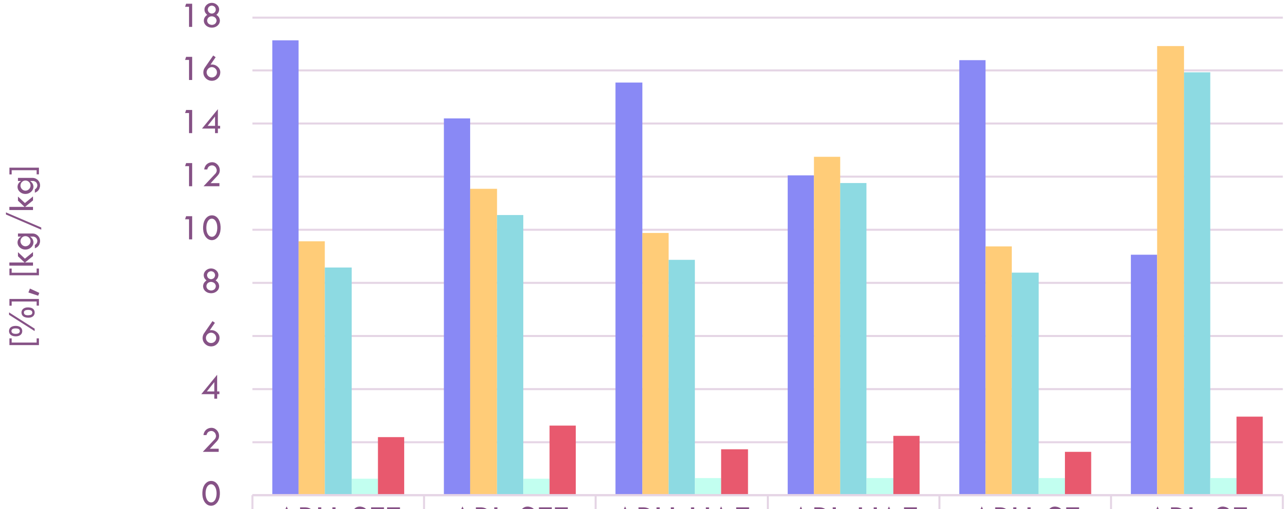


	SE			UAE			SFE
	EtOH	EtOH 50%	Water	EtOH	EtOH 50%	Water	EtOH 50%
Catechin	26.51	142.83	49.95	37.12	119.88	56.96	50.12
Epicatechin	45.17	178.81	122.92	23.57	269.37	75.26	123.34

Figure 9. Catechin and Epicatechin content in the Avocado Peel Extracts from var. Loretta

Tremocoldi et al. studied the extraction of APH using UAE and an 80% v/v ethanol solution as solvent [59]. The results showed a TPC of 6,350 mg GAE/100 g, a DPPH of 31,000 µmol Trolox/100 g, and an ABTS of 79,150 µmol Trolox/100 g. CAT concentrations of 364 mg/100 g and EpiCAT of 4,021 mg/100 g were found when identifying the components present

Results: Simulation



	APH SFE	APL SFE	APH UAE	APL UAE	APH SE	APL SE
Yield*	17.14	14.2	15.55	12.05	16.39	9.07
PMI [kg/kg]	9.58	11.56	9.88	12.76	9.38	16.94
MLI [kg/kg]	8.58	10.56	8.88	11.76	8.38	15.94
RMI [kg/kg]	0.61	0.61	0.65	0.65	0.65	0.65
SII [kg/kg]	2.18	2.63	1.73	2.23	1.64	2.96

* kg/100 kg AP

Figure 10. Technical indicators obtained from the simulations

- The APH requires less solvent that the APL
- Low PMI values (<25,000): low waste generation
- The APH present the lowest mass loss (MLI)
- Similar values of renewability was obtained (RMI)

PMI (Process Mass Intensity)
MLI (Mass Loss Index)
RMI (Renewability Material Index)
SII (Solvent Intensity Index).

Results: Simulation

Table 1. Economic indicators estimated in this work.

Item	Units	APH SFE	APL SFE	APH UAE	APL UAE	APH SE	APL SE
Production cost	USD/kg	14.07	16.98	11.01	14.21	**8.21**	14.84
Profit margin	%	6.19	-	26.62	5.30	**45.24**	1.05
CapEx	USD	**1,056,442.98**	**1,056,444.58**	615,264.26	615,253.33	374,824.11	374,816.71
OpEx	USD/year	**384,944.53**	**384,842.00**	273,160.31	273,142.27	214,870.20	214,841.66
Payback period	years	8.33	-	4.63	**8.29**	2.32	9.33
NPV final	USD	172,713.27	**-244,180.52**	592,446.22	103,510.59	1,044,815.28	22,055.95
MPSEF	tonne/day	0.37	**0.64**	0.19	0.38	0.10	0.43
Minimum selling price	USD/kg	13.92	**16.80**	10.91	14.08	8.16	14.74

Extract sale price:
15 USD/kg

Conclusions

- The extraction of catechins from APs is recommended the use of conventional technologies such as SE.

- Both varieties are good sources of flavonoids. A difference in the indicators can be appreciated when considering the economic part in which the process yields are involved. As a result, the var. Hass shows a higher profit margin than the var. Loretta. As a result, the extract of the var. Hass has a lower cost in the market and is a more promising raw material for its valorization through extraction processes.

References

F. G. Albrecht, D. H. König, N. Baucks, and R. U. Dietrich, “A standardized methodology for the techno-economic evaluation of alternative fuels – A case study,” Fuel, vol. 194, pp. 511–526, Apr. 2017, doi: 10.1016/j.fuel.2016.12.003.

W. Brand-Williams, M. E. Cuvelier, and C. Berset, “Use of a free radical method to evaluate antioxidant activity,” LWT - Food Science and Technology, vol. 28, no. 1, pp. 25–30, 1995, doi: 10.1016/S0023-6438(95)80008-5.

H. Chen, Y. Zuo, and Y. Deng, “Separation and determination of flavonoids and other phenolic compounds in cranberry juice by high-performance liquid chromatography,” J Chromatogr A, vol. 913, no. 1–2, pp. 387–395, 2001, doi: 10.1016/S0021-9673(00)01030-X.

N. G. T. Meneses, S. Martins, J. A. Teixeira, and S. I. Mussatto, “Influence of extraction solvents on the recovery of antioxidant phenolic compounds from brewer’s spent grains,” Sep Purif Technol, vol. 108, pp. 152–158, Apr. 2013, doi: 10.1016/J.SEPPUR.2013.02.015.

M. Ozgen, R. N. Reese, A. Z. Tulio, J. C. Scheerens, and A. R. Miller, “Modified 2,2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS) method to measure antioxidant capacity of selected small fruits and comparison to ferric reducing antioxidant power (FRAP) and 2,2′-diphenyl-1- picrylhydrazyl (DPPH) methods,” J Agric Food Chem, vol. 54, no. 4, pp. 1151–1157, Feb. 2006, doi: 10.1021/jf051960d.

R. Re, N. Pellegrini, A. Proteggente, A. Pannala, M. Yang, and C. Rice-Evans, “Antioxidant activity applying an improved ABTS radical cation decolorization assay,” Frre Radical & Medicine, vol. 26, no. 9/10, pp. 1231–1237, 1999.

M. R. Rover and R. C. Brown, “Quantification of total phenols in bio-oil using the Folin-Ciocalteu method,” J Anal Appl Pyrolysis, vol. 104, pp. 366–371, 2013, doi: 10.1016/j.jaap.2013.06.011.

J. C. Solarte-Toro, M. Ortiz-Sanchez, D. L. Restrepo-Serna, P. Peroza Piñeres, A. Pérez Cordero, and C. A. Cardona Alzate, “Influence of products portfolio and process contextualization on the economic performance of small- and large-scale avocado biorefineries,” *Bioresour Technol*, vol. 342, 2021, doi: 10.1016/j.biortech.2021.126060.

R. J. Wooley and V. Putsche, “NREL/MP-425-20685 Development of an Aspen Pus property database for biofuels components,” National Renewable Energy Laboratory, 1996.

“Use of Dinitrosalicylic Acid Reagent for Determination of Reducing Sugar,” Anal Chem, vol. 31, no. 3, pp. 426–428, 1959.

Acknolowments

Minciencias

Plan Bienal de Convocatorias

Más conocimiento, mayor desarrollo y mejores oportunidades para todos.

Convocatoria del Fondo de Ciencia, Tecnología e Innovación del Sistema General de Regalías para la conformación de una lista de proyectos elegibles para ser viabilizados, priorizados y aprobados por el OCAD en el marco del Programa de Becas de Excelencia

UNIVERSIDAD NACIONAL DE COLOMBIA
SEDE MANIZALES

Minciencias

The avocado peel as a source of catechins: a comparison between extraction technologies and the influence of fruit variety

Thank you for your attention

Daissy Lorena Restrepo Serna IQ, MSc, PhD Candidate Email: dlrestrepos@unal.edu.co
Carlos Ariel Cardona Alzate IQ, MSc, PhD **Email: ccardonaal@unal.edu.co**

Research group in Chemical, Catalytic and Biotechnological processes
Instituto de Biotecnología y Agroindustria
Universidad Nacional de Colombia
Facultad de Ingeniería y Arquitectura, Departamento de Ingeniería Química
Manizales, Colombia

2023