Valuation of industry apple juice concentrate by-products

Elisabete Coelho, Rita Bastos, Marco Cruz, Mariana Pinto, Manuel A. Coimbra

Portugal

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Industrial process - Apple juice concentrate

- Receiving
- Washing Sorting
- Enzyme treatment
- Pressing
- Apple pomace
- Ultrafiltration
- Retentate
- Storage
- Concentration
Apple Pomace
# Samples

<table>
<thead>
<tr>
<th>Apple varieties</th>
<th>Conservation</th>
<th>Date</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 % Golden</td>
<td>Harvesting season</td>
<td>15-10-2013</td>
<td>SP-oct13</td>
</tr>
<tr>
<td>10 % Royal Gala</td>
<td>Harvesting season</td>
<td>15-10-2013</td>
<td>SP-oct13</td>
</tr>
<tr>
<td>10 % Starking</td>
<td>Cold storage</td>
<td>31-01-2014</td>
<td>SP-jan14</td>
</tr>
<tr>
<td>70 % Golden</td>
<td>Cold storage</td>
<td>31-01-2014</td>
<td>SP-jan14</td>
</tr>
<tr>
<td>15 % Starking</td>
<td>Harvesting season</td>
<td>25-09-2014</td>
<td>SP-sep14</td>
</tr>
<tr>
<td>10 % Royal Gala</td>
<td>Harvesting season</td>
<td>25-09-2014</td>
<td>SP-sep14</td>
</tr>
<tr>
<td>60 % Royal Gala</td>
<td>Harvesting season</td>
<td>25-09-2014</td>
<td>SP-sep14</td>
</tr>
<tr>
<td>30 % Starking</td>
<td>Harvesting season</td>
<td>25-09-2014</td>
<td>SP-sep14</td>
</tr>
<tr>
<td>8 % Golden</td>
<td>Harvesting season</td>
<td>25-09-2014</td>
<td>SP-sep14</td>
</tr>
<tr>
<td>2 % Reinnete and others</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Chemical characterization

- **H₂O**: 81%
- **Solids**: 19%
  - Polysaccharides: 55%
  - Sugars: 18%
  - Protein: 6%
  - Fat: 3%
  - Ashes: 1%
  - Others: 17%

Carbohydrate composition analysis

- **Glc (53)**
- **Fru (72)**
- **HexA (15)**
- **Glc (44)**
- **Fru (72)**
- **HexA (16)**
- **Glc (41)**
- **Fru (76)**

**Similar composition between lots**
Chemical characterization

Aminoacids analysis

- Essential Aminoacids

Concentration (mg/g)
Sequential water extraction

Soluble fiber extraction – boiling water

Apple Pomace

Water extraction 100°C, 10 min, 1:25 Filtration

res.water 1

sn.water 1

Water extraction 100°C, 10 min, 1:25 Filtration

res.water 2

sn.water 2

Water extraction
The first water extraction allowed the recovery of apple pomace sugars together with the fibres.
Polysaccharides extractions at 100°C, 10 min

1st extraction

Yield: 22%

Pectic polysaccharides

2nd extraction

Yield: 6%

More branched pectic polysaccharides and starch (nutritionally balanced dietary fibre)
Sequential water extraction

Soluble fiber extraction – Microwave assisted extraction (140°C)

Apple Pomace

Water extraction 100°C, 10 min, 1:25 Filtration

res.water 1    sn.water 1

Water extraction 100°C, 10 min, 1:25 Filtration

res.water 2    sn.water 2

MAE 140°C, 5 min, 1:14 Filtration

res.MAE 1    sn.MAE 1

MAE 140°C, 5 min, 1:14 Filtration

res.MAE 2    sn.MAE 2

Water extraction

Microwave assisted extraction (MAE)
Polysaccharides extractions at 140°C, 5 min (MAE)

**1st cycle**
- **Yield:** 8%
- High branched pectic polysaccharides

**2nd cycle**
- **Yield:** 4%
- Ratio Ara/HexA decrease (debranched pectic polysaccharides) and increase the extraction of xylans
Sequential water extraction

Soluble fiber extraction – Microwave assisted extraction (180°C)

Apple Pomace

Water extraction 100°C, 10 min, 1:25 Filtration

res.water 1  sn.water 1

Water extraction 100°C, 10 min, 1:25 Filtration

res.water 2  sn.water 2

MAE 140°C, 5 min, 1:14 Filtration

res.MAE 1  sn.MAE 1

MAE 140°C, 5 min, 1:14 Filtration

res.MAE 2  sn.MAE 2

MAE 180°C, 2 min, 1:28 Filtration

Final residue (FR)  sn.MAE 3
Polysaccharides extractions at 180°C, 2 min (MAE)

Yield: 5%

Xylose rich fibres, possibly xylans and xyloglucans
Remaining polysaccharides of final residues

45% of unextracted polysaccharides

Final residue is rich in cellulose
Apple pomace drying
Apple pomace drying

Apple pomace wet mass = 500,0 g

Lower relative air moisture increases drying efficiency
Apple pomace infusions

Different drying temperatures lead to infusions with different colors and flavors.
Apple pomace and its infusions volatiles

Dried Apple Pomace
Toasted, caramel, sweet, and green notes.

Apple Pomace Infusion
Fruity, apple-like, citrus, and spicy notes.

Apple Pomace Infusion with sugar
Almond, caramel, and sweet notes.
Apple pomace possible applications

- Meal for Laying hens 1%
- Extruded for pet 1.5%
- Animal Feed
- Apple infusions
- Soluble fiber

http://www.massivemov.com/profitapple
Retentate
Industrial process - Apple juice concentrate

1. Receiving
2. Washing
3. Sorting
4. Enzyme treatment
5. Pressing
6. Ultrafiltration
7. Diafiltration
8. Retentate UF
9. Retentate DF

Indu mape
Industrialização de Fruta, S.A.
Chemical characterization

Retentate DF

Water 92%
Solids 8%

Fiber 6%
Lipids 5%
Protein 13%
Sugars 48%
Other 28%
Separation

Retentate DF

Centrifugation

Residue 1

Extract 1
51% (w/w)
Sugar analysis of Extract 1

<table>
<thead>
<tr>
<th>Carbohydrates (mol%)</th>
<th>Total carbohydrate (mg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ara 2,8</td>
<td>Xyl 1,0</td>
</tr>
</tbody>
</table>

Retentate DF

Centrifugation

Residue 1

Extract 1 51% (w/w)
Water extraction

Retentate DF

Centrifugation

Residue 1

Extract 1

51% (w/w)

H₂O, 40 °C, 15 min

Residue 2

Extract 2

26% (w/w)

5% (w/w)
Sugar analysis of Extract 2

<table>
<thead>
<tr>
<th>Carbohydrates (mol%)</th>
<th>Total carbohydrate (mg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ara</td>
<td>2,7</td>
</tr>
<tr>
<td>Xyl</td>
<td>0,8</td>
</tr>
<tr>
<td>Glc</td>
<td>21,3</td>
</tr>
<tr>
<td>Fru</td>
<td>75,2</td>
</tr>
<tr>
<td>Suc</td>
<td>v</td>
</tr>
</tbody>
</table>

The total carbohydrate content is 876,9 mg/g.
Composition of Residue 2

- 31% of protein
- 14% of fibers
- 12% of lipids
- 1.5% of phenolic compounds
Protein

![Bar graph showing the concentration of various amino acids. The graph includes bars for Alanine, Glycine, Valine, Threonine, Serine, Leucine, Isoleucine, Proline, Asparagine/Aspartic acid, Phenylalanine, Glutamine/Glutamic acid, Lysine, and Tyrosine. The x-axis represents the different amino acids, and the y-axis represents the concentration (mg/g).]

6 essential amino acids
Lipids characterization

- Free Fatty Acids: 30%
- Others: 40%
- Sterols: 26%
- Triacylglycerides: 4%
- Alcohols: 0.04%
- 67% Palmitic acid
- 16% Linoleic acid
- 37% Linoleic acid
- 34% Palmitic acid
- 93% β-Sitosterol
Fiber composition

- Hemicelluloses
- Resistant starch
- Pectic polysaccharides

- Uronic acid (13.8)
- Glucose (43.9)
- Galactose (19.6)
- Mannose (5.2)
- Xylose (5.6)
- Arabinose (9.0)

- Fucose (1.4)
- Rhamnose (1.5)
Apple retentate possible applications

- Liquid
- Solid

**Animal Feed**
- Protein rich extruded 15%

**Fruit/Apple tisanes**

**Competition Pigeons**
Thanks for your attention