Effect of Carboxymethyl Cellulose (CMC) on the Physico-Chemical Properties of Masa/Water Mixtures

By

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Why are we interested in CMC?

- Tortillas are the fastest growing segment of U.S. baking industry.
- Tortilla industry is the largest consumer of food-grade CMC. CMC is the most expensive ingredient in corn tortillas.
- CMC is added for shelf-life extension and to maintain a pliable texture.
- The mode of action of CMC in tortilla is unknown.

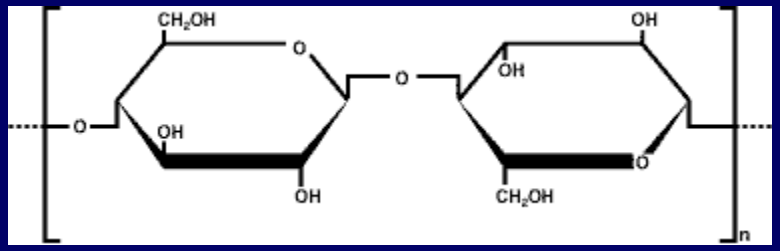
Objectives

- Characterize the effect of different quantities of CMC on unheated masa/water mixtures during storage using thermoanalytical techniques.

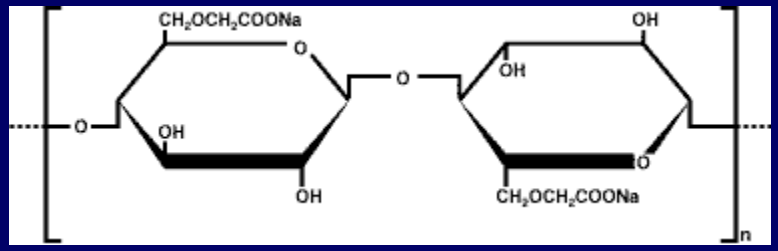
- Characterize the state of water and starch in heated masa/water mixtures with varying CMC's and water contents using thermal analysis techniques during storage.

Background:
Structure of CMC

- **Unit structure of cellulose**

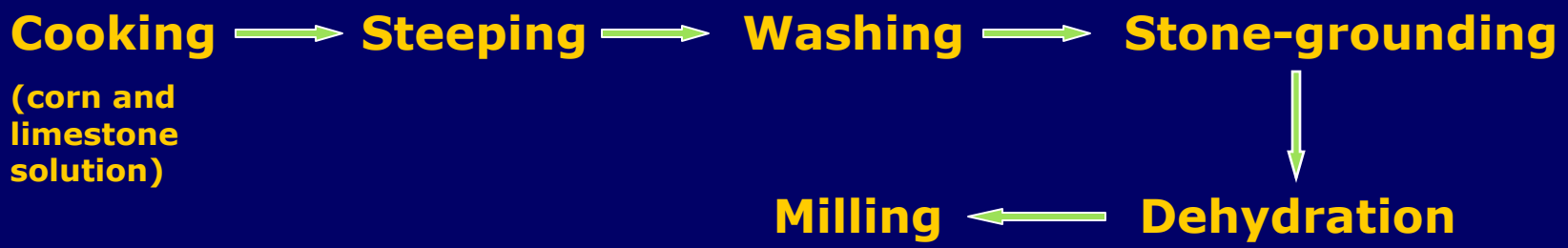


- **Idealized unit structure of CMC with a DS (degree of substitution) of 1.0 (DS Generally in the range of 0.65-0.9)**

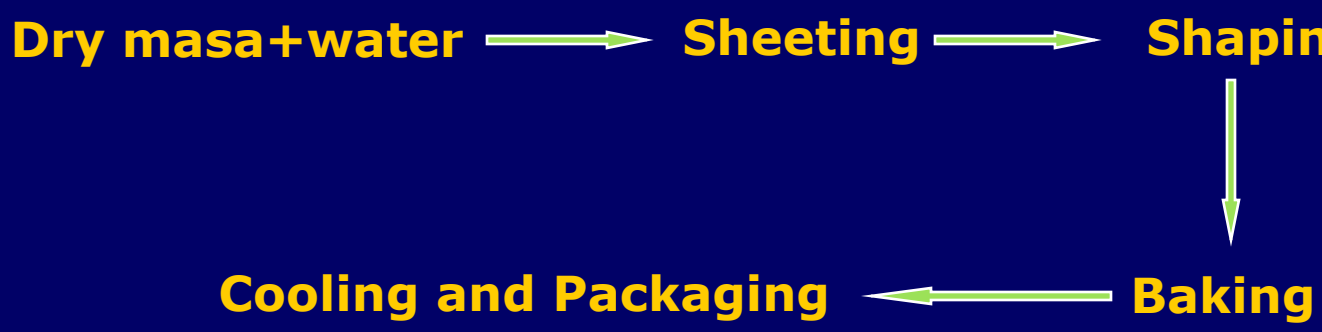


Background
Masa and corn tortillas

Masa (Nixtamalization)

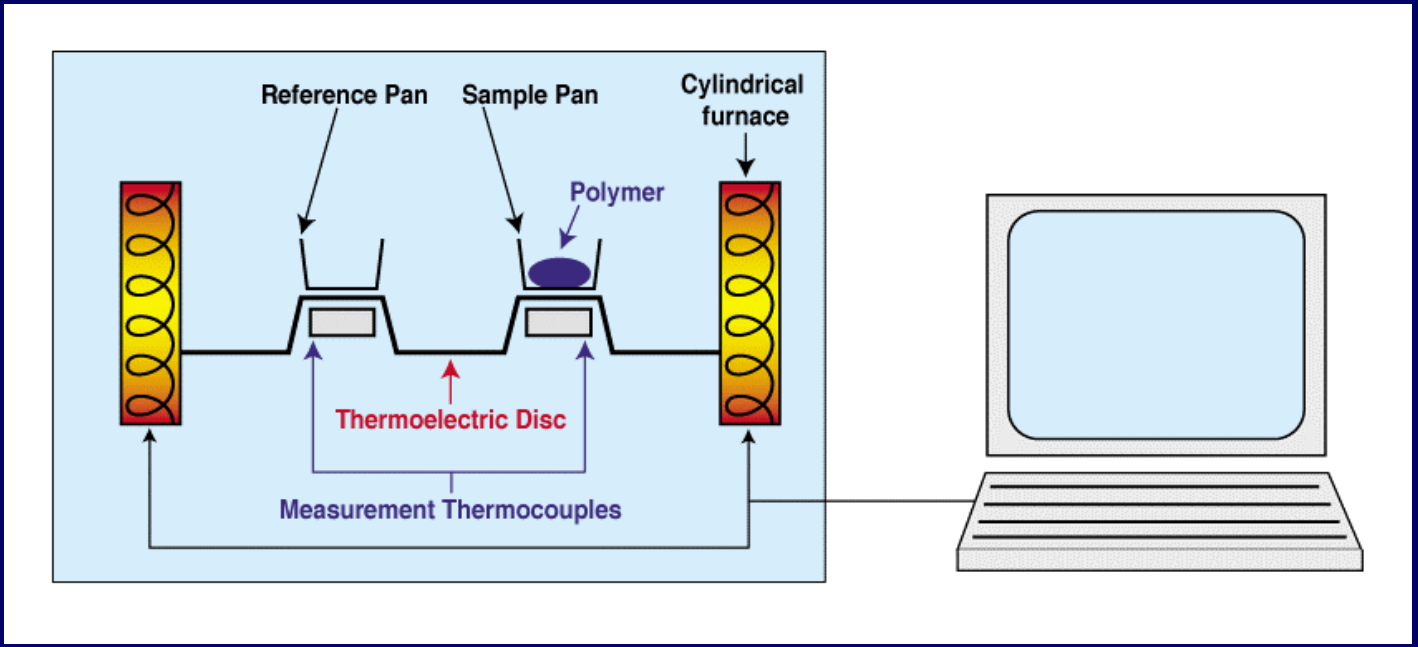


Corn tortillas making



Background
DSC-Differential Scanning Calorimetry

- **DSC works by comparing the rate of heat flow of a sample to an inert material as both are heated or cooled at a programmed rate.**



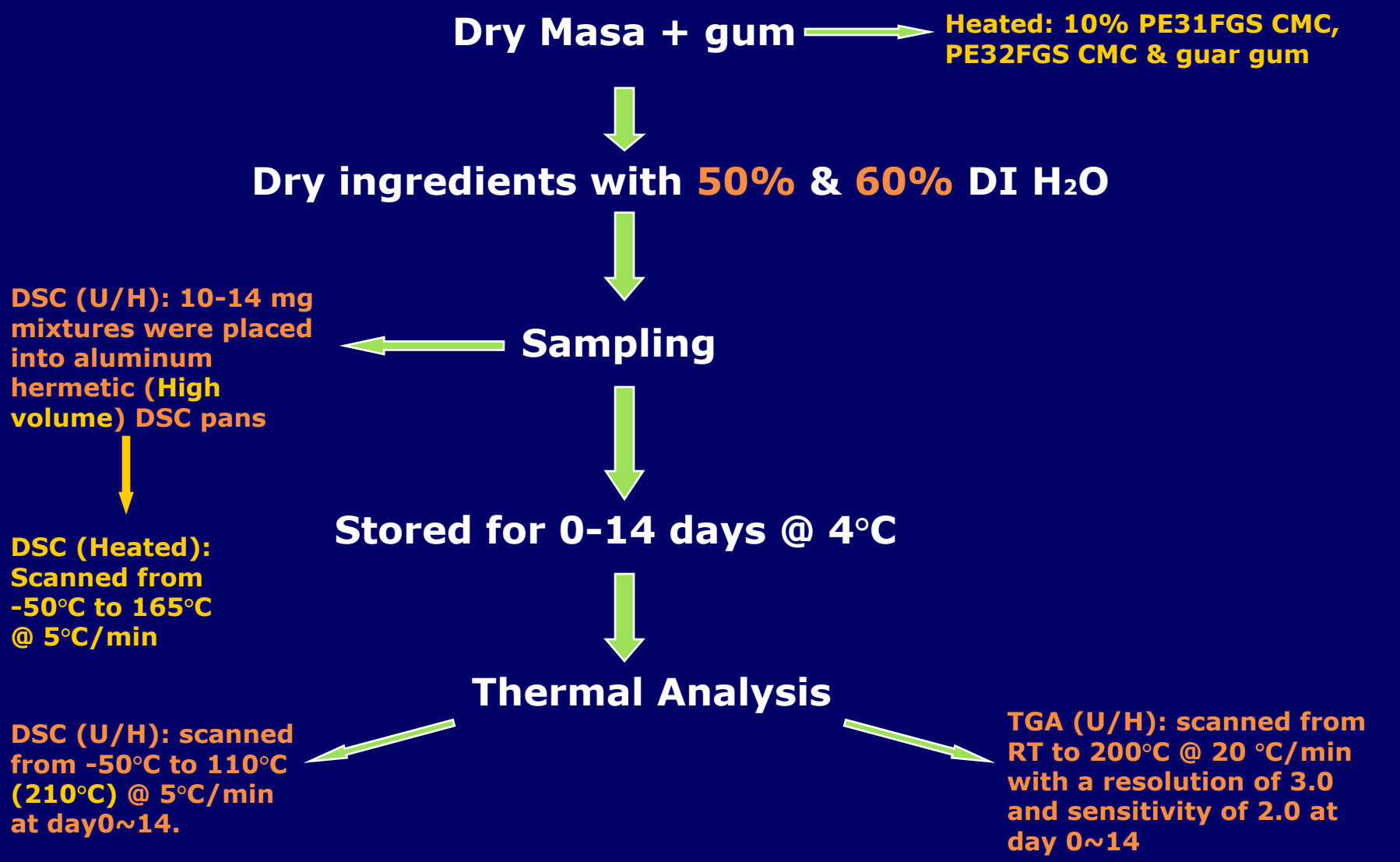
DSC 2920 (TA Instruments, New Castle, DE)

Background
TGA-Thermogravimetric Analysis

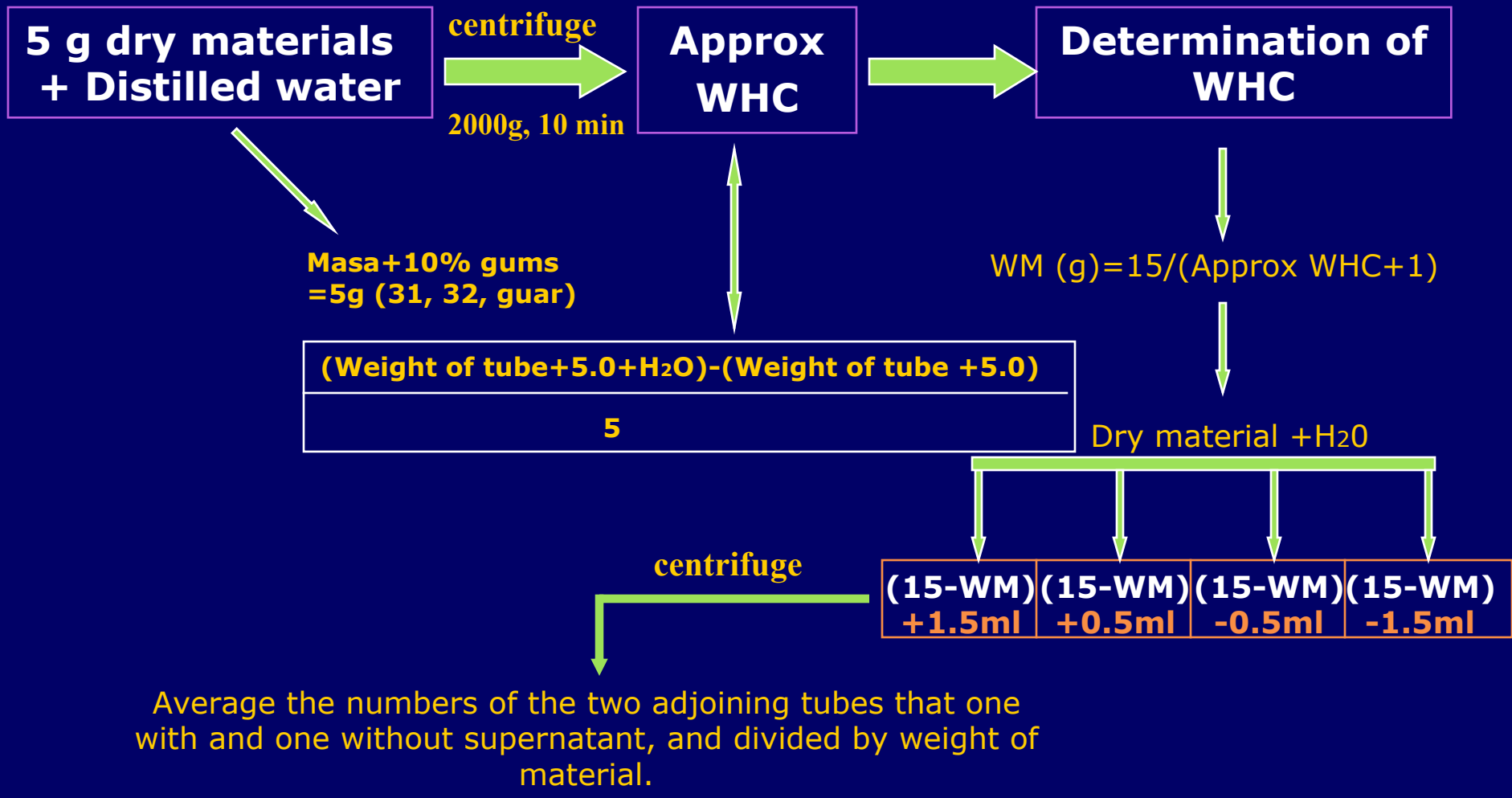
- **TGA measures the amount and rate of weight change in a material as a function of temperature or time.**

TGA 2950 (TA Instruments, New Castle, DE)

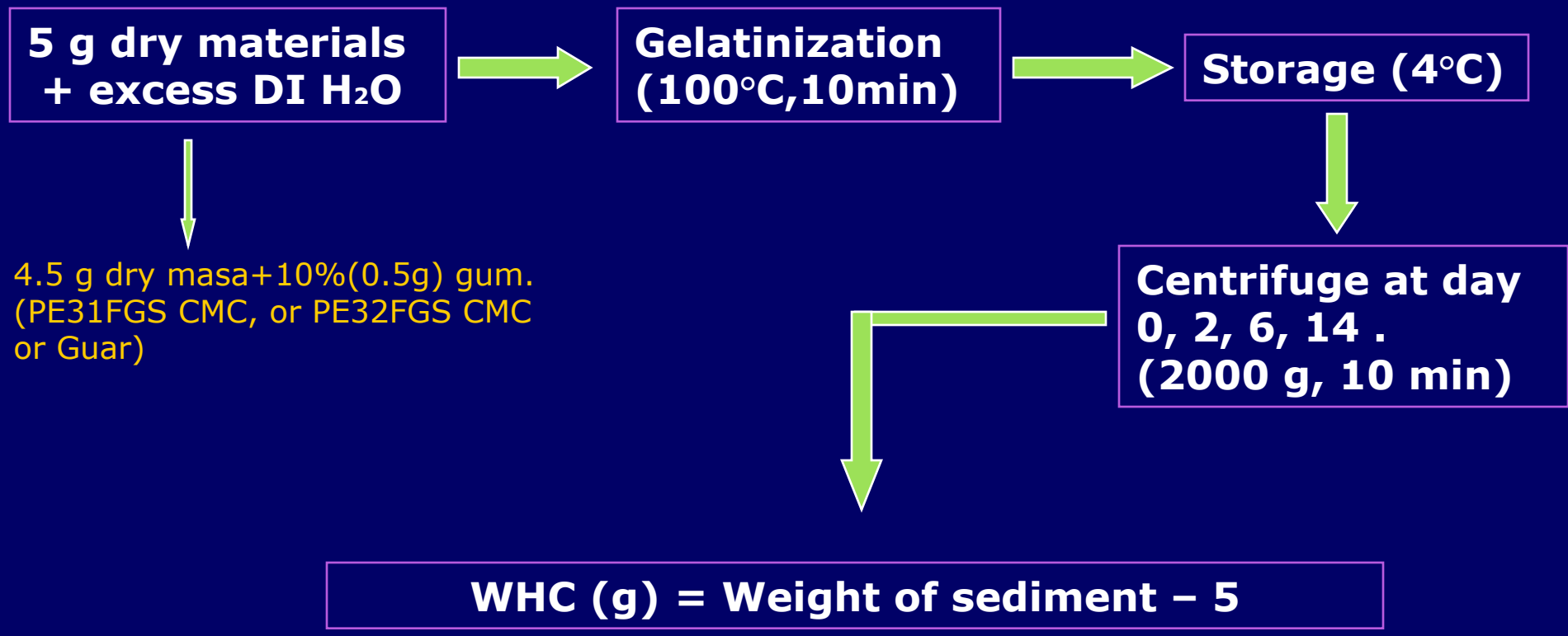
Materials and Methods
A: Thermal Analysis



Materials and Methods
B: Water Holding Capacity



Materials and Methods
B: Water Holding Capacity(Heated)



Materials and Methods
C: Viscosity Measurement

Moisture determination

5 g gum heated in vacuum oven at 105°C for at least 3 hours (PE31FGS CMC, PE32FGS CMC, guar)

% MC in gum:

$$\frac{\text{(5-dry gum weight)}}{5} * 100\%$$

Solution Preparation

H_2O=Weight of undried gum * (99-mc of gum)

gum+H_2O (1% solution)

Agitated at 27.0*1000 rpm For 2 hours using Polytron PT 3100

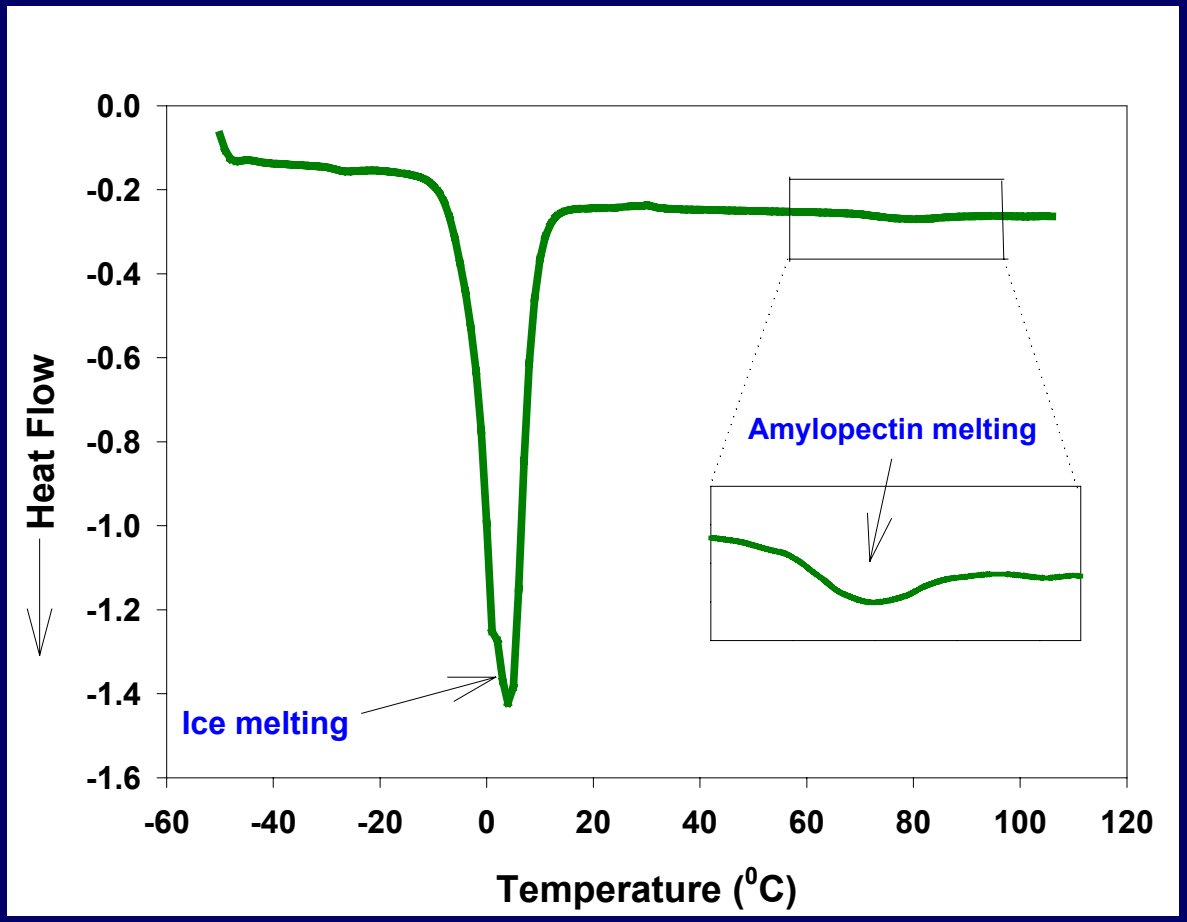
Placed into water bath at 25°C for 1 Hour prior to the measurement

Viscosity measurement

Viscosity measured by Brookfield Digital Viscometer Using Spindle No 3 at 30rpm

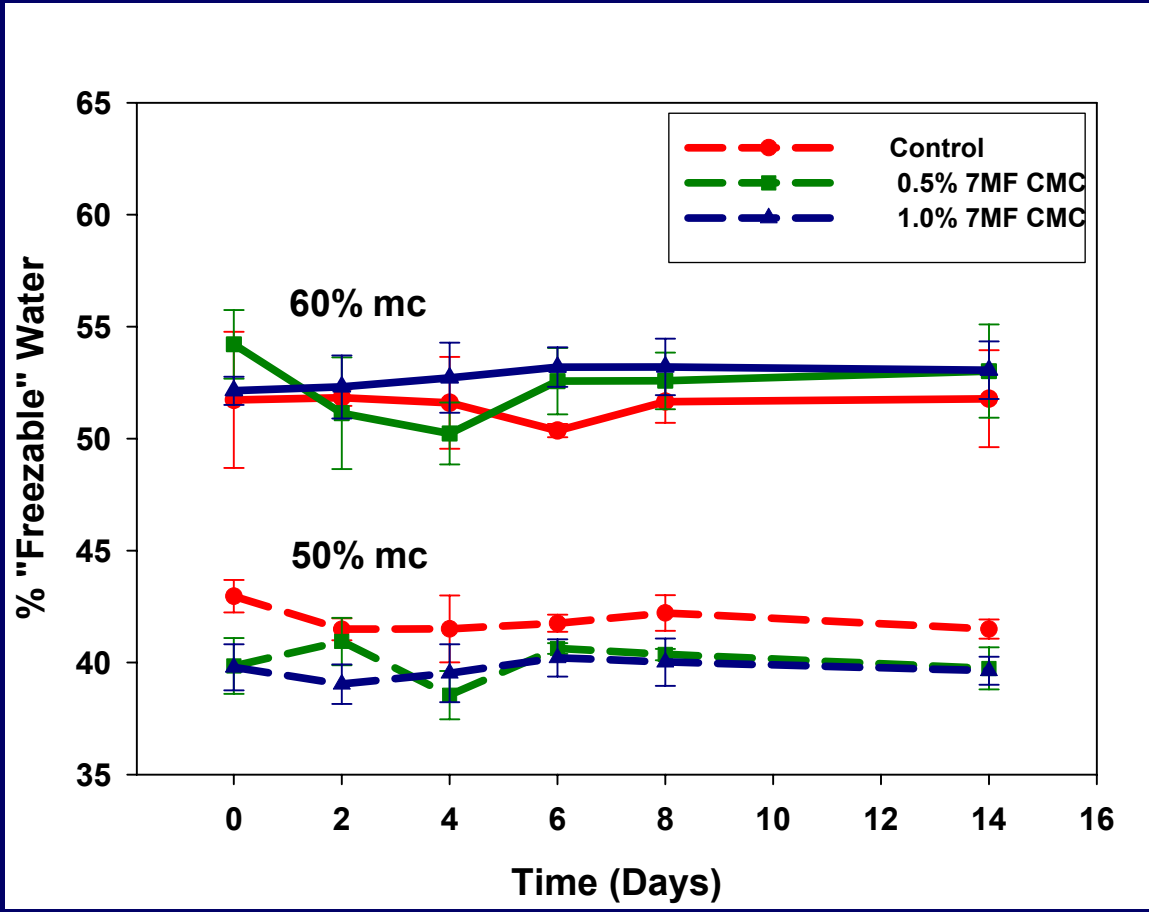
Results and Discussions (unheated)

DSC results: Typical DSC thermogram



Results and Discussions (unheated)

DSC results: Effect of CMC on % FW



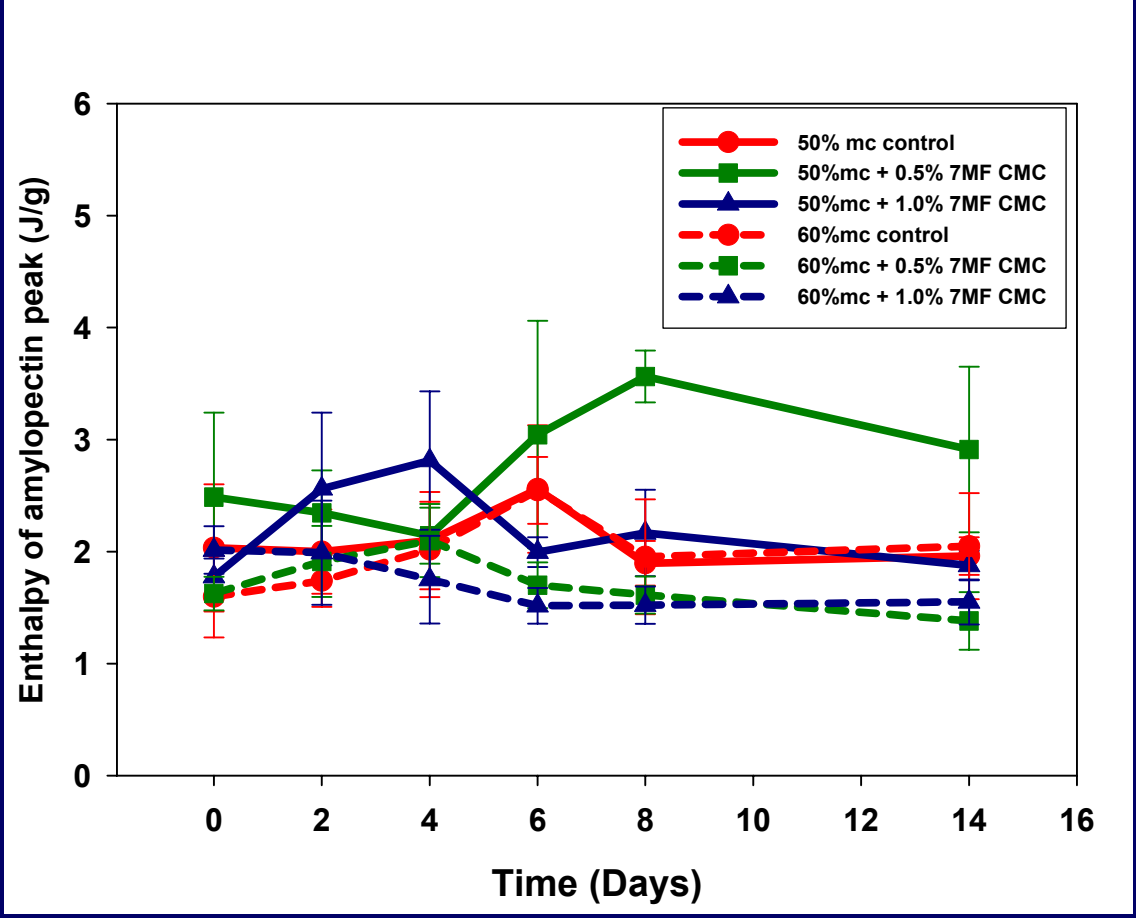
50% mc:
FW in control > Others at day 0&14.
(All $P<0.05$)

60% mc:
Gum addition had no impact on % FW
(all $p>0.05$)

For each mixture, during entire storage time, no significant difference observed.
(all p values > 0.05)

Results and Discussions (unheated)

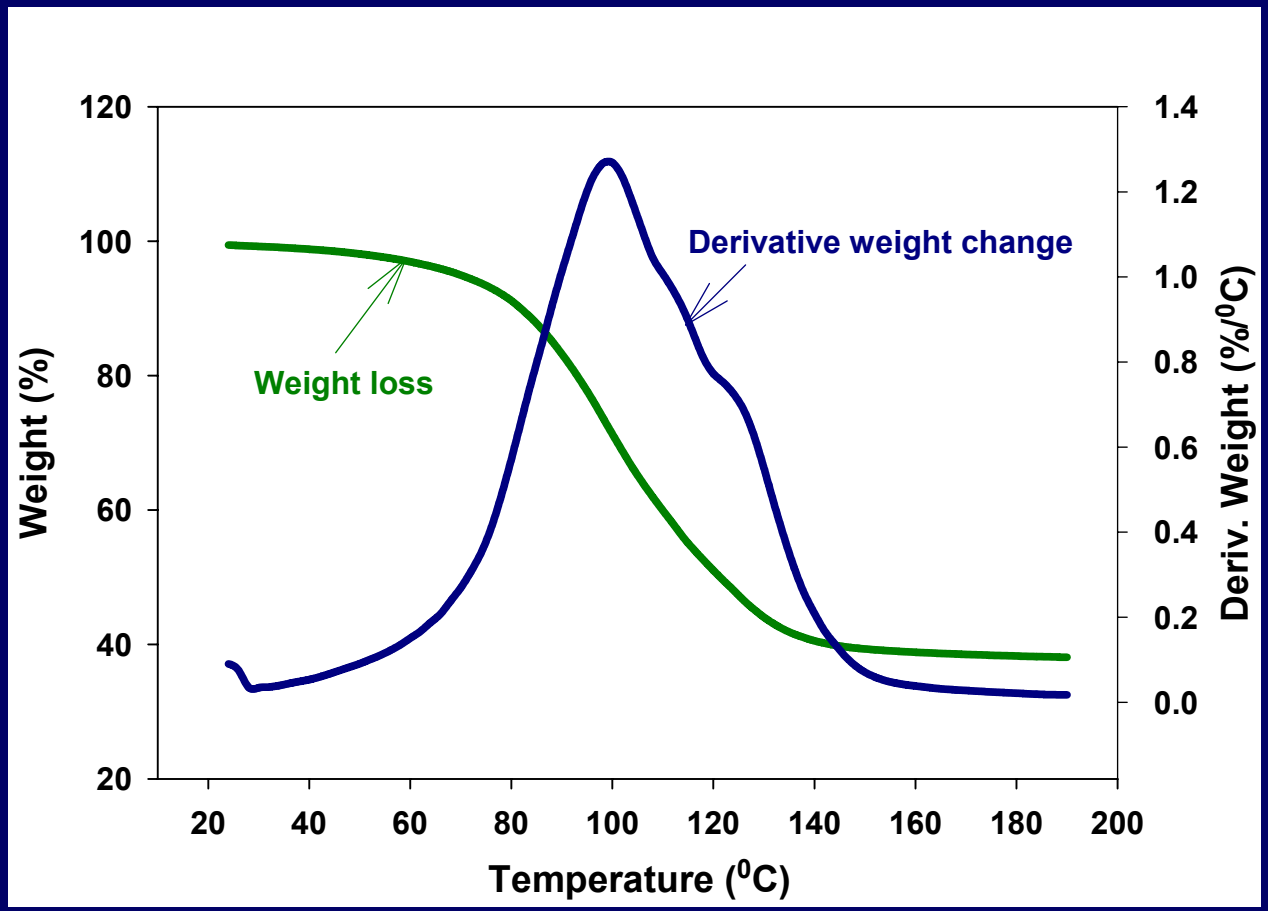
DSC results: Effect of CMC on starch recrystallization.



CMC addition, storage time and moisture content had no significant impact on amyloectin recrystallization.

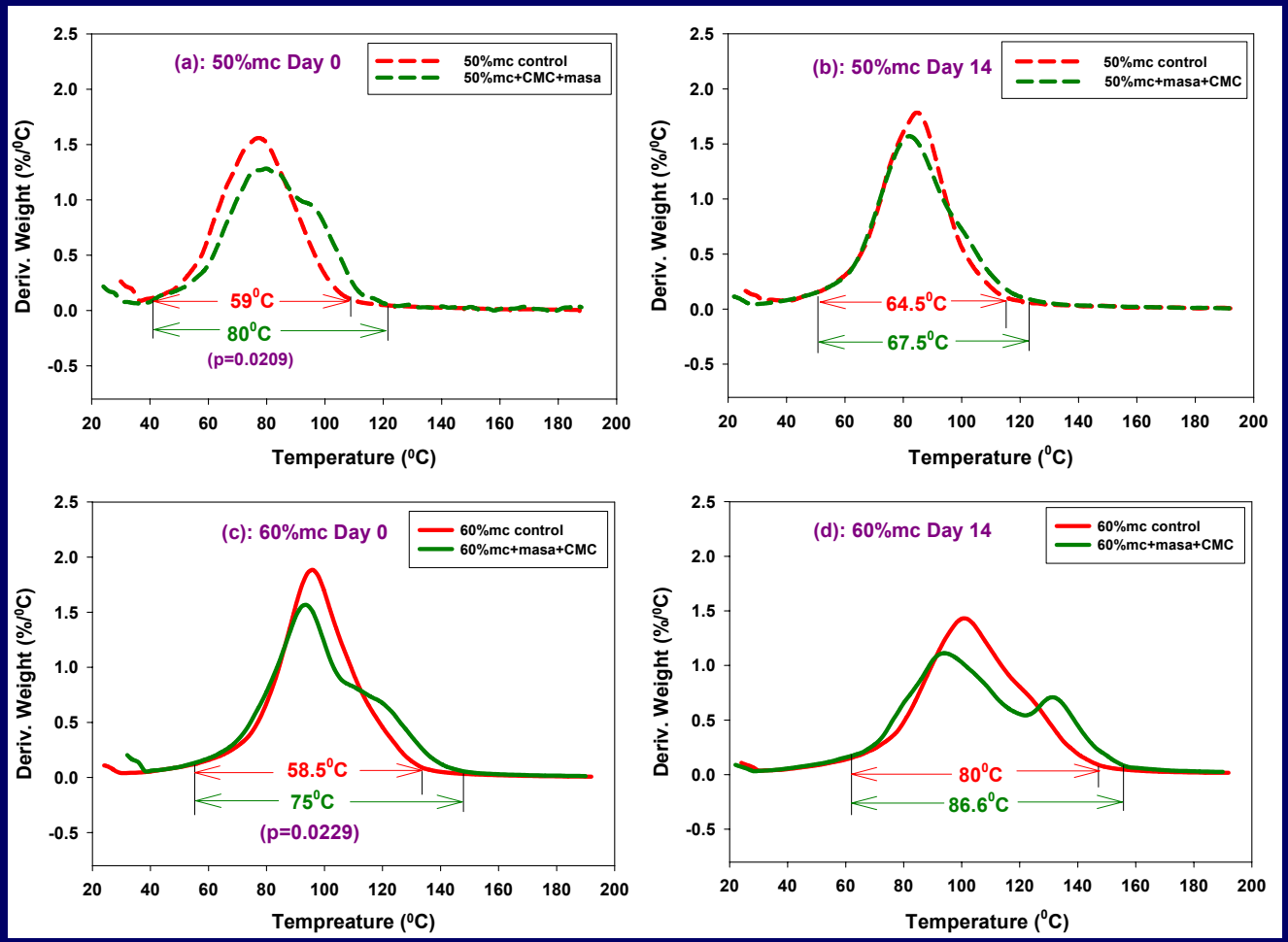
Results and Discussions (unheated)

TGA results: Typical TGA thermogram.



Results and Discussions (unheated)

TGA results: Effect of CMC on water distribution



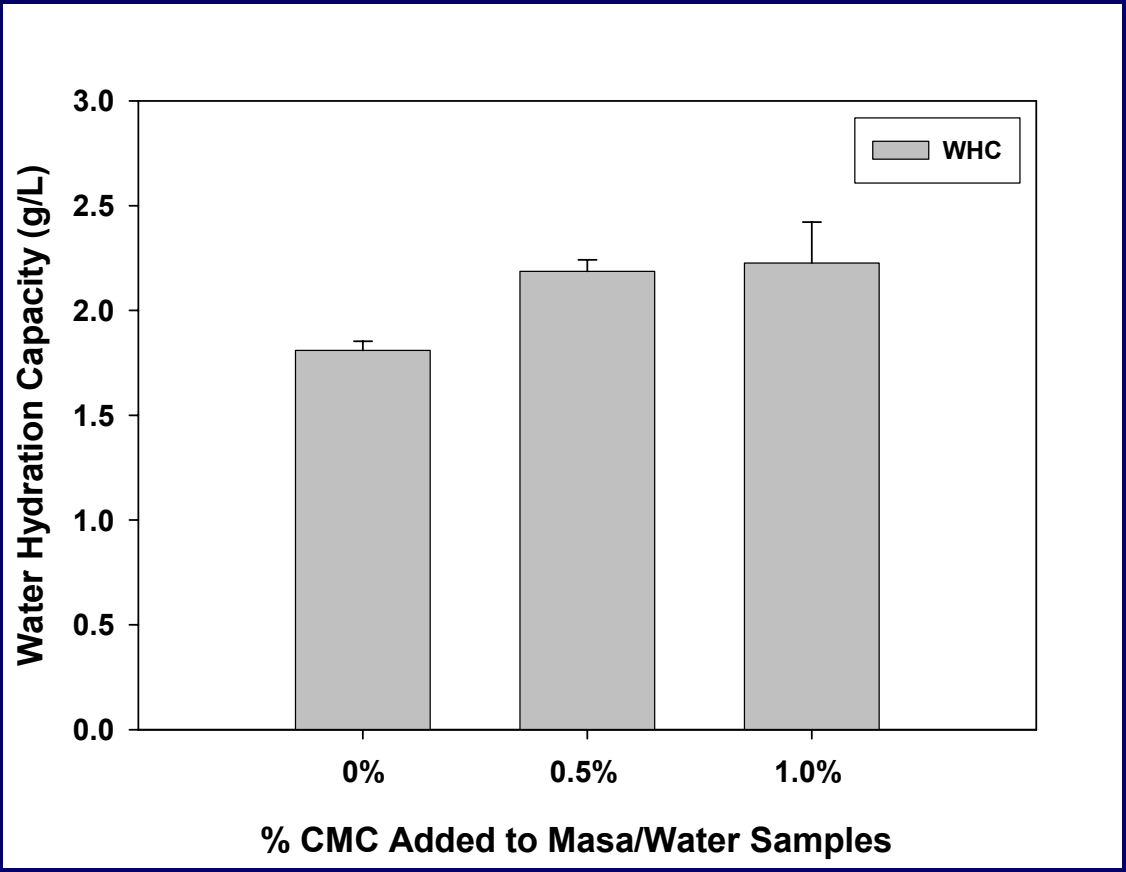
CMC addition causes water distribution to be more heterogeneous.

Storage time:
50%mc control:no change
50%mc+ CMC: more homogeneous
60%mc control:more heterogeneous
60%mc+CMC: no change

Moisture content:
Day 0: No impact.
Day 14: Higher mc causes water distribution to be more heterogeneous.

Results and Discussions (unheated)

WHC results: Effect of CMC on water retention



Significantly larger amount of water were retained in the presence of CMC (p=0.0109).

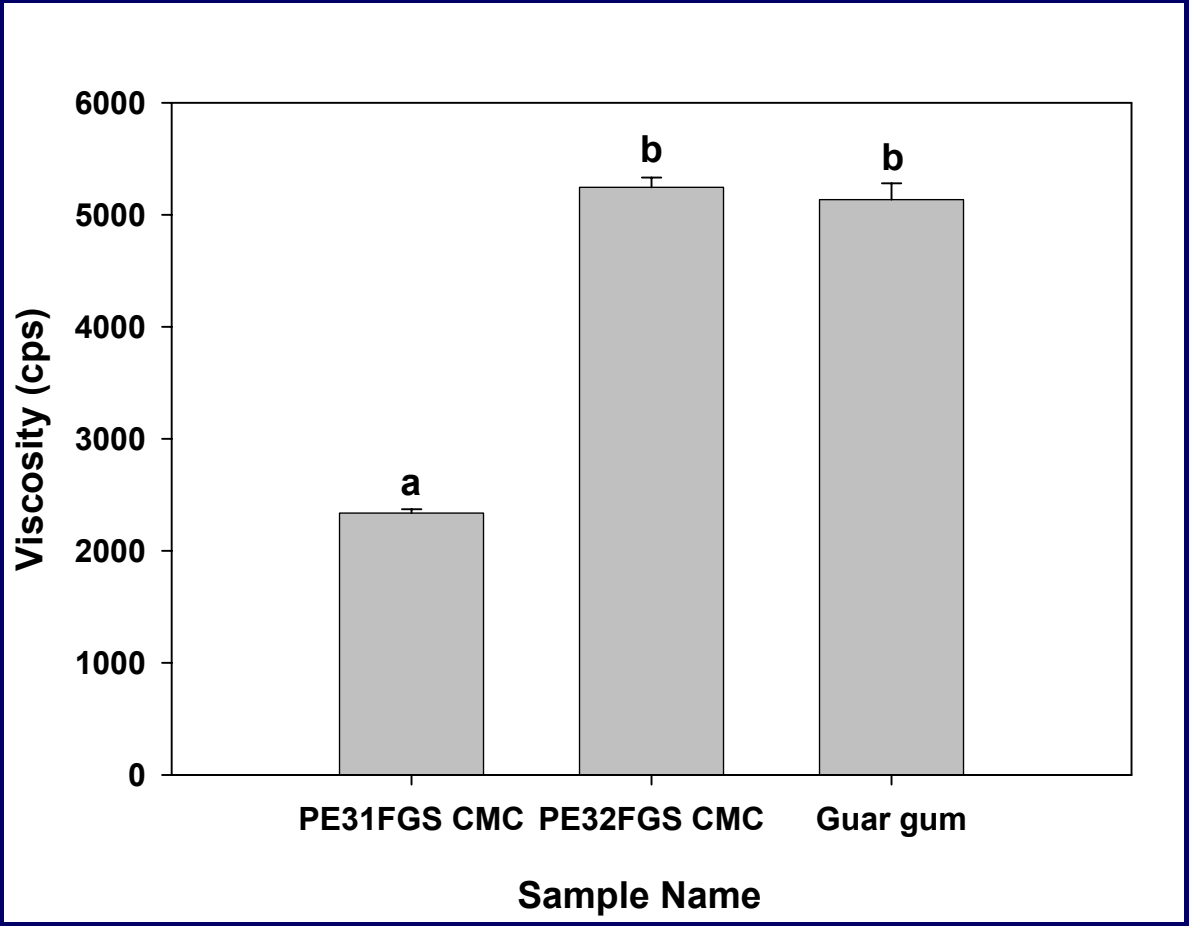
No significant difference (p=0.7502) in WHC between the CMC concentration used (0.5 & 1.0%).

Conclusions (unheated)

- CMC addition at certain level (0.5%) may increase water retention, decrease % FW (50%mc), cause water distribution more heterogeneous but no impact on starch recrystallization in the unheated mixtures.
- Storage time had no significantly impact on % FW and amount of amylopectin recrystallization.
- Higher MC resulted in an increasing FW content, and more heterogeneity of water distribution (Day 14).

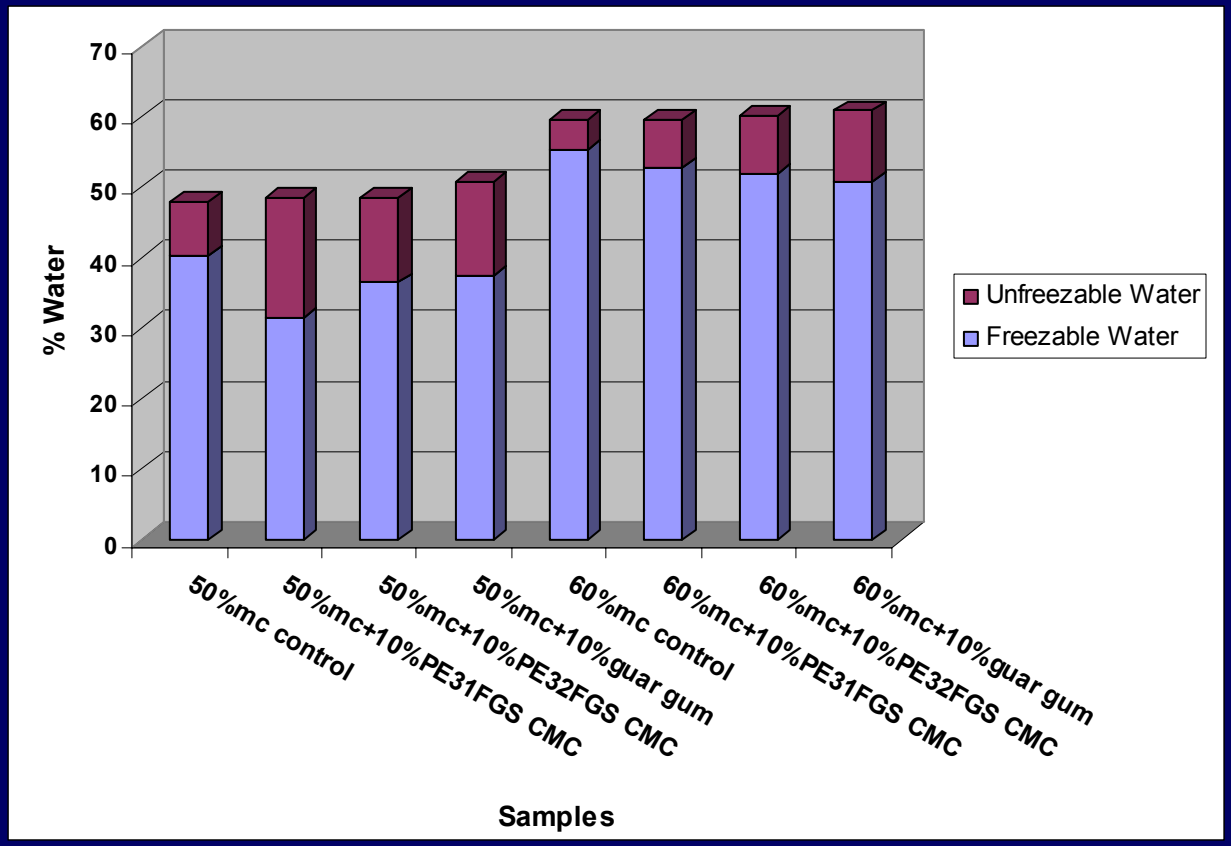
Results and Discussions (Heated)

Viscosity of each 1% gum solution



Results and Discussions (Heated)

DSC results: FW and UFW at day 0

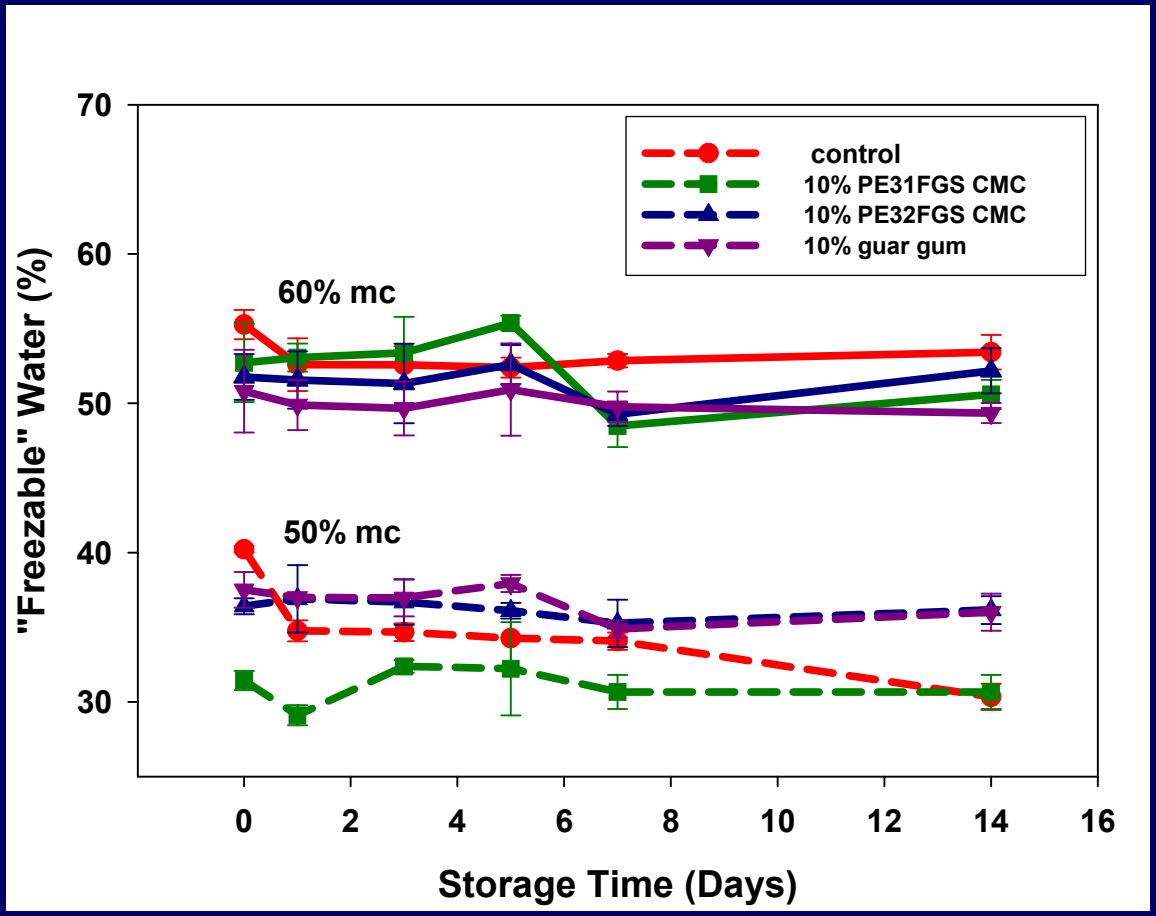


50%mc: p=0.0000
FW in Control > Others

60%mc: p=0.0984
No significant difference in FW obtained.

Results and Discussions (Heated)

DSC results: Effect of gums on % FW

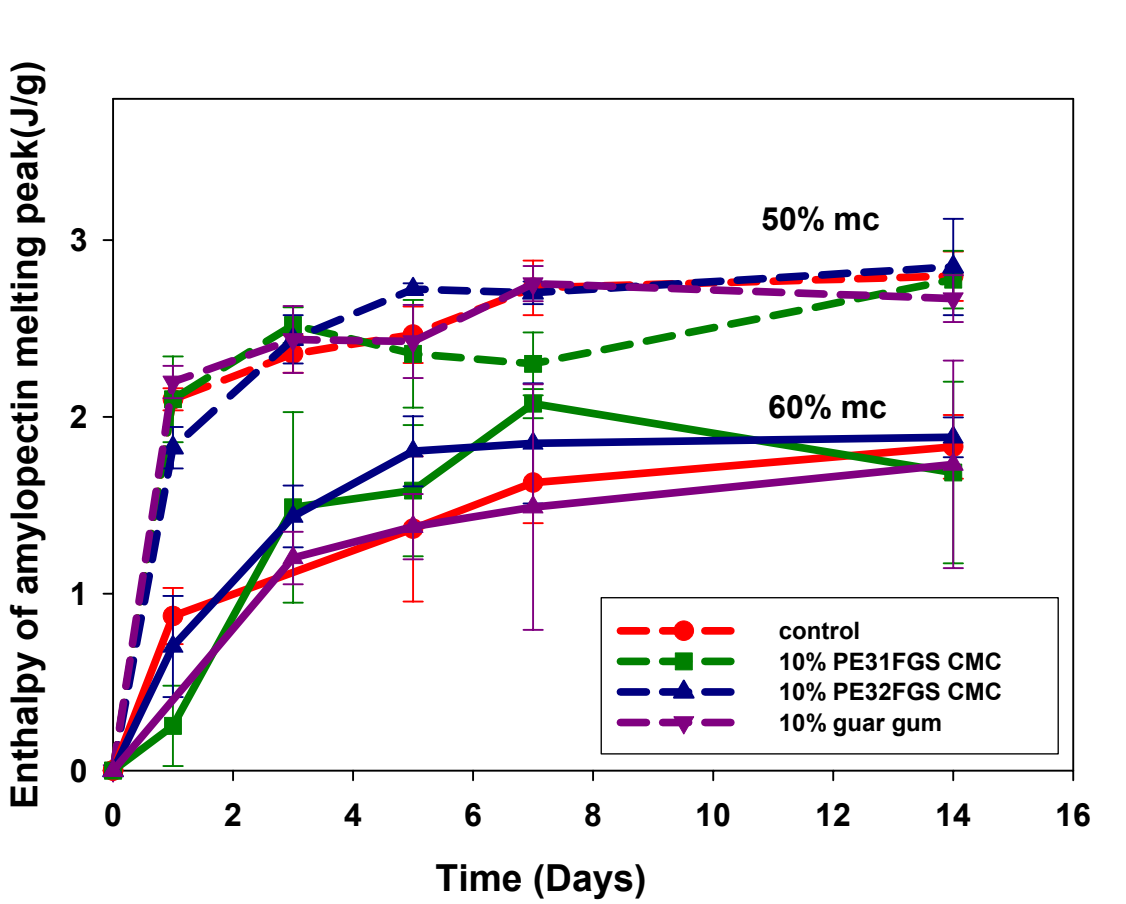


50%mc:
During storage, only FW in control decreased significantly ($p=0.004$).
(Other P values >0.05)

60%mc:
During storage,only FW in samples with 10% PE31FGS CMC decreased significantly ($p=0.0418$).
(Other P values >0.05)

Results and Discussions (Heated)

DSC results: Effect of gum addition on amylopectin recrystallization



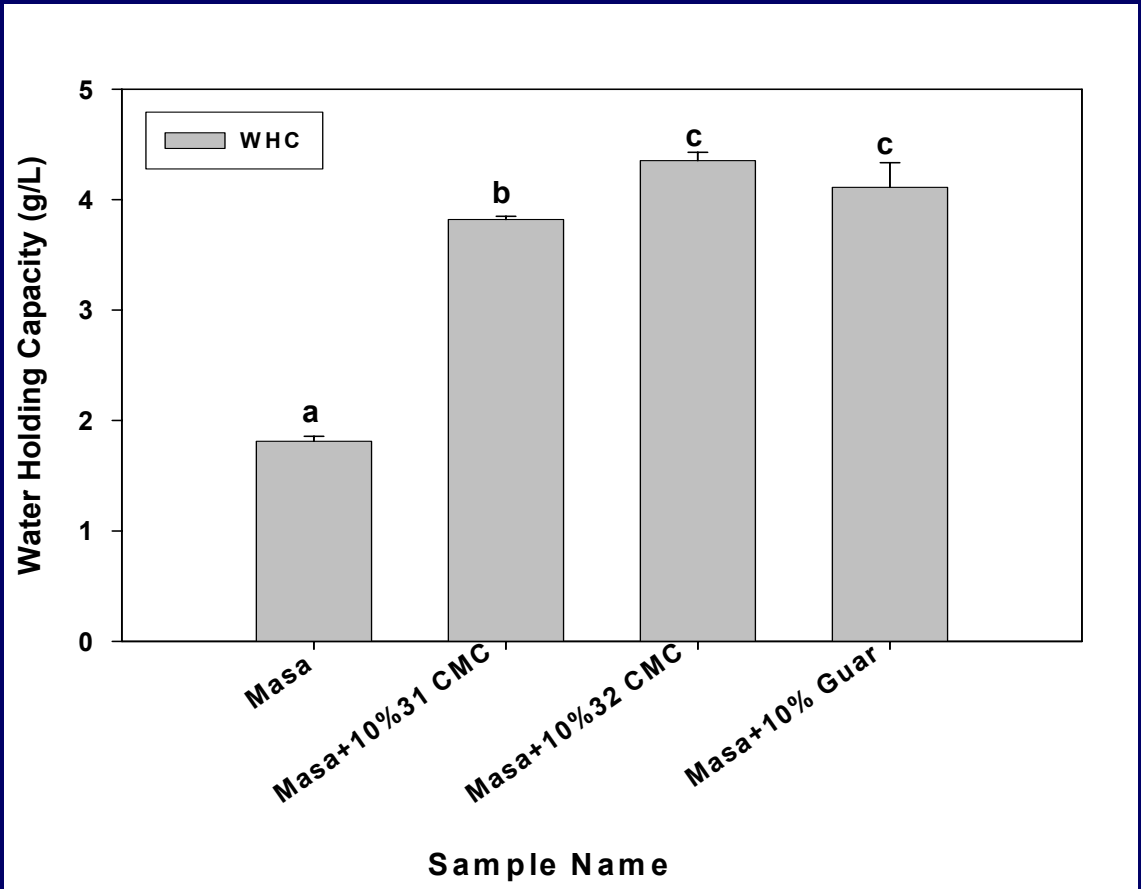
Gum addition had no impact on the melting enthalpy of recrystallized amylopectin. (all $p>0.05$).

The melting enthalpy Increased with storage time.

Moisture content affected the melting enthalpy. Certain MC (50%) provides optimum conditions for starch recrystallization.

Results and Discussions (Heated)

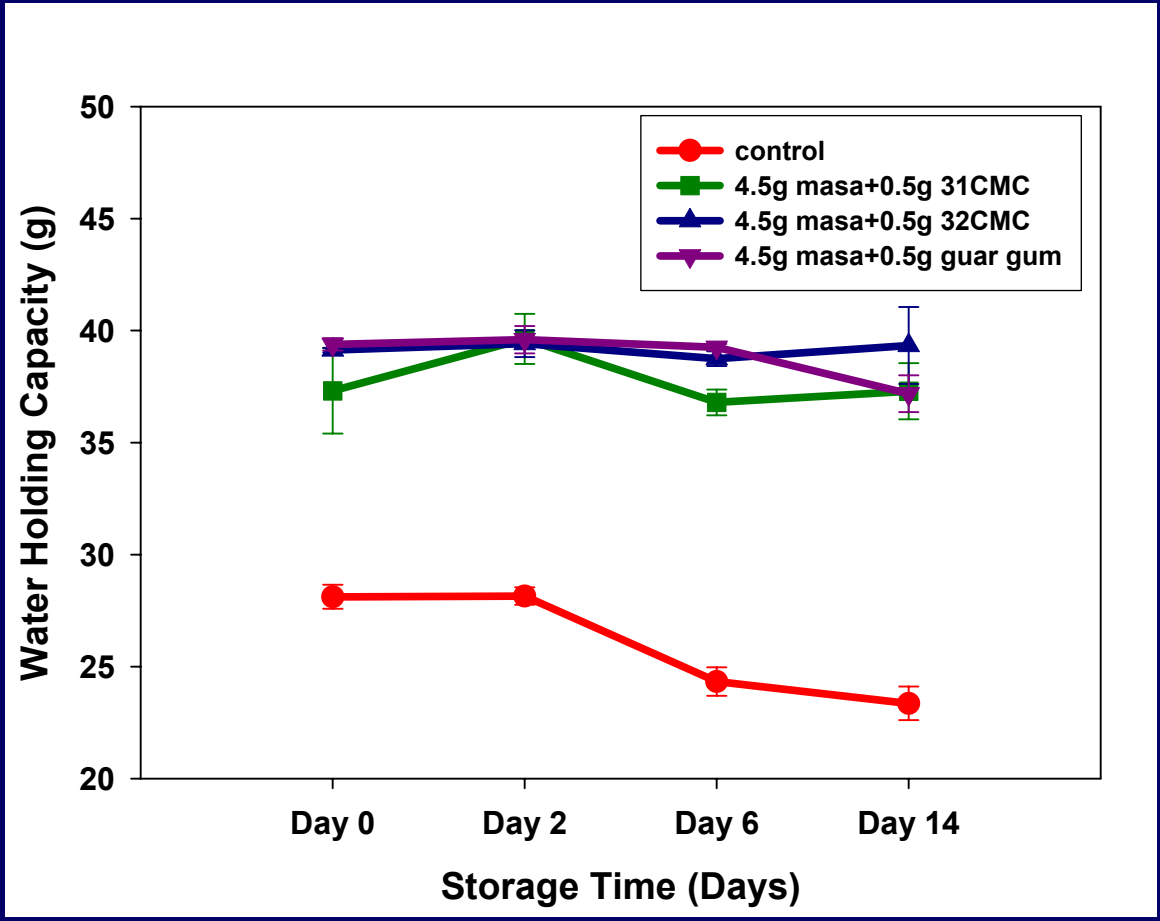
WHC results: Effect of gums on water retention



Gum addition increased WHC and related to gum's viscosity.

Results and Discussions (Heated)

WHC results: Effect of gums on water retention during storage

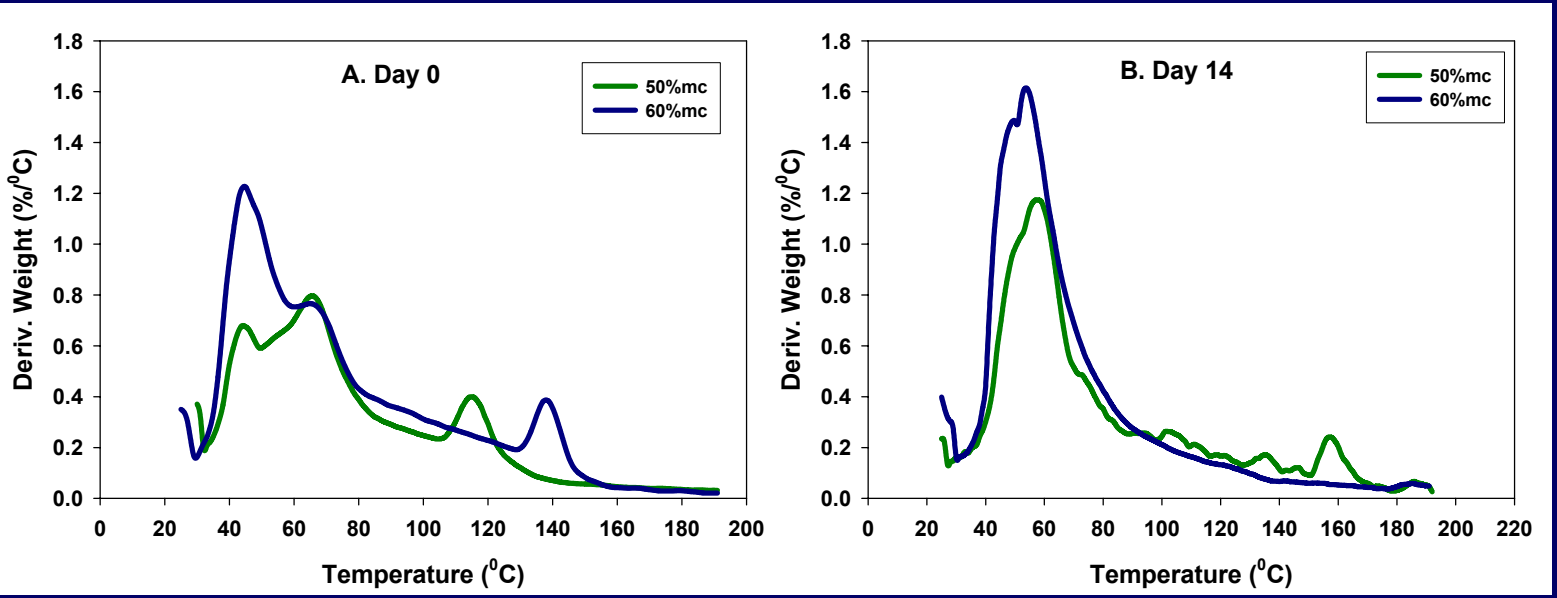


Gum addition increased WHC throughout storage.

WHC in control sample and sample with guar gum decreased significantly . (p=0.0001/p=0.005)

Results and Discussions (Heated)

TGA results: Effect of gums on water distribution



A: The rate of weight loss showed a bimodal distribution in all samples with or without gum addition at day 0.

B: After storage, both 50%mc &60%mc samples lost water more homogeneously (single curve)

Conclusions (heated)

- Gum addition increased WHC and "unfreezable" water (in 50%mc) in heated masa/water mixtures.
- FW content in most samples did not change during storage. Water distribution became more homogeneously after storage.
- Recrystallization of amylopectin ↑ as ↑ storage time, Certain MC (50%) provides optimum conditions for starch recrystallization. It was not affected by gum addition.
- These results seem to indicate that lack of flexibility in tortillas may have more to do with water redistribution and possible changes in amorphous phase than amylopectin recrystallization.

Future Work

- These results need to be verified on a molecular level with such techniques as Nuclear Magnetic Resonance (NMR) spectroscopy.

Questions?

Thanks!