A new process for producing high-quality, low-cost pectin with increased gelling capacity and a broadened scope of applications

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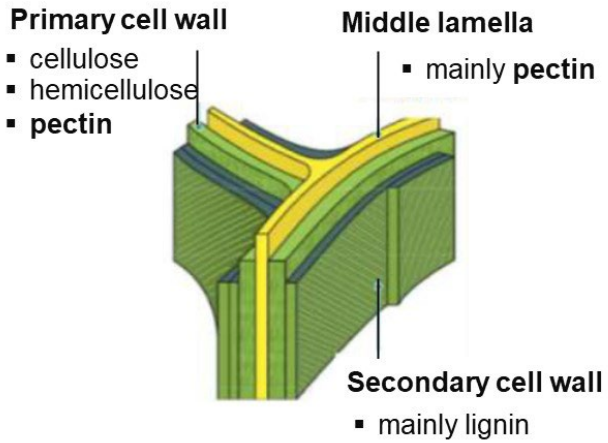
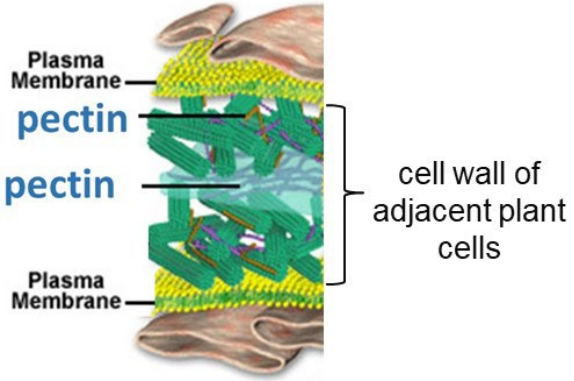
Pectin is a natural complex polysaccharide

- exists in the cell walls of most land plants
- bind the cells together

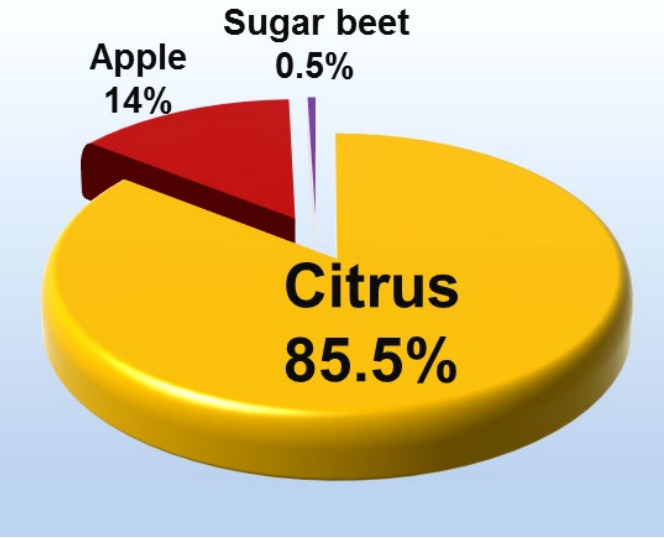




- Extracted pectin is widely used in the food and pharmaceutical industry, due to its gelling property
- Pectin is classed as Generally Recognized As Safe (GRAS) by FDA

Citrus By-products – the Volume and the Value

- Citrus peel is the major source of commercial pectin
- Florida citrus juice industry produces 1-2 million tons of peel waste annually



- Global market:
  - over one billion USD annually
  - expected to over two billion USD by 2025

- Around 6300 tons of commercial pectin are annually used worldwide in the food industry

jam & jellies

bakery fillings

fruit preparations

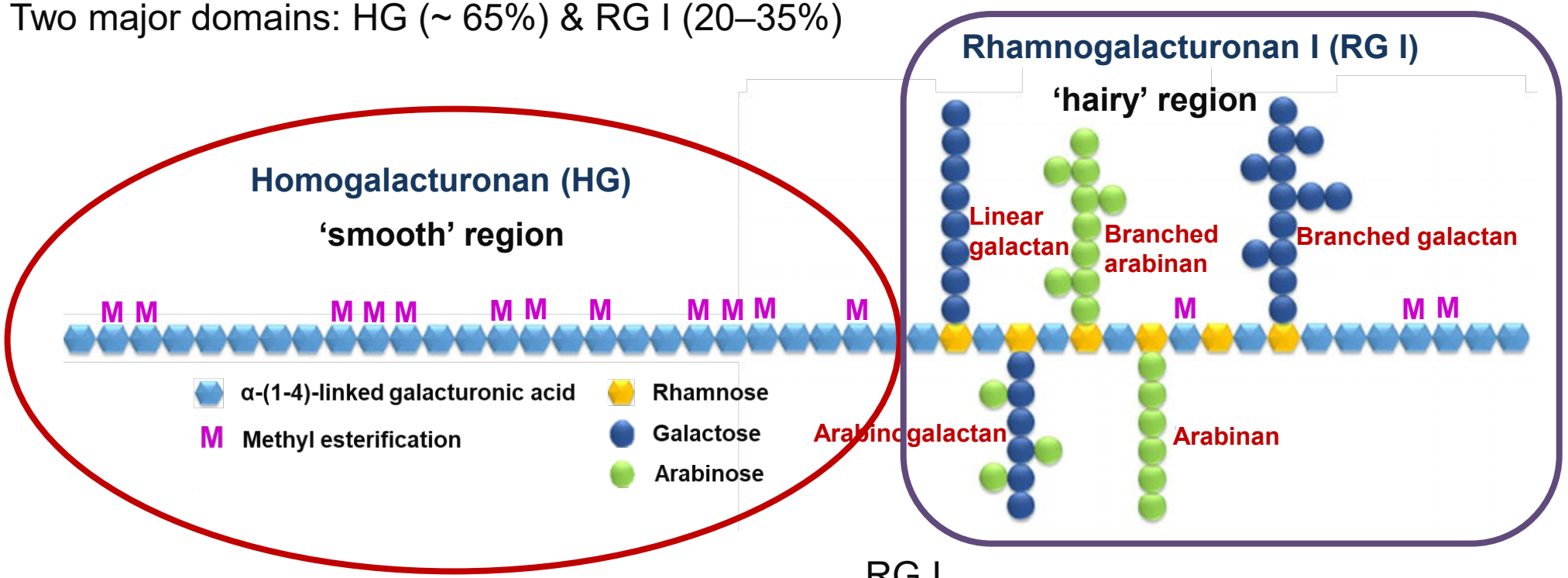
fruit beverages & sauces

confectionery

yogurt

Pectin Structure

❖ Two major domains: HG (~ 65%) & RG I (20–35%)



HG

- Linear polymer of galacturonic acid (GalA)
- Some of the GalA are methyl-esterified
- Responsible for gel-forming

RG I

- branched polymer
- Backbone: repeating dimer of rhamnose and GalA
- Side chains: rich in galactose and arabinose

High Methoxyl (HM) Pectin (DM 55-75%)

- Gelling requires the presence of **high sugar** (> 60%), and **low pH** (2.8-3.2)

- Used for **high-sugar** food products

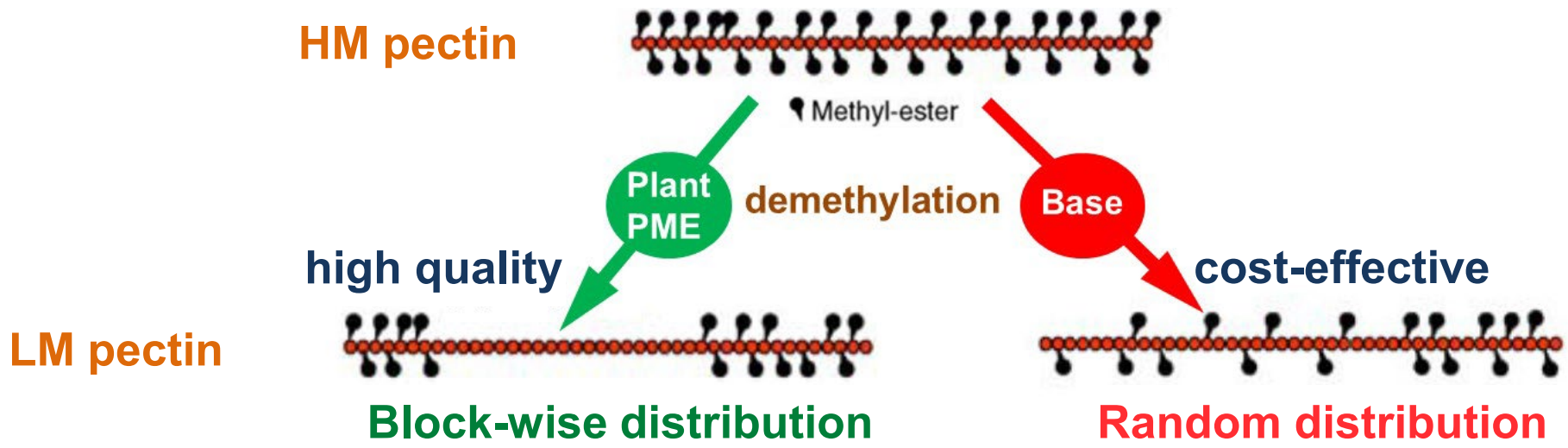
Low Methoxyl (LM) Pectin (DM 20-40%)

- Gel in the presence of small amounts of calcium
  -- independent of sugar content
  -- over a wide range of pH

- Can be used for **low-sugar** food products

- **There is a growing demand for LM pectin with the increasing demand for reduced-sugar food products**

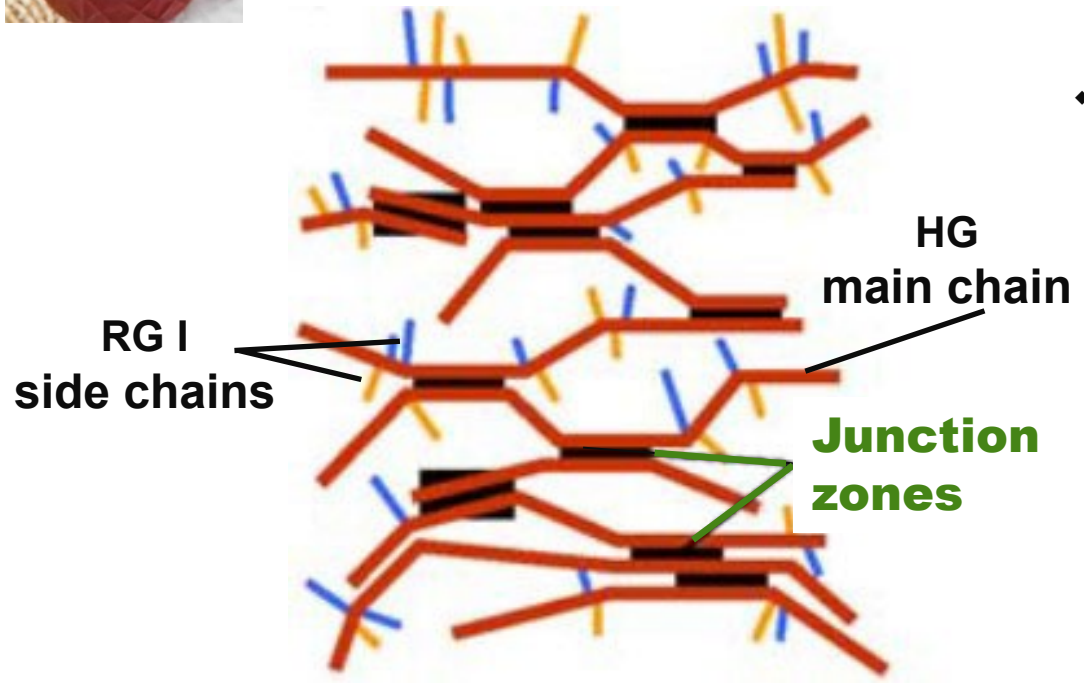
- **HM: obtained directly from the pectin extraction**
- **LM: generated from HM pectin**
  - enzymatic demethylation with pectin methyl-esterase (PME)
  - chemical demethylation with acid or alkali



❖ **Pectin produced by enzymatic demethylation with a plant PME is high-quality, with much better gelling properties**

Pectin gelation depends on junction zones

- Pectin gels when HG chains are joined at junction zones
  - -- to form a cross-linked network
  - -- trapping water and other molecules



- LM pectin gel junction zones: blocks of contiguous non-methylesterified GalA
- HM pectin gel junction zones: blocks of contiguous methylesterified GalA

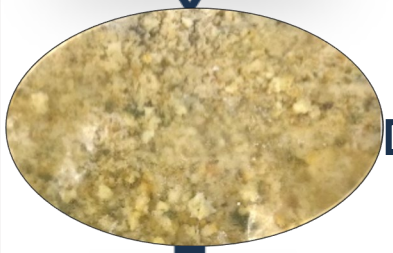
- A block-wise distribution
  - facilitates the formation of stable and highly cooperative junction zones

- We developed a new process to modify pectin in the source plant material
  - activation of the endogenous plant PME was involved.

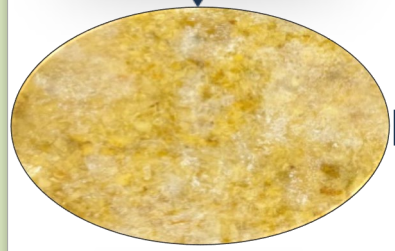
- Produce high-quality, low-cost pectin
  - with block-wise distribution
  - gelling capacities of both LM and HM pectins.

- No post-extraction demethylation is needed.

shredding



a process



pectin extraction

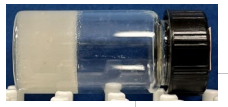
pectin extraction

commercial extraction method

Control pectin

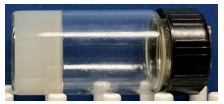
Ca^{2+} gel

sugar-acid gel

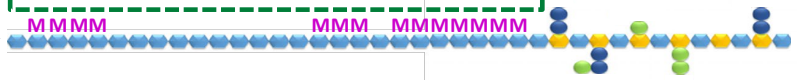


New process produced pectin

Ca^{2+} gel



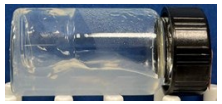
sugar-acid gel



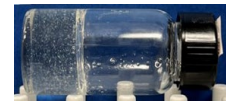
Compared with commercial pectins

Commercial HM pectin

Ca^{2+} gel



sugar-acid gel



Commercial LM pectin

Ca^{2+} gel

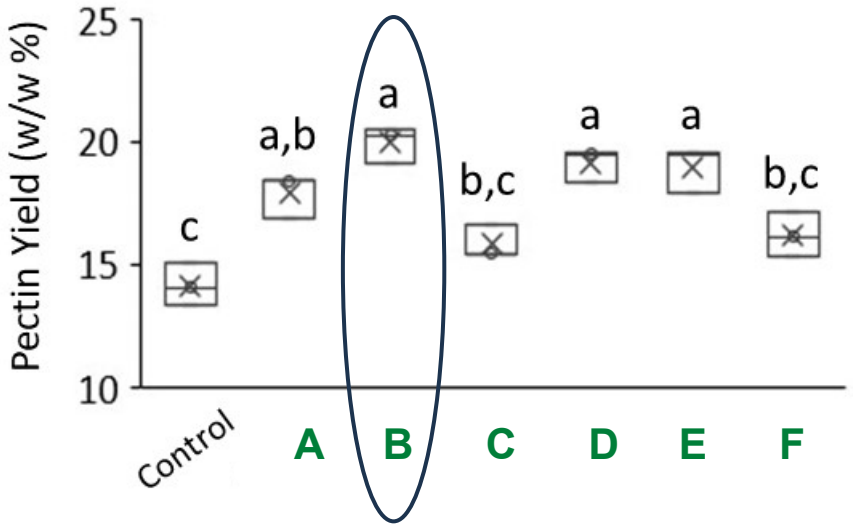
sugar-acid gel

- The effects of the new process has been intensively evaluated
  - Pectin yield
  - Structure
  - Gelling properties
  - Compared with commercial HM and LM pectins

Increase the pectin yield

❖ The new process increased pectin yield by 41.10 %

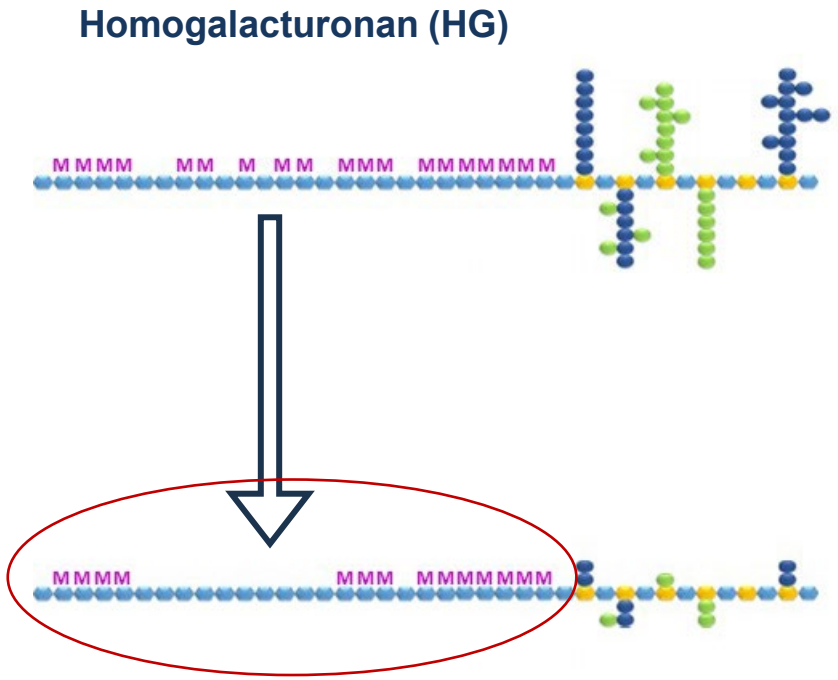
extracted pectin



Pectin extraction yield (%) shown with the box and whisker plot. n= 4

The new process modify pectin structure
-- HG main chain

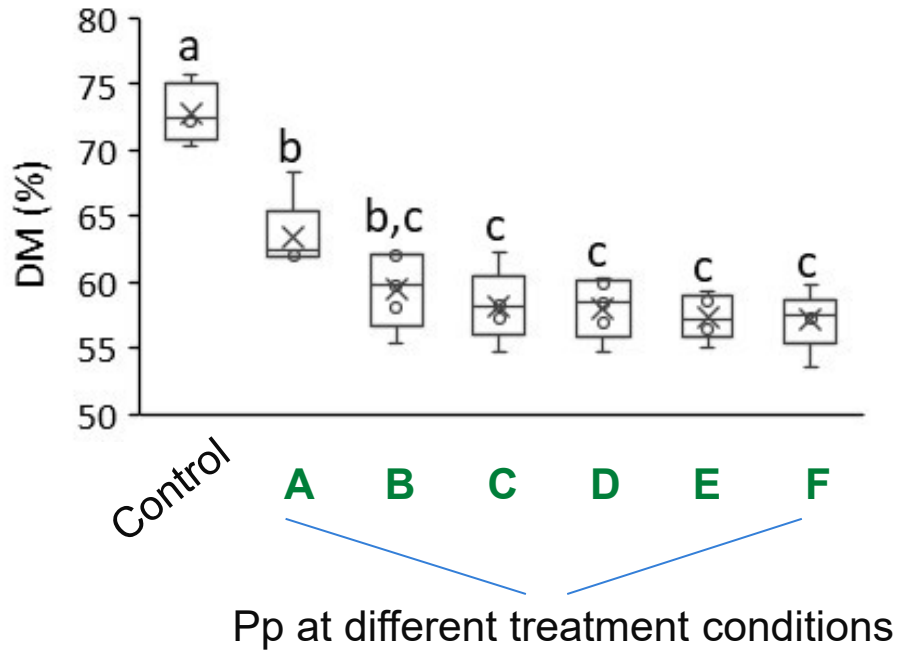
- Let to partial demethylation of pectin
- accompanied by a block-wise distribution of methyl esters



Experimental data

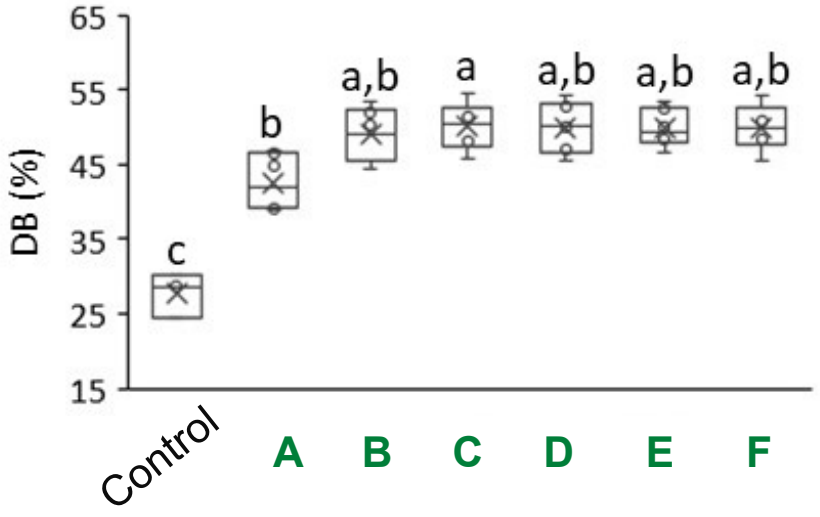
❑ Degree of methyl-esterification (DM)

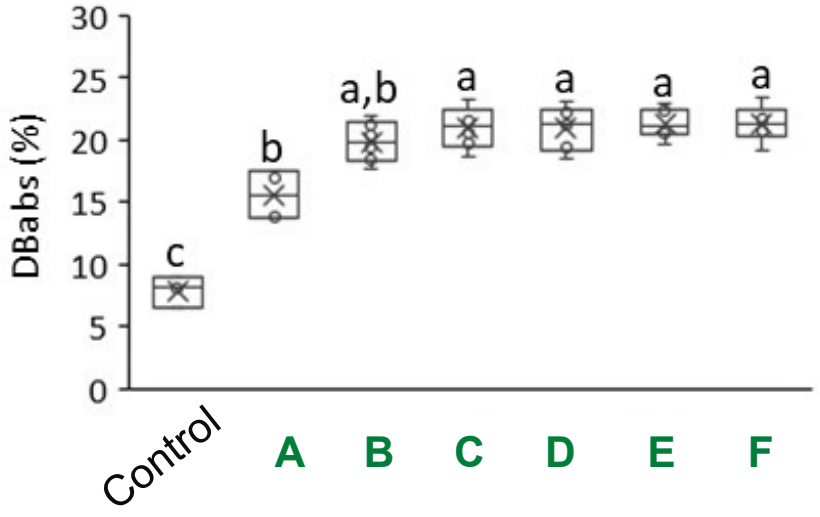
➢ The new process extracted pectin (**Pp**) had lower DM



Experimental data

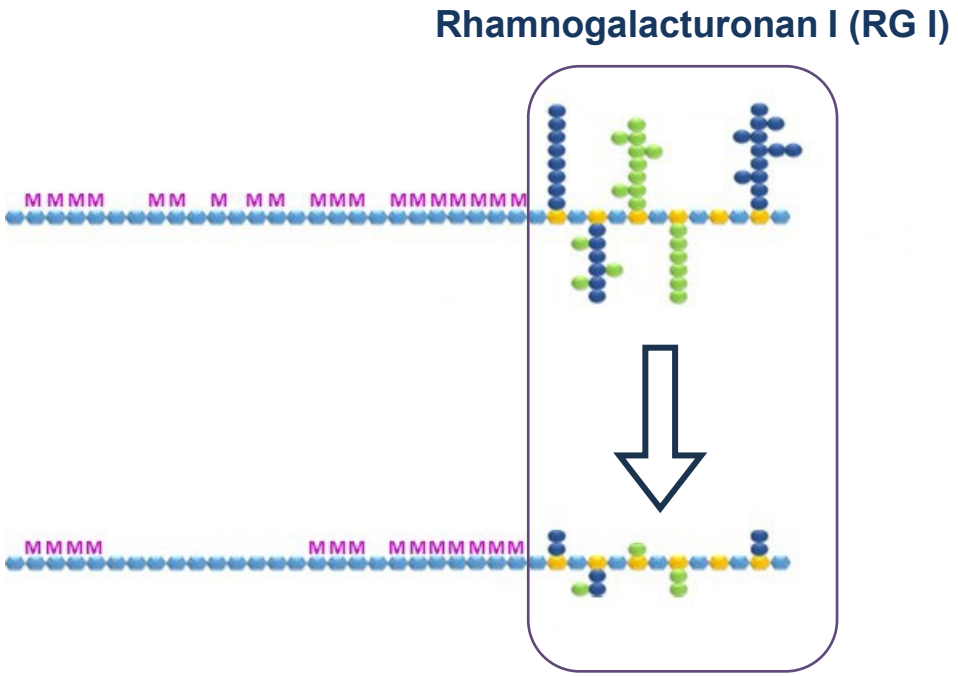
- distribution of methyl-esterification was quantified
  - -- degree of blockiness (DB) and absolute degree of blockiness (DBabs)
    - Pp had higher DB and Dbabs
    - block-wise distribution of methyl esters





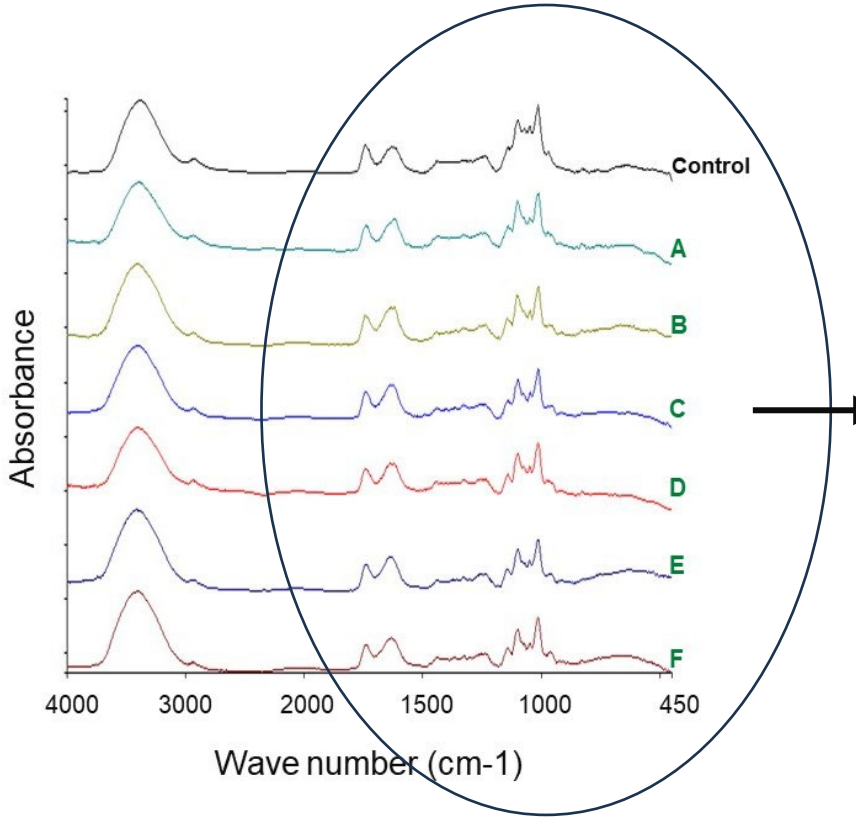
The new process modify pectin structure
-- RG I side chain

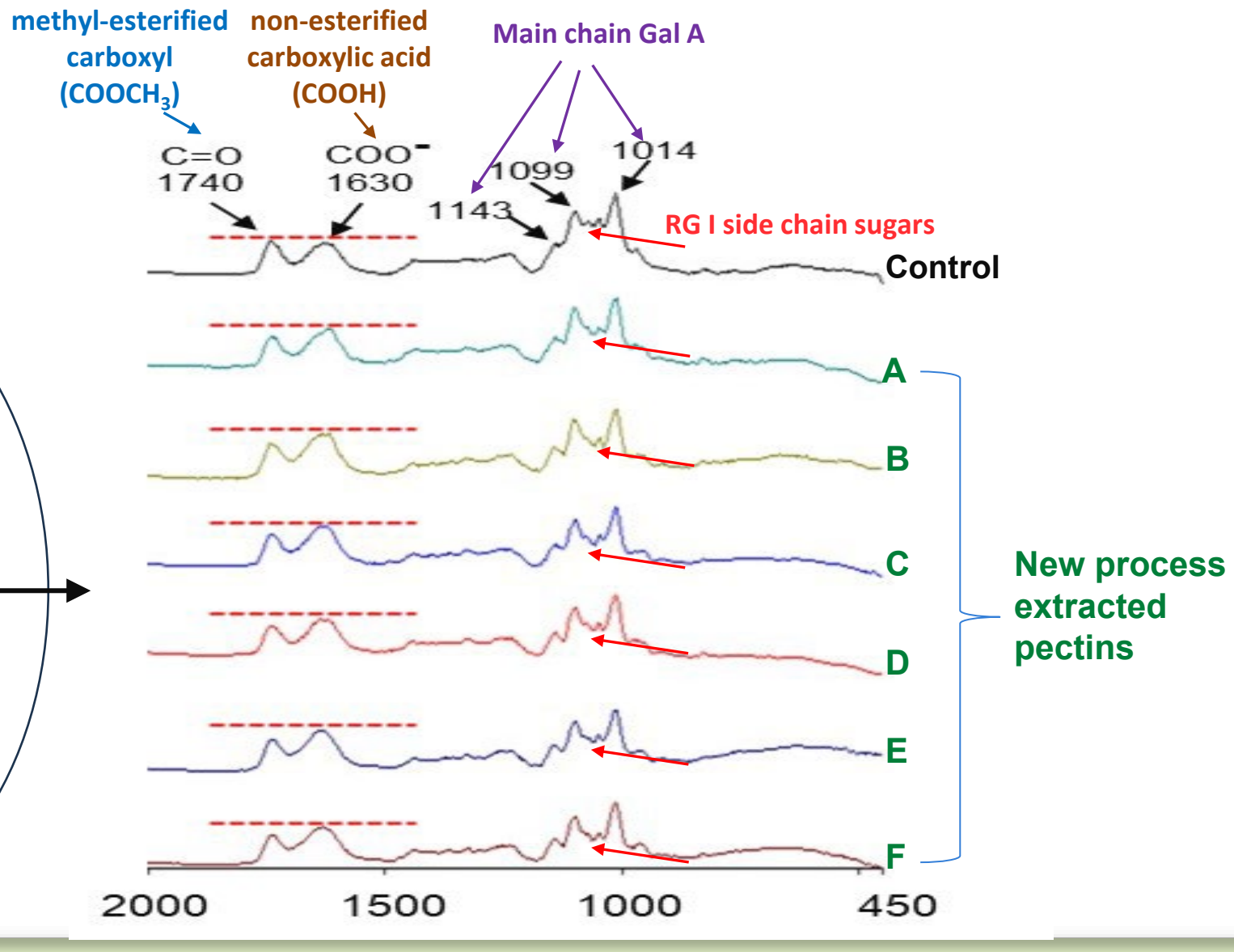
- debranch pectin RG I side chains
- pectin main chain remain un-degraded



❖ Structural analysis - Fourier Transform Infrared Spectroscopy (FTIR)

FTIR: a method for analyzing the **chemical composition** by measuring the infrared (IR) light absorbed or emitted by molecules.





Experimental results indicate

- The effects of the new process on pectin structure were similar to the reported effects of enzymatic demethylation of an HM pectin with a plant PME

  - partial de-esterification of pectin HG without degradation of HG backbone
  - was accompanied with an increase of degree of blockiness

Functionality analyses

- **The functionalities of the pectins were evaluated and compared with commercial low- and high-methoxyl pectins**
  - Commercial pectins compared

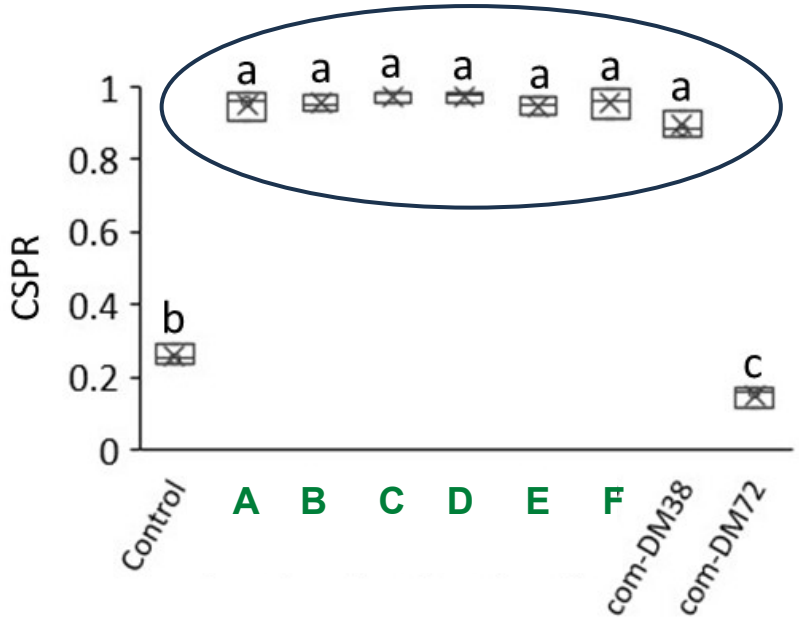
    LM: com-DM38 (DM = 38%)

    HM: com-DM72 (DM = 72%)

  - Calcium sensitivity
  - Calcium-mediated gelation
  - Sugar-acid-mediated gelation

Calcium Sensitivity

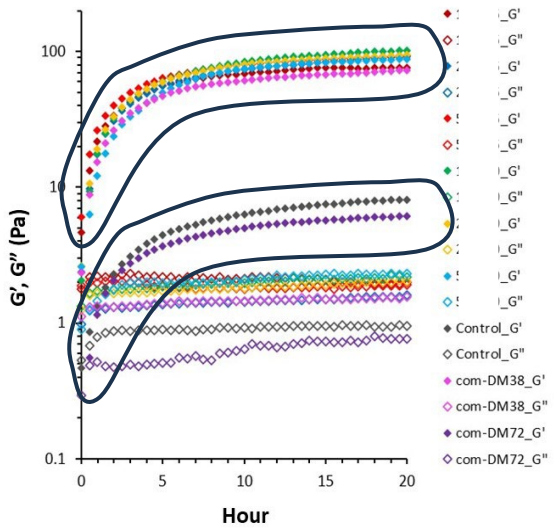
- **Calcium Sensitivity was quantified by measuring calcium sensitive pectin ratio (CSPR)**

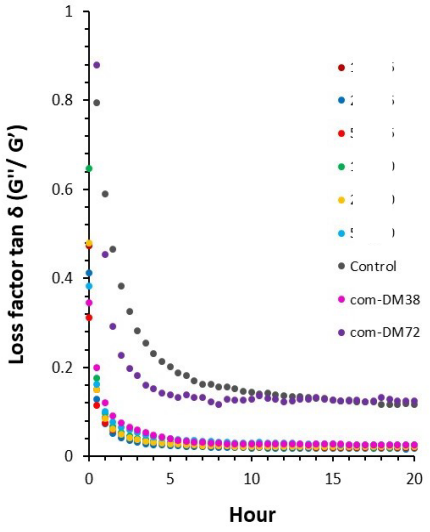


- Calcium Sensitivity of Pp were remarkably higher than the control and commercial HM pectin
- comparable to the commercial LM pectin

Capacity for calcium-mediated gelation
--- rheological analysis

- ❖ Calcium mediated gelation was monitored for 20 hours with a rheometer
- ➢ Time sweep analysis indicates Pp had a similar curing profile as commercial LM pectin



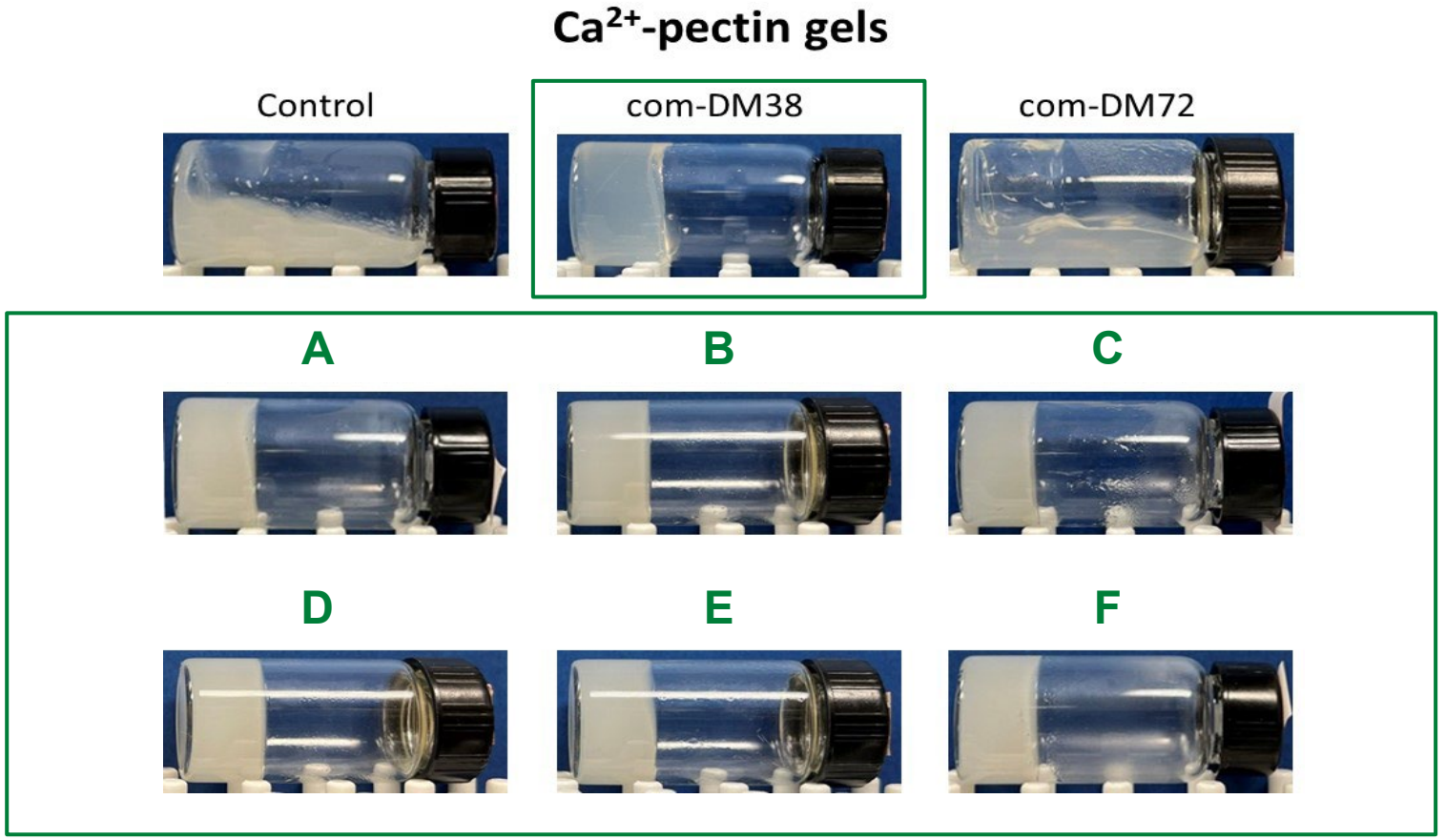


Rheological analysis- time sweep

- ➢ Pp gels were much more elastic than the control and commercial HM pectin

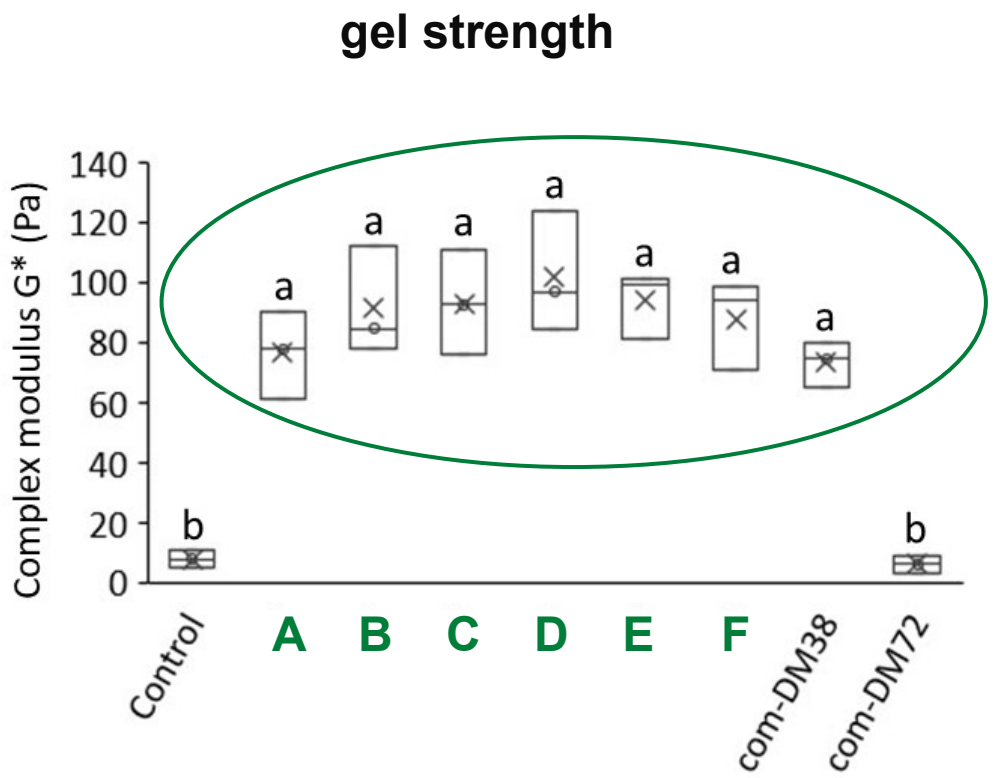
G′: storage, or elastic modulus
G”: loss, or viscous modulus

- Pp can form calcium gel without the presence of sugar, like a commercial LM pectin
- The control pectin and commercial HM pectin cannot



❖ Gel Strength was quantified

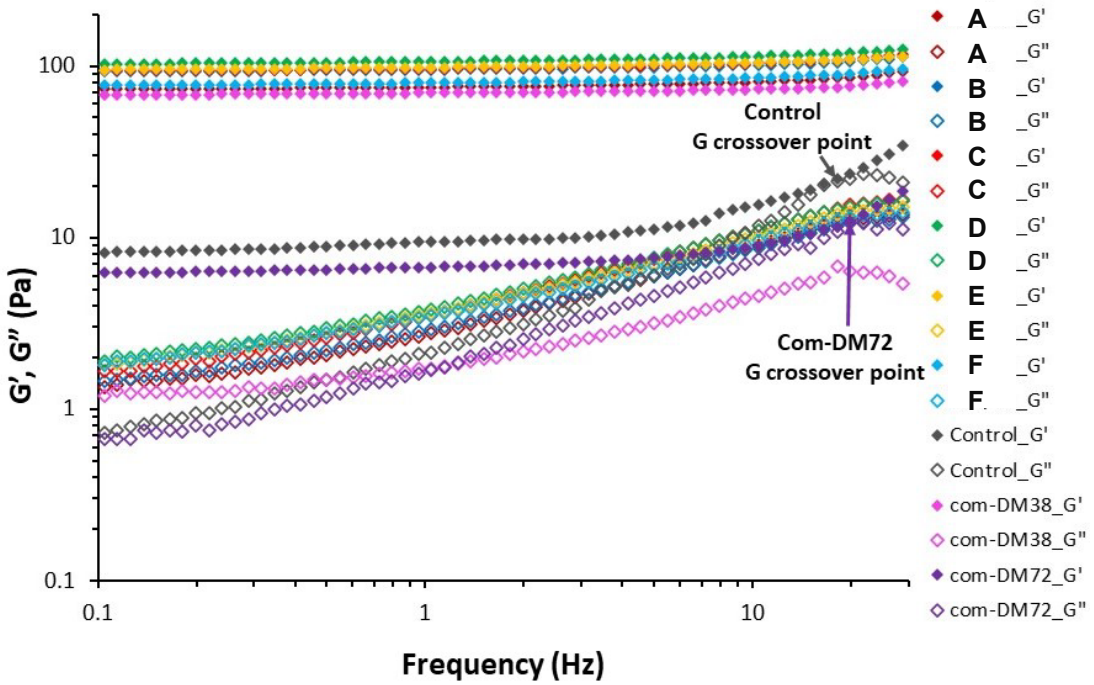
- gel strength of Pp was comparable to commercial LM pectin
- much higher than the control and commercial HM pectin



Calcium gel

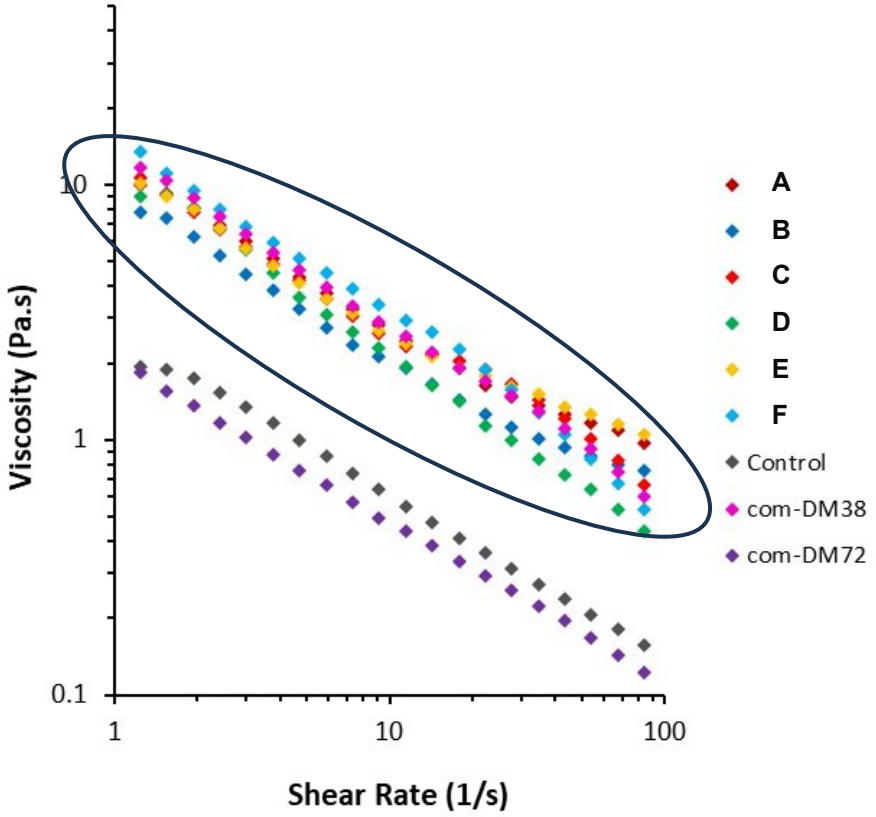
-- rheological analysis

- ❖ Frequency sweep test can tell the **stability of cross-linked network** after gel forming
- ➢ Results indicate calcium gels of Pp and commercial LM pectin had more stable cross-linked network than the control and commercial HM pectin.



Oscillatory frequency sweep test

❖ Apparent viscosity of a gel under shear stresses is correlated with sensory attributes such as texture/mouthfeel of foods



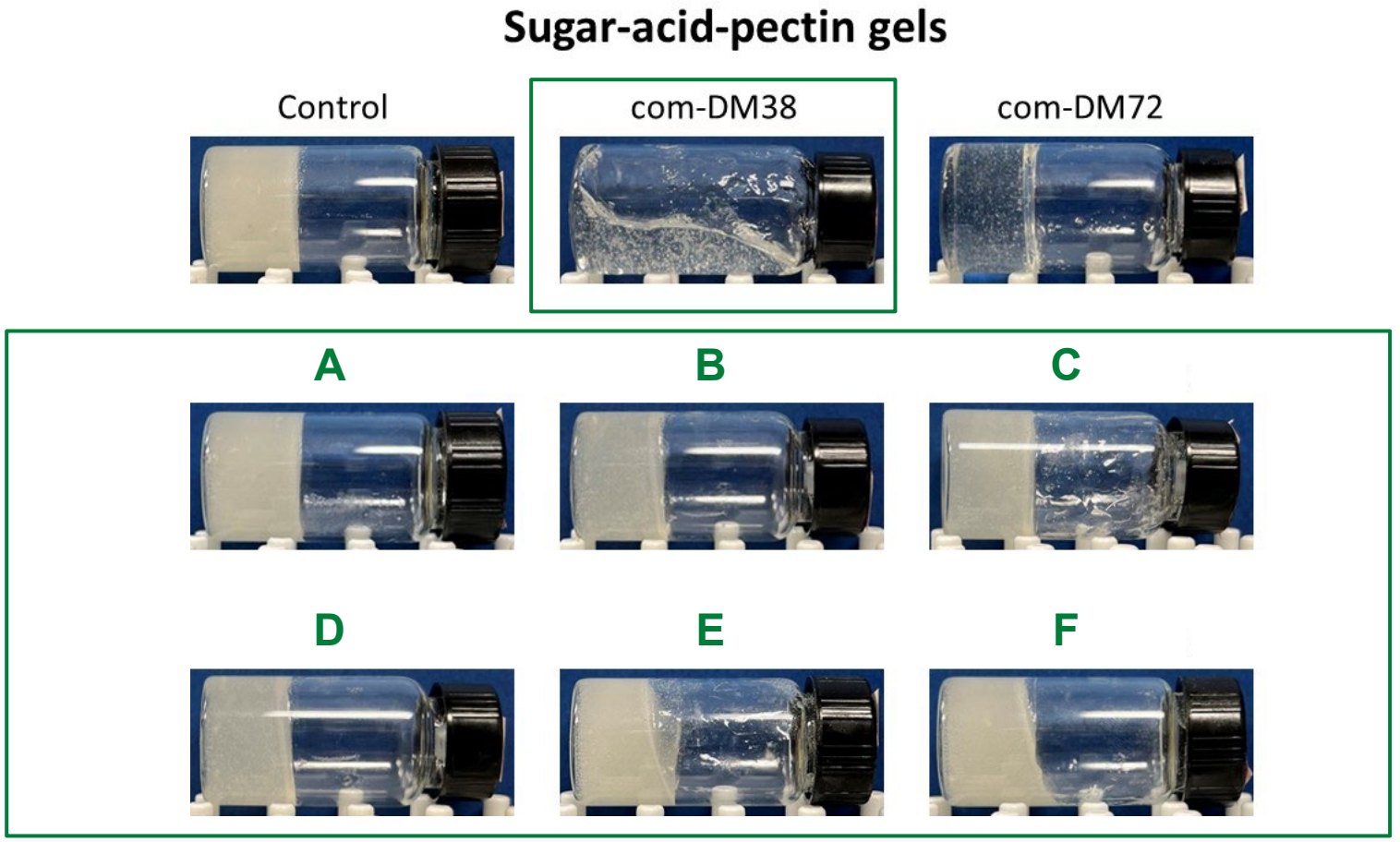
Effects of shear rate on the apparent viscosity of different calcium-pectin gels.

➢ The calcium gels of Pp and commercial LM pectin (com-DM38) had similar apparent viscosities

❖ Suggest these calcium gels would have similar mouthfeel when used in food products.

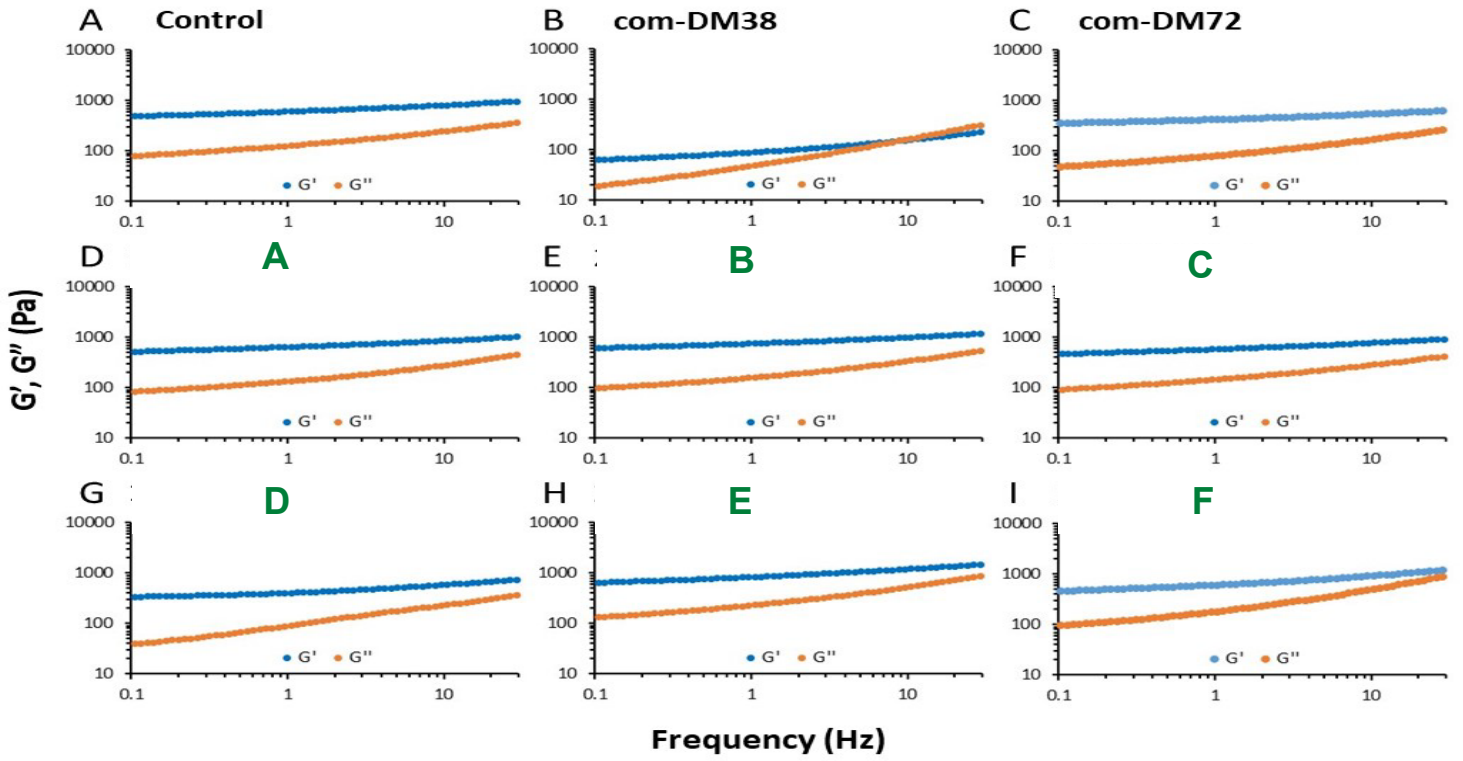
Sugar-acid mediated gelation

- Pp can also form a sugar gel
  - better than a commercial LM pectin in this regard



Sugar-acid-mediated gelation
--- rheological analysis

- Rheological analysis indicate quality of sugar gels of most of Pp was comparable to the commercial HM pectin.



Oscillatory frequency sweep test

Summary

❖ **The new process increased pectin extraction yield, improved pectin gelling capacity**

Effects on pectin structure

- partial demethylation of pectin.
- generating a block-wise distribution of methyl esters on pectin backbone.
- debranching pectin side chains without degradation of backbone.

Effects on pectin functionality

- Increase pectin capacity for calcium-mediated gelation.
  --- the quality of calcium gel was comparable to a commercial LM pectin
- Still remained the capacity for sugar-mediated gelation.
  --- comparable to a commercial HM pectin

❖ high-quality pectin with increased gelling capacity and a broadened scope of applications

❖ No post-extraction demethylation is required -- reduce cost

Thank you!

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