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

Sebastian Schalow[1], Mary Baloufaud[2], Thibaut Cottancin[2], Jürgen Fischer[3], Stephan Drusch[1]

[1]Department of Food Technology and Food Material Science, TU Berlin, Germany

[2]IUT Lyon 1, France

[3]Fiberstar Inc., USA

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# Dietary Fibre

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

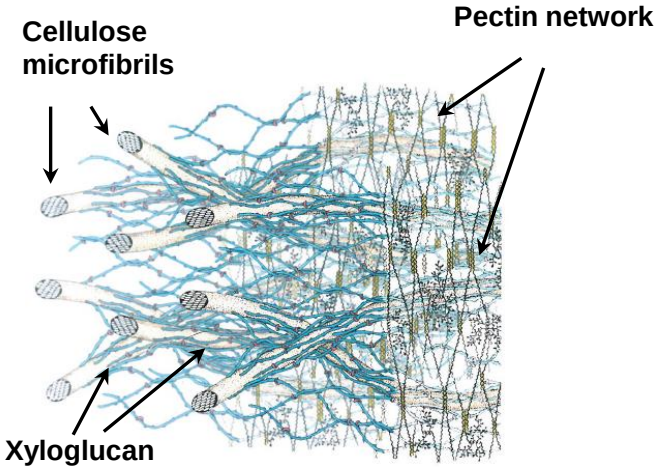
Codex Alimentarius (2009)

**Physical effects**

- Water binding
- Viscosity increase

- Blood cholesterol regulation
- Blood sugar regulation
- Fermentation in large intestine

**Physiological effects**




Cell wall model type I - Dicotyledons
Carpita & Gibeaut (1993)

**By-products rich in cell walls**

**Citrus peels**

**Apple pomace**

# Upcycling of fruit processing by-products

## Isolation of pectin

**Citrus peels**

- 20-30 % extractable pectin

Extraction

↓

Filtration → **Depectinised by-product (Fibre)**

↓

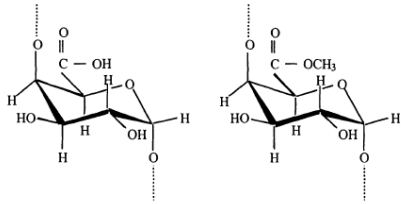
Precipitation
Washing
Drying

↓

**Pectin**

**pH: 1…3**
**T: 60…90°C**
**t: 3…12 h**

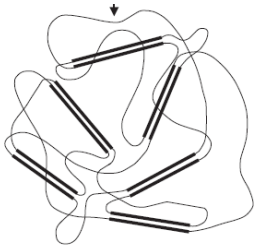
GalA: main component in pectin




free carboxyl group  methoxylated

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**

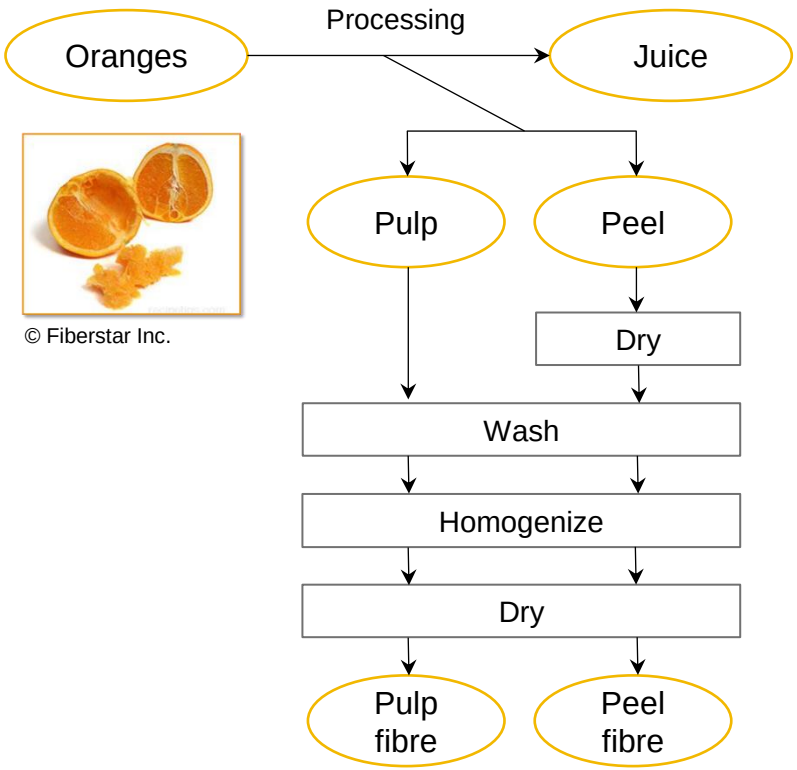


Kastner et al. (2014)

➢ Stabilizing jams and fruit spreads

FAO statista (2016); Fava et al. (2013); May (1990); Thibault et al. (2003)

# Minimally processed orange fibres




© Fiberstar Inc.

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

*Particle size (90th percentile): 150 µm

- **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?**

# Aims and methods

- Investigation of the water binding properties as affected by external factors during rehydration.
- Determination of the gelling effiency 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
  - $CaCl_2$ 0.05 … 0.50 mL

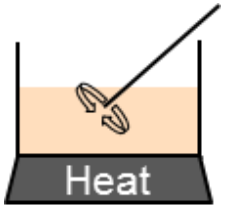
## Gel preparation

**Experimental design**

| Material (Conc.) | Solids | Citric acid |
|---|---|---|
| Pulp, Peel (1%) | 55%, 60% | 6mL, 10mL |
| Citrus pectin* (0,28%) | 55%, 60% | 3mL, 6mL |

*GalA: 80.9%, Dmeth: 69.8%

- Dry blend fibre/pectin + sugar
- Suspend in water
- Boil 5 min
- Add citric acid

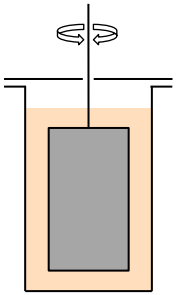


# Gel characterization

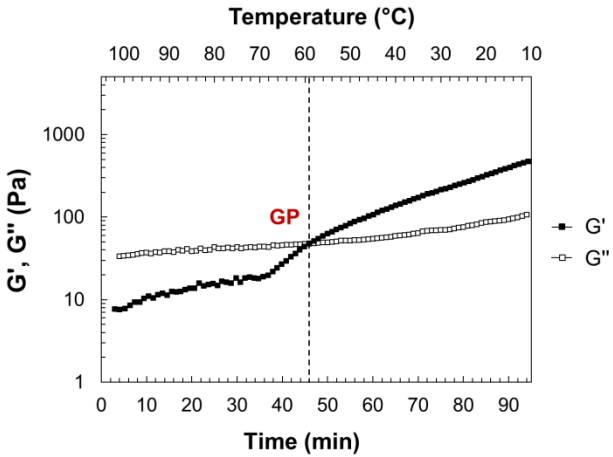
## Rheology – gel formation

- **Gel point (GP): T (°C) at G‘ = G‘‘**
  - Oscillation test
  - γ (const.): 0.001
  - f (const.): 1 Hz
  - Cooling rate: 1 K/min

    from 105 ° to 10°C

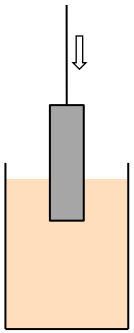


UDS 200 (Paar Physica)

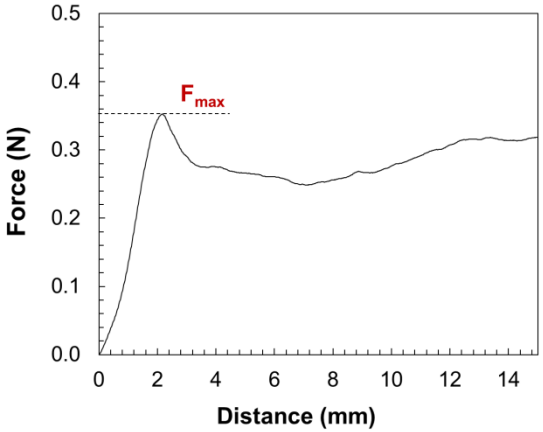



## Texture analysis – gel elasticity

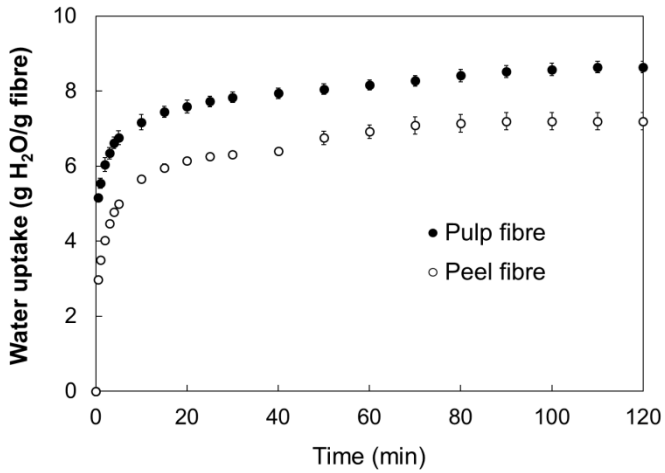
- **Breaking strength $F_{max}$ (N)**
  - Pressure test after 24 h (20°C)
  - Cylinder probe ∅: 10 mm
  - Penetration depth: 15 mm
  - Penetration speed: 1 mm/s

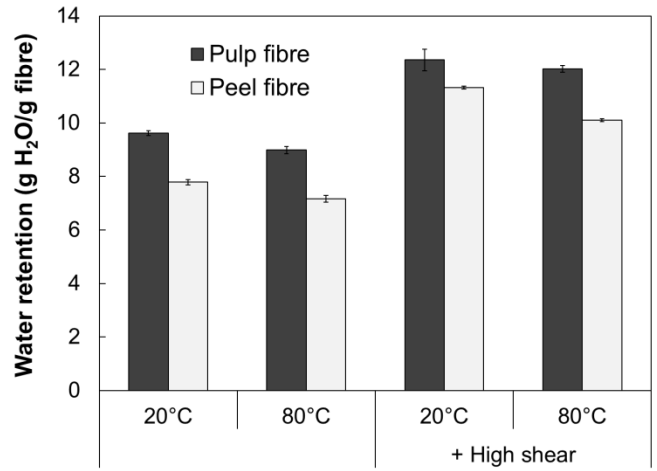


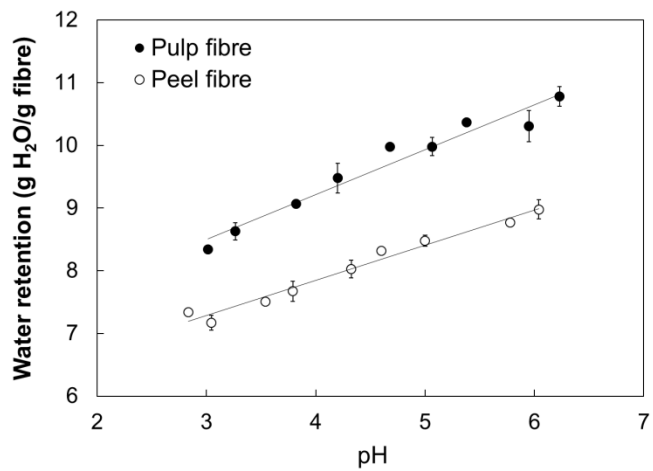
Zwick Z0.5 (Zwick/Roell)

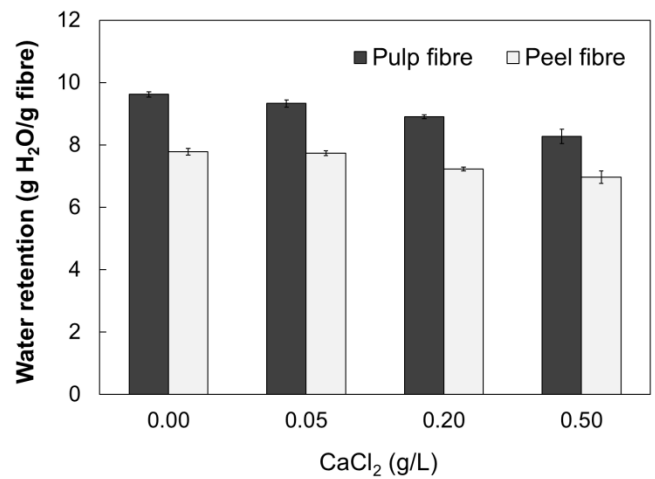


# Water binding properties of fibres

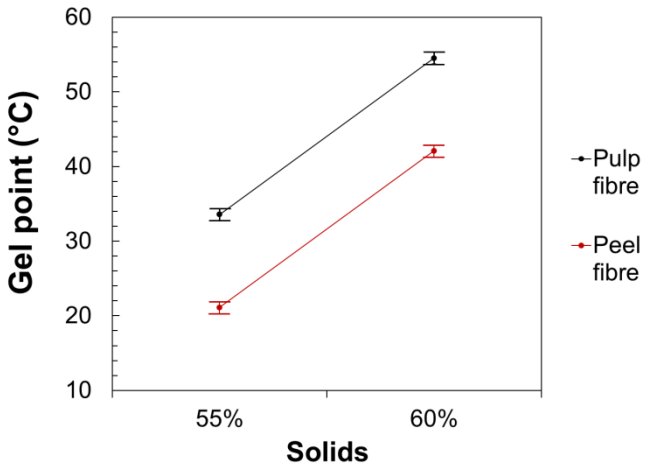


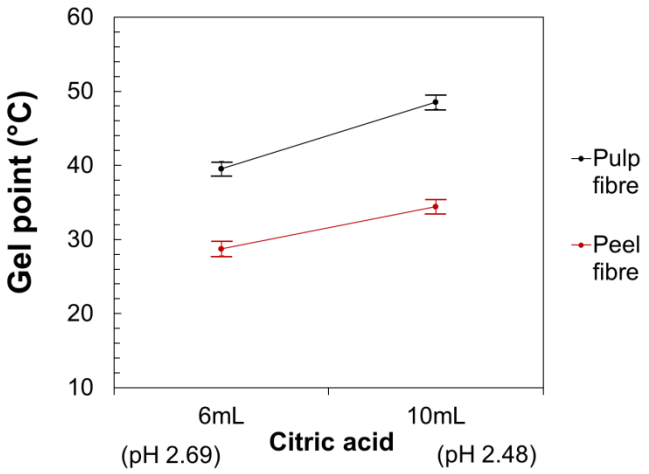



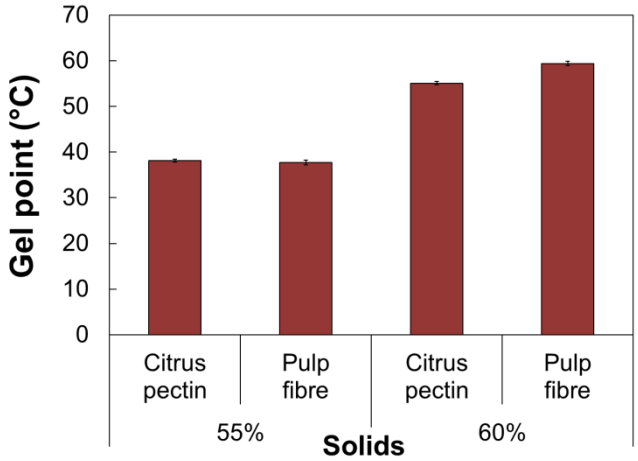



# Fibre gel properties (gel points)



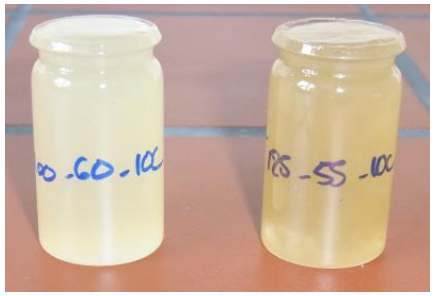



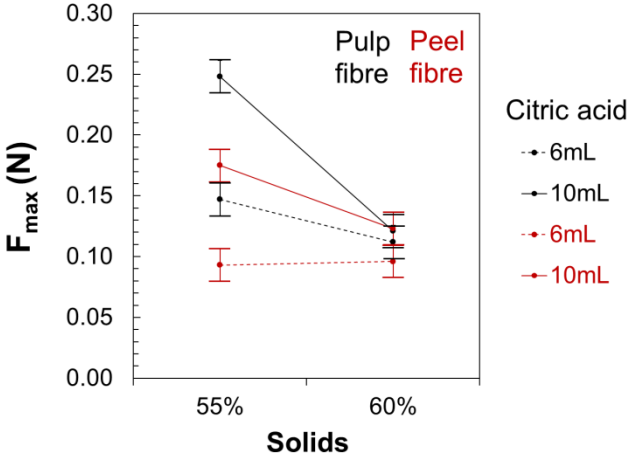

- Very low pH values are necessary to form sugar-acid gels
- Pulp fibre shows similar gel points compared with isolated citrus pectin

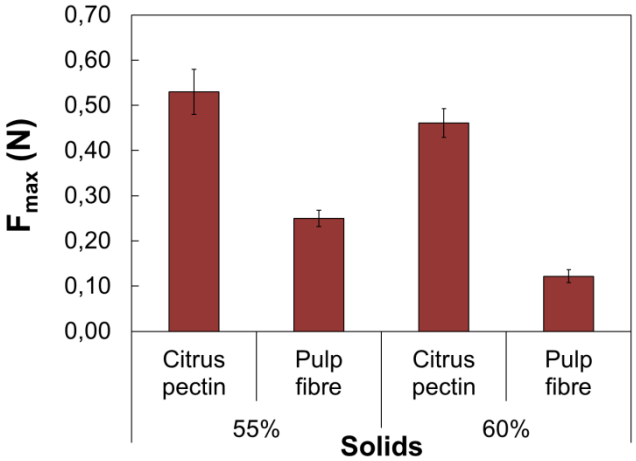
# Fibre gel properties (gel texture)

**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 rentention
    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!

Dr. Sebastian Schalow
Department of Food Technology and Food Material Science
Institute of Food Technology and Food Chemistry
Technische Universität Berlin
**s.schalow@tu-berlin.de**