Orange pulp and peel fibres: minimally processed by-products for water binding and gelling in foods

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Dietary Fibre

Carbohydrate polymers, non-digestible by endogenous enzymes of the small intestine

*Codex Alimentarius (2009)*

**Physical effects**

- Water binding
- Viscosity increase
- Blood cholesterol regulation
- Blood sugar regulation
- Fermentation in large intestine

**Physiological effects**

[Diagram showing cell wall model type I - Dicotyledons: Carpita & Gibeaut (1993)]

Cellulose microfibrils

Pectin network

Xyloglucan

By-products rich in cell walls

Citrus peels

Apple pomace

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Upcycling of fruit processing by-products

Isolation of pectin

Citrus peels
- 20-30 % extractable pectin

Gelling mechanism of high-methoxylated pectins
- Junctions zones by H-Bonds and hydrophobic interactions
- Conditions
  - Sugar > 55%
  - pH: 2.5… 3.5
  - T: 50…100°C
- Stabilizing jams and fruit spreads

FAO statista (2016); Fava et al. (2013); May (1990); Thibault et al. (2003)
Minimally processed orange fibres

- Can pectin-rich orange fibres be directly utilized as a gelling agent in foods?
- Do the functional properties of pulp and peel fibre differ from each other?

<table>
<thead>
<tr>
<th></th>
<th>Pulp fibre*</th>
<th>Peel fibre*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lightness (L)</td>
<td>85.4</td>
<td>76.5</td>
</tr>
<tr>
<td>Intensity red (a)</td>
<td>0.8</td>
<td>2.1</td>
</tr>
<tr>
<td>Intensity yellow (b)</td>
<td>18.4</td>
<td>20.0</td>
</tr>
<tr>
<td>Physical parameters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tapped density (g/cm³)</td>
<td>0.64</td>
<td>0.72</td>
</tr>
<tr>
<td>True density (g/cm³)</td>
<td>1.50</td>
<td>1.49</td>
</tr>
<tr>
<td>Porosity</td>
<td>0.58</td>
<td>0.52</td>
</tr>
<tr>
<td>Molecular parameters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GalA (% DS)</td>
<td>27.8</td>
<td>29.4</td>
</tr>
<tr>
<td>Dmeth (%)</td>
<td>68.6</td>
<td>65.7</td>
</tr>
<tr>
<td>Protein (% DS)</td>
<td>7.4</td>
<td>5.5</td>
</tr>
<tr>
<td>Ash (% DS)</td>
<td>2.6</td>
<td>3.2</td>
</tr>
</tbody>
</table>

*Particle size (90th percentile): 150 µm
Aims and methods

• Investigation of the water binding properties as affected by external factors during rehydration.
• Determination of the gelling efficiency in dependence of sugar-acid ratio during gel preparation.
• Comparison of the texture properties of fibre gels with gels from isolated pectins.

Water binding properties

- Water uptake capacity (WUC)
  Capillary suction (2 h) at 20°C

- Water retention capacity (WRC)
  Soaking (18 h) at 20°C / 80°C
  - High shear
  - pH 3.0 ... 6.0
  - CaCl₂ 0.05 ... 0.50 mL

Gel preparation

Experimental design

<table>
<thead>
<tr>
<th>Material (Conc.)</th>
<th>Solids</th>
<th>Citric acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulp, Peel (1%)</td>
<td>55%, 60%</td>
<td>6mL, 10mL</td>
</tr>
<tr>
<td>Citrus pectin* (0.28%)</td>
<td>55%, 60%</td>
<td>3mL, 6mL</td>
</tr>
</tbody>
</table>

*GalA: 80.9%, Dmeth: 69.8%
Gel characterization

Rheology – gel formation

- Gel point (GP): $T$ (°C) at $G' = G''$
  - Oscillation test
  - $\gamma$ (const.): 0.001
  - $f$ (const.): 1 Hz
  - Cooling rate: 1 K/min
  from 105 ° to 10°C

Texture analysis – gel elasticity

- Breaking strength $F_{\text{max}}$ (N)
  - Pressure test after 24 h (20°C)
  - Cylinder probe $\varnothing$: 10 mm
  - Penetration depth: 15 mm
  - Penetration speed: 1 mm/s
Water binding properties of fibres

Water uptake (g H₂O/g fibre)

Water retention (g H₂O/g fibre)

Water retention (g H₂O/g fibre)

Water retention (g H₂O/g fibre)

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Fibre gel properties (gel points)

- Very low pH values are necessary to form sugar-acid gels
- Pulp fibre shows similar gel points compared with isolated citrus pectin
Fibre gel properties (gel texture)

**Fibre gels**

- **Pulp**
- **Peel**

**Hypotheses**

- Increased gel elasticity at lower solids load
- Larger junction zones / pectin aggregation
- Pectin „Annealing“ during long term-storage
Conclusions

Minimally processed orange fibres

Multi-functional food processing by-products rich in pectin

- Water binding properties
  - Rapid water absorption / high water retention
    sensitive to pH, T, cations, shearing

- Gelling properties
  - Slow setting gels with soft texture
    sensitive to sugar-acid ratio

Promising ingredients for stabilizing food systems

Pulp fibre vs. Peel fibre

Functionality

Differences in physical and chemical structure

Processing (Drying)

Plant tissue (Endocarp/Albedo)
Thank you!

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