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
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Avocado peel and its applications

Definition of extraction conditions and simulation considerations (technical and economic)

Experimental and simulations results (technical and economic)

The Avocado Peels from Colombia is a potential raw material to obtain an extract rich in catechins?
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
  - Gallic acid
  - Vanillic acid
  - Syringic acid

- Flavonoids
  - Catechin
  - Epicatechin
  - Apigenin

- Tanins

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

### Conventional technology

**Solid-Liquid extraction (SE)**

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

### Non-conventional technology

**Ultrasound Assisted Extraction (UAE)**

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

**Supercritical Fluid Extraction (SFE)**

Principle: combining the solid with a solvent (supercritical fluid) in which the metabolite is soluble. The metabolite solubility in the solvent is modified 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

### Objectives:

- To identify the technology that improves 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. 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)

4. Experimental extractions
   - Solid concentration: 0.2 g/mL
   - Solvents: Ethanol, Water, Ethanol 50%
   - Time: 60 min.
   - Temperature: 60°C
   - Agitation: 200 rpm

3.1 SE
   - 100 % amplitude, power of 50W, 20 kWh
   - Energy consumption, and 30 kHz frequency.

3.2 UAE
   - Pressure: 120 bar and 240 bar
   - Ethylene glycol as refrigerant
   - Supercritical fluid: CO₂
   - Operation: dynamic mode (CO₂ feed continuously) in a ratio 1:18

3.3 SFE
   - TPC: Folin-Ciocalteu
   - Antioxidant activity: DPPH and HPLC: Catechin and Epicatechin ABTS methods
   - Reducing sugars: DNS method

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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

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

**Figure 6.** Yield [kg/100 kg AP and Reducing Sugars (RS) [mg/100 g AP content 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.
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

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

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

The APH requires less solvent than the APL

Low PMI values (<25,000): low waste generation

The APH present the lowest mass loss (MLI)

Similar values of renewability were obtained (RMI)

**Figure 10.** Technical indicators obtained from the simulations

<table>
<thead>
<tr>
<th>Indicator</th>
<th>APH SFE</th>
<th>APL SFE</th>
<th>APH UAE</th>
<th>APL UAE</th>
<th>APH SE</th>
<th>APL SE</th>
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<tbody>
<tr>
<td>Yield*</td>
<td>17.14</td>
<td>14.2</td>
<td>15.55</td>
<td>12.05</td>
<td>16.39</td>
<td>9.07</td>
</tr>
<tr>
<td>MLI [kg/kg]</td>
<td>8.58</td>
<td>10.56</td>
<td>8.88</td>
<td>11.76</td>
<td>8.38</td>
<td>15.94</td>
</tr>
<tr>
<td>RMI [kg/kg]</td>
<td>0.61</td>
<td>0.61</td>
<td>0.65</td>
<td>0.65</td>
<td>0.65</td>
<td>0.65</td>
</tr>
<tr>
<td>SII [kg/kg]</td>
<td>2.18</td>
<td>2.63</td>
<td>1.73</td>
<td>2.23</td>
<td>1.64</td>
<td>2.96</td>
</tr>
</tbody>
</table>

* kg/100 kg AP

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.

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

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


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.
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

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