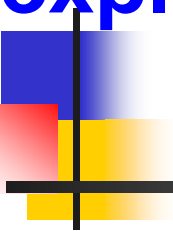


Effects of extraction rate, particle size, and chlorination extent on flour functionality explored by SRC, DSC, RVA and cake baking



Meera Kweon

USDA, ARS, Soft Wheat Quality Lab, Wooster, OH 44691

Comparison of ingredients for cookie and cake

Ingredient	Cookie	Cake
Sucrose	high	high
Fat	high	high
Water	low	high
Flour	Non-chlorinated	Chlorinated



Effects of chlorination on flour

- Modify amylose-associated phospholipid
- Enhance amylose pasting
- Decrease gluten strength
- Decrease flour pH



Objective

Explore the effects of extraction rate, particle size, and chlorination extent on flour functionality by SRC, DSC, RVA and cake baking.

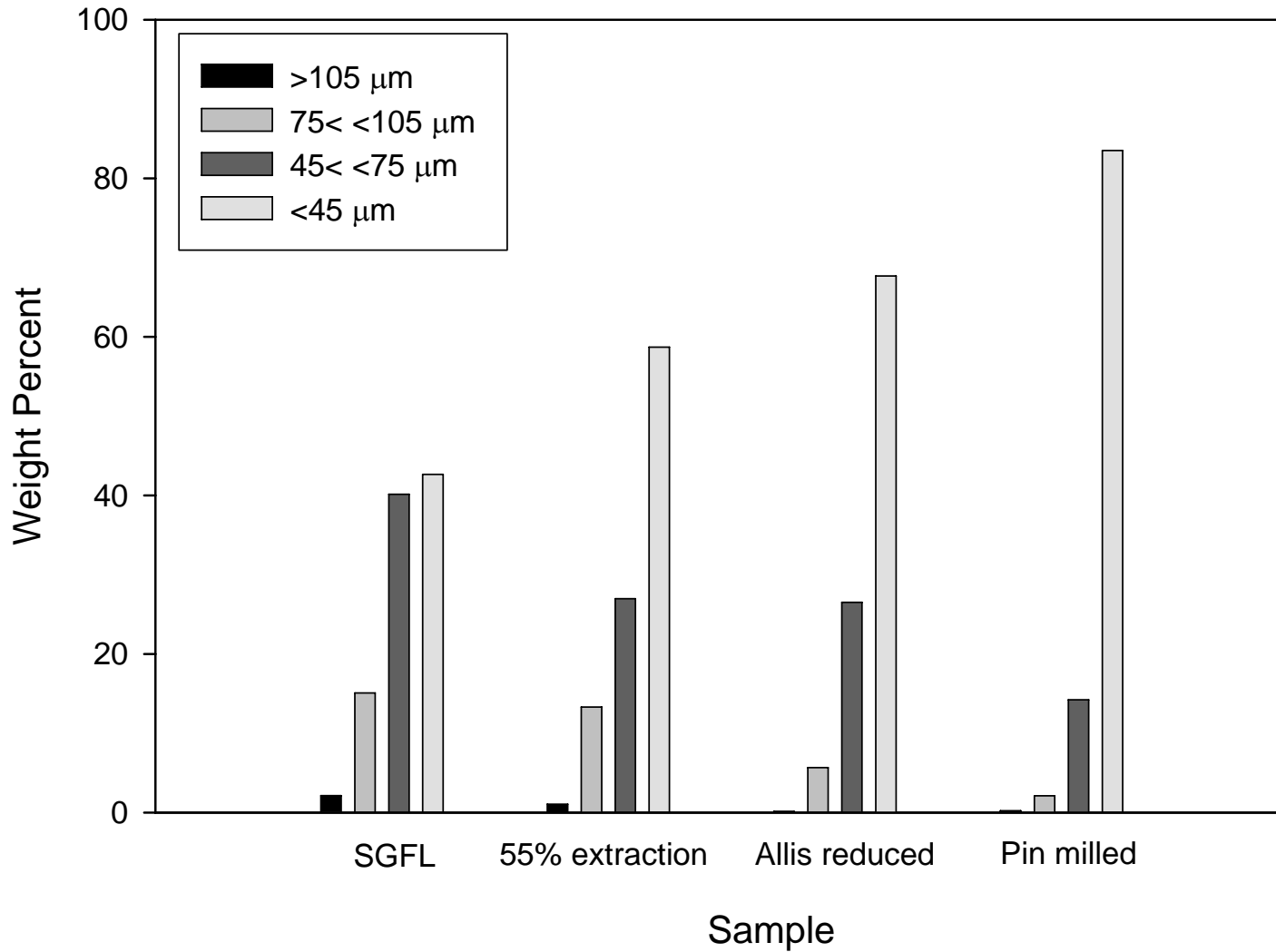
Flour preparation

Croplan 594W (supersoft SRW): milled with Miag Mill

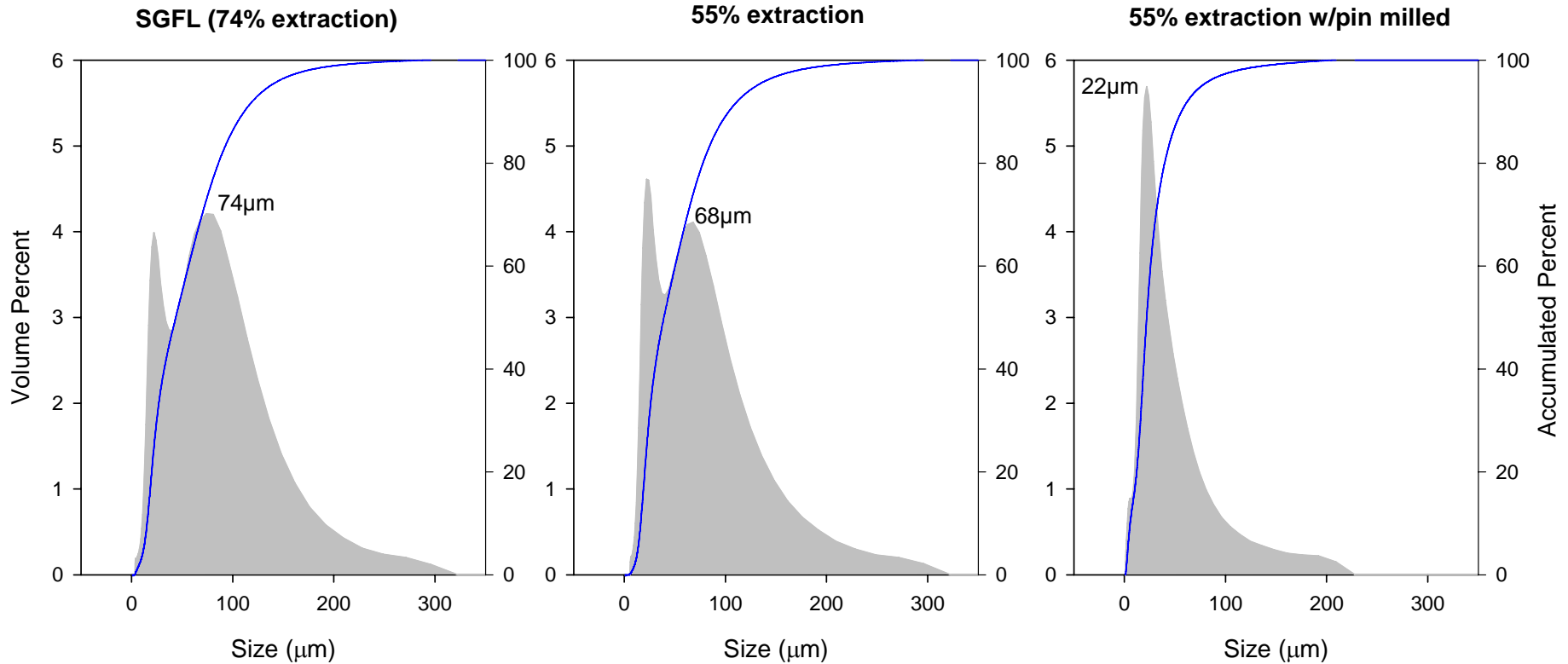
Extraction rate	Particle size reduction	Extent of chlorination	Extraction rate	Particle size reduction	Extent of chlorination
74%	-	pH 5.92 4.98 4.83 4.38 3.99	55%	Pin milled	pH 5.72 5.22 4.87 4.64 4.34 4.04 3.68
55%	-	pH 5.70 5.03 4.85 4.59 4.04 3.96 3.75	55%	Allis reduced	pH 5.75 4.86 4.77 4.66 4.44 4.22 3.93

Weight percent by Ro-tap

Used sieves: US standard #, 140 (105 μ m), 200 (75 μ m), and 325 (45 μ m)



Particle size of flour samples (measured by Microtrac S3000)



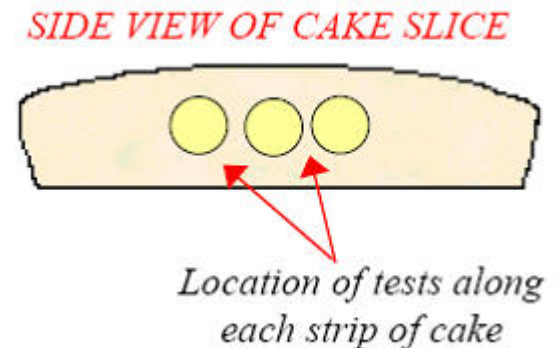


Methods

- **Solvent Retention Capacity (SRC)**
 - AACC 56-11 Method
- **Differential Scanning Calorimetry (DSC)**
 - DSC model: DSC 7 (Perkin Elmer, CT, USA)
 - Sample concentration: 1:1 flour:solvent
 - Heating rate: 10°C/min
 - Heating range: 30 – 130C
 - Reference pan: Empty pan
- **Rapid Visco Analyzer (RVA)**
 - Model: RVA-4 (Newport Scientific, Australia)
 - Sample concentration: 3.5g (db) flour + 25mL solvent
 - Heating rate: 5°C/min
 - Temperature range: 50C→95C→50C

Methods (Cont'd)

- **Cake Baking**
 - AACC 10-90 Method with formula modification
- **Cake Texture (measured by TAXT2)**
 - Combined procedure of AIB standard and Texture Technologies Corp study 40W
 - TPA test
 - Pre-test speed: 2.0 mm/sec
 - Test speed: 2.0 mm/sec
 - Post-test speed: 2.0 mm/sec
 - Compression distance: 10.0 mm
 - Probe: ½" diameter acrylic cylinder (w/rounded edge)

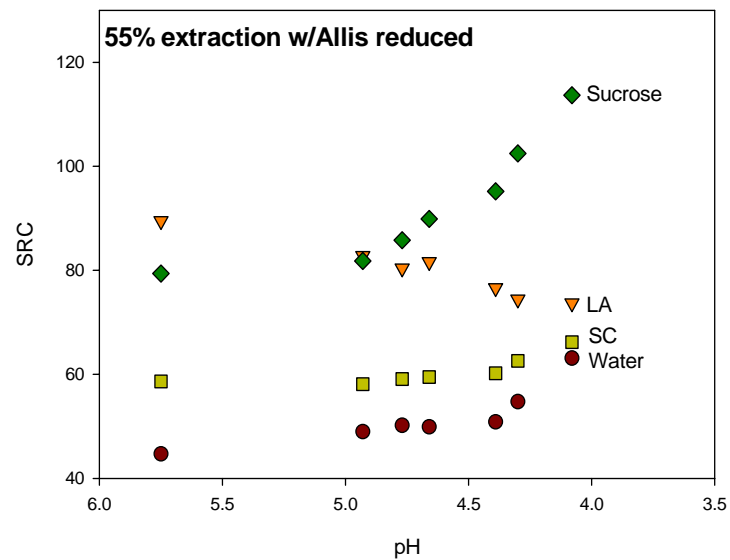
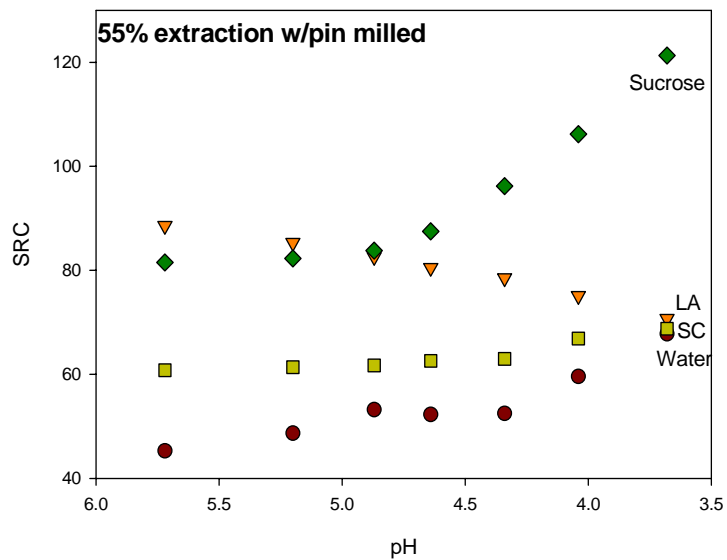
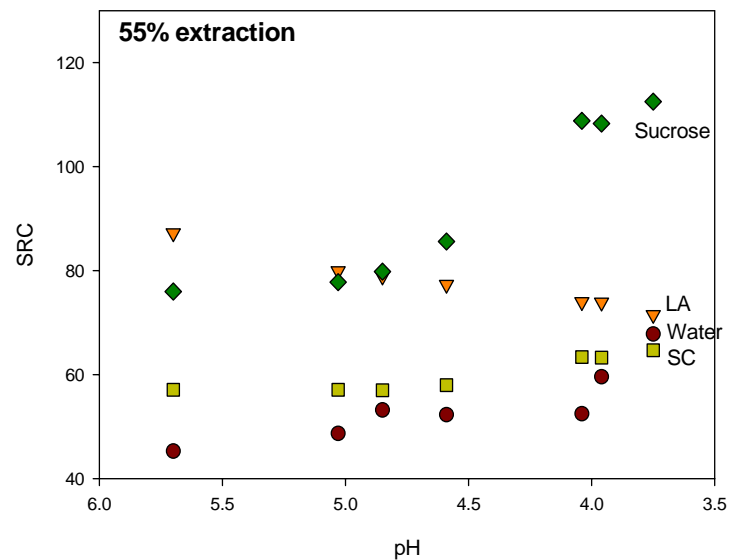
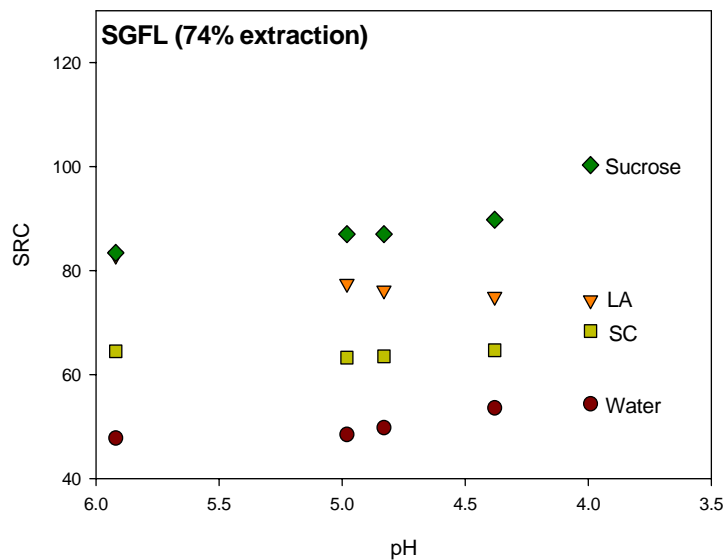


Ingredients and formula for cake

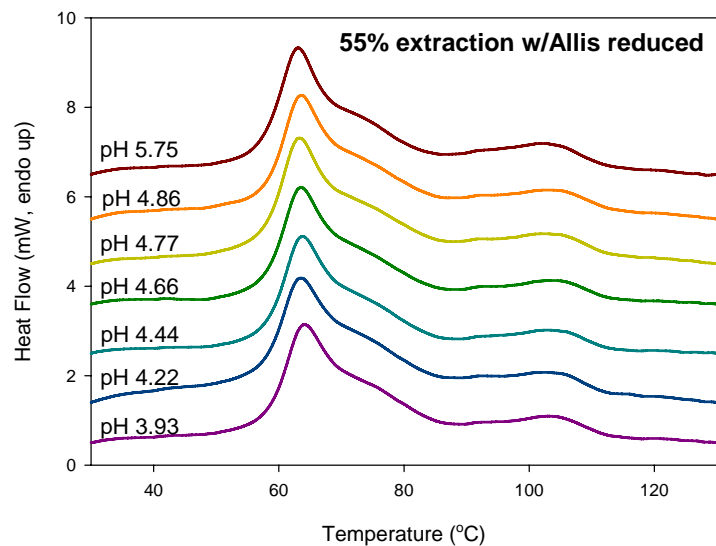
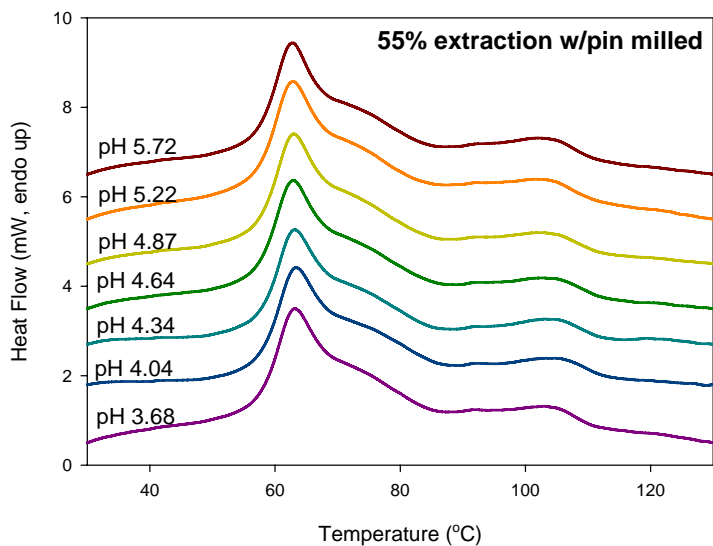
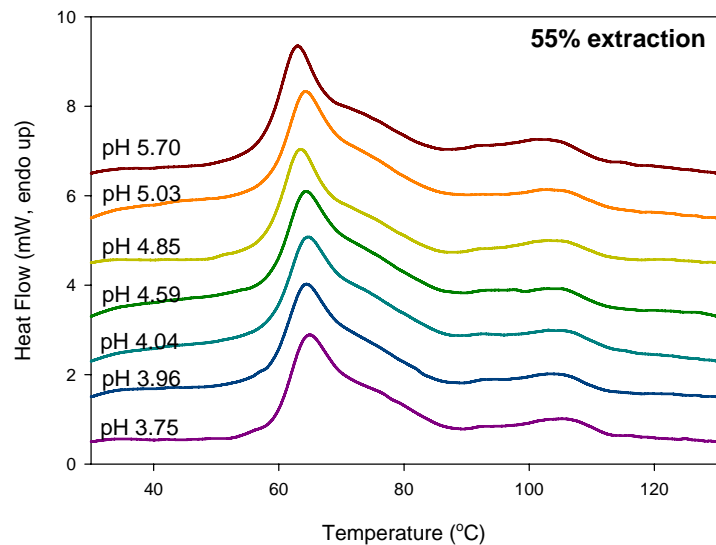
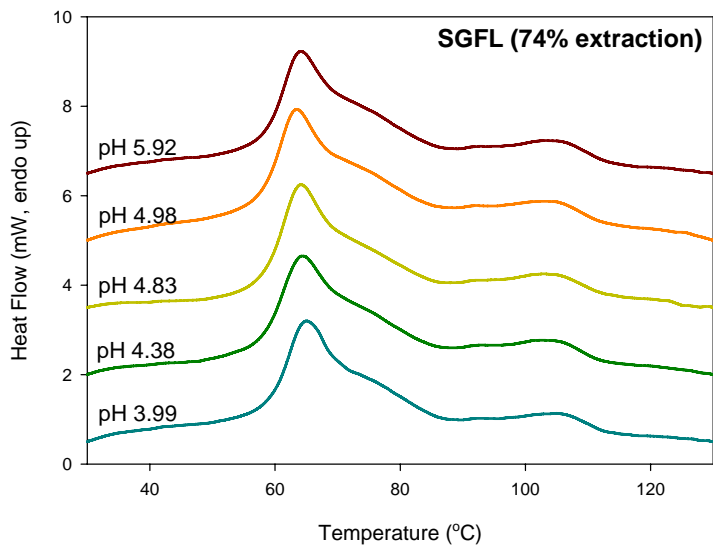
Ingredients	Cake (g)
Flour	100.0
Sugar	137.5
NFDM	12.0
Egg White	9.0
Salt	3.0
Soda	1.95
SAPP	0.29
MCP	2.05
Shortening	37.5
Water	137.5
Baking temp. (°F)	340
Baking time (min)	35

Notes: Sugar concentration (%S) is 50% w/w, the same as used for DSC and RVA studies.
Total solvent (TS) is 275g.

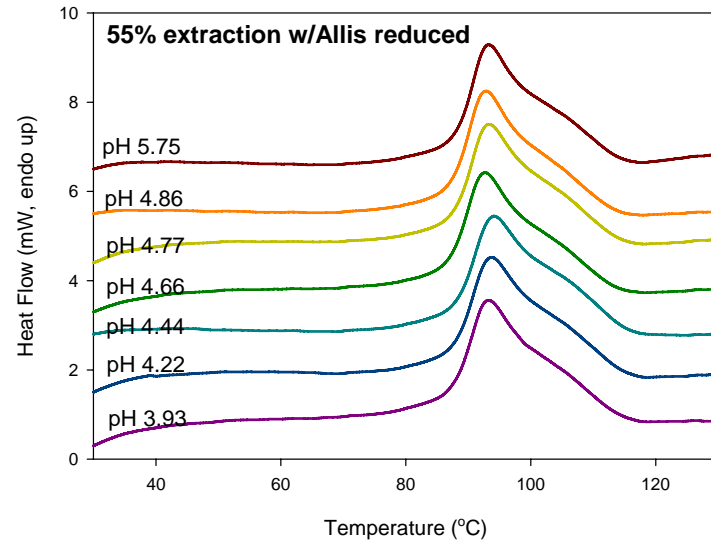
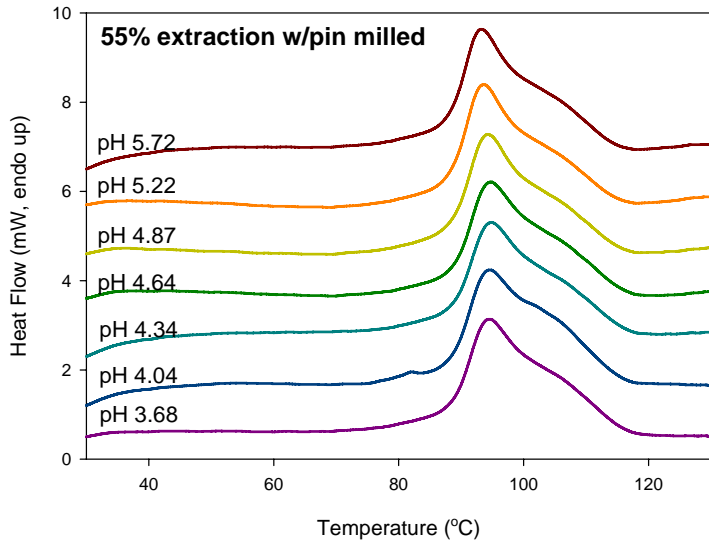
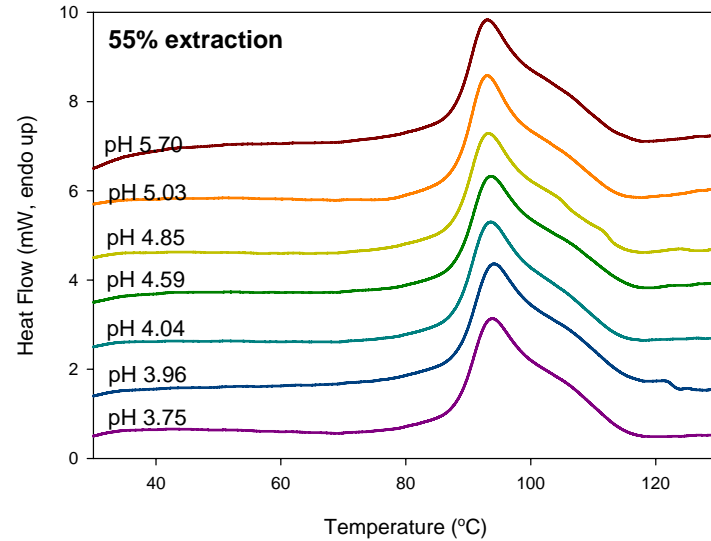
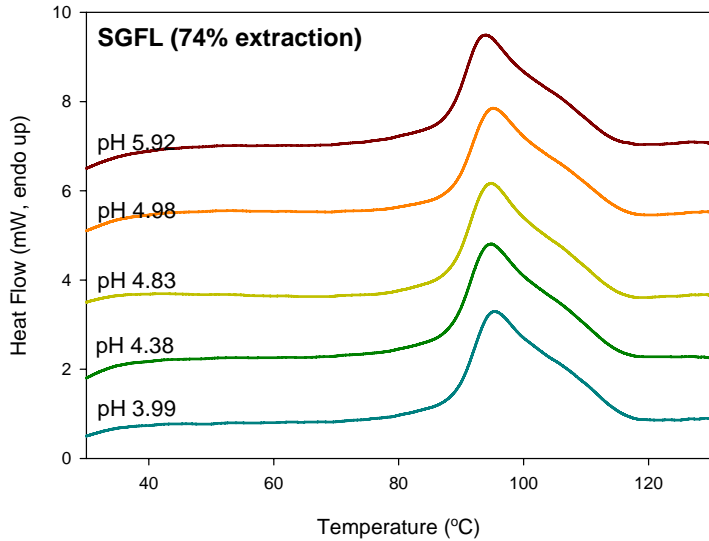
SRC patterns of Croplan 594W 32.9% BFY as a function of extraction rate, particle size, and chlorination extent



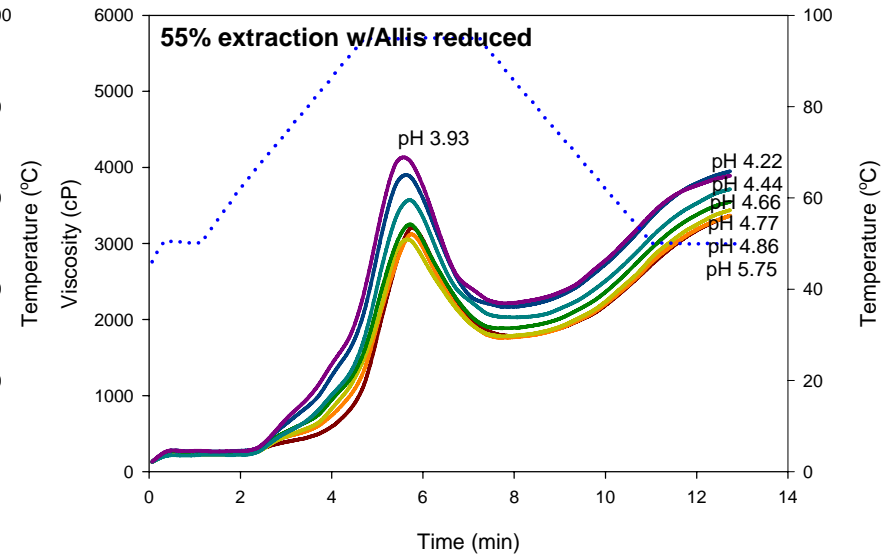
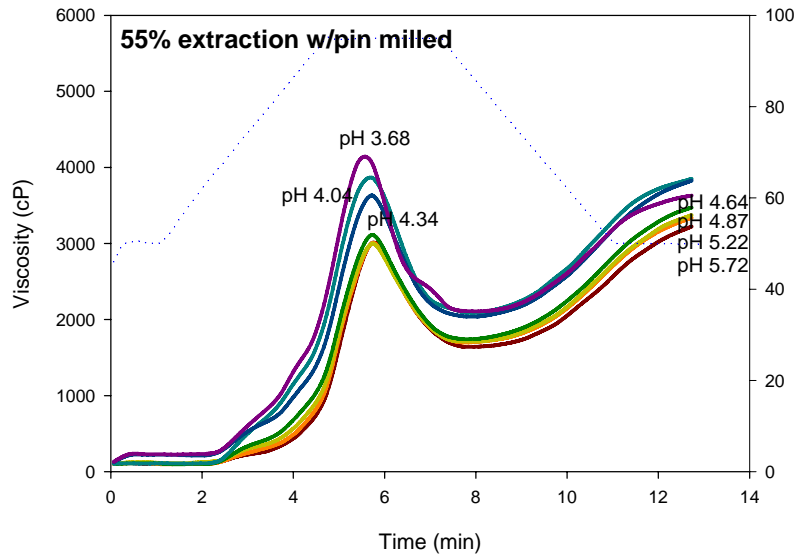
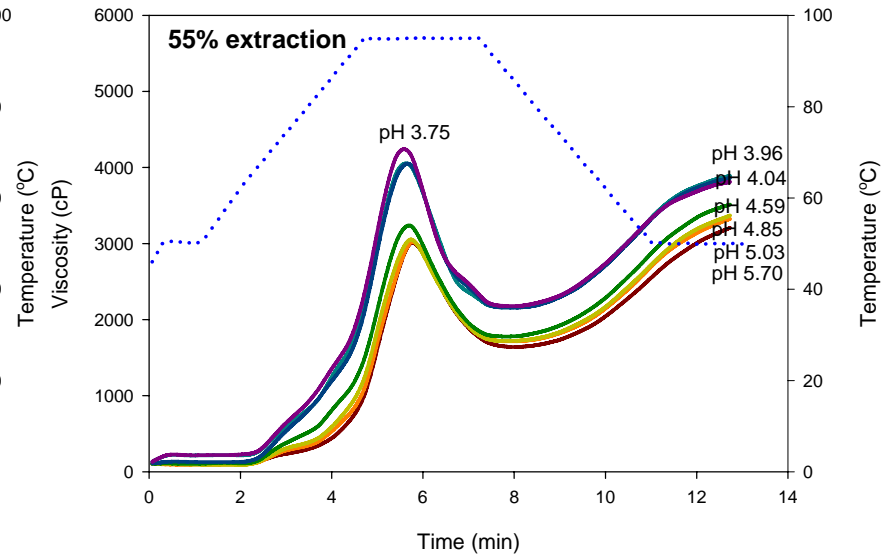
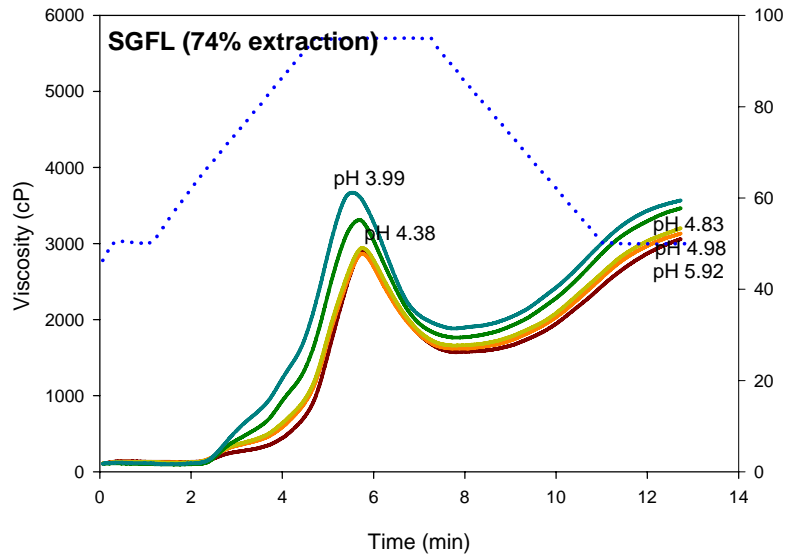
DSC thermograms of flour samples in water



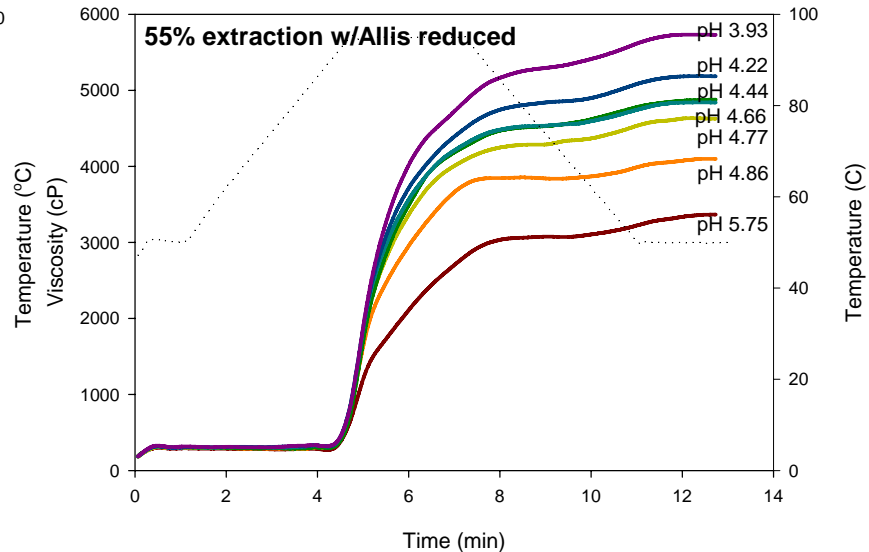
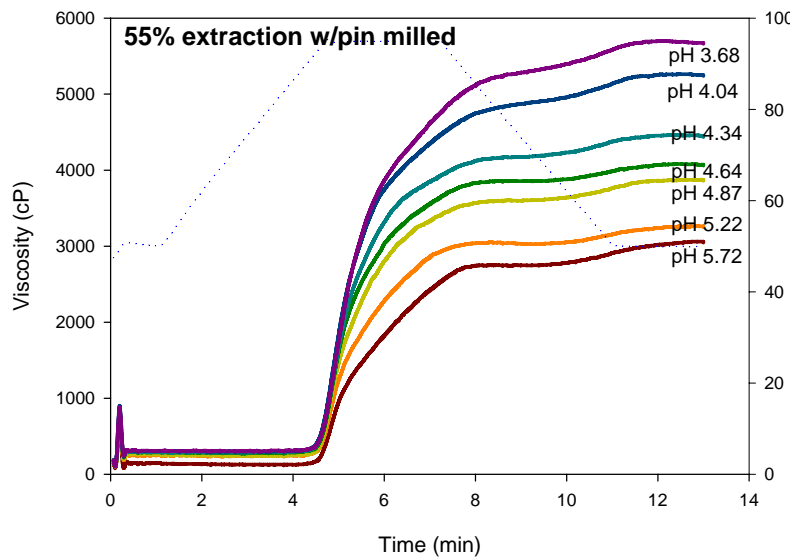
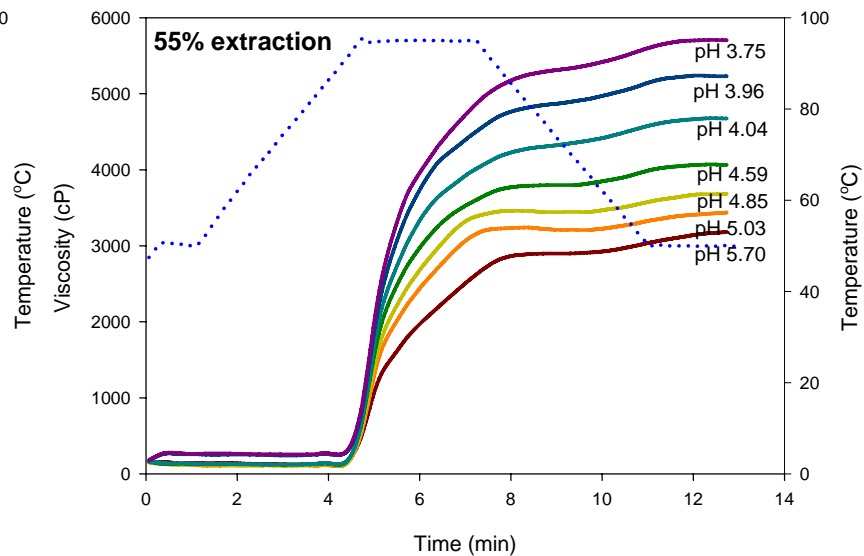
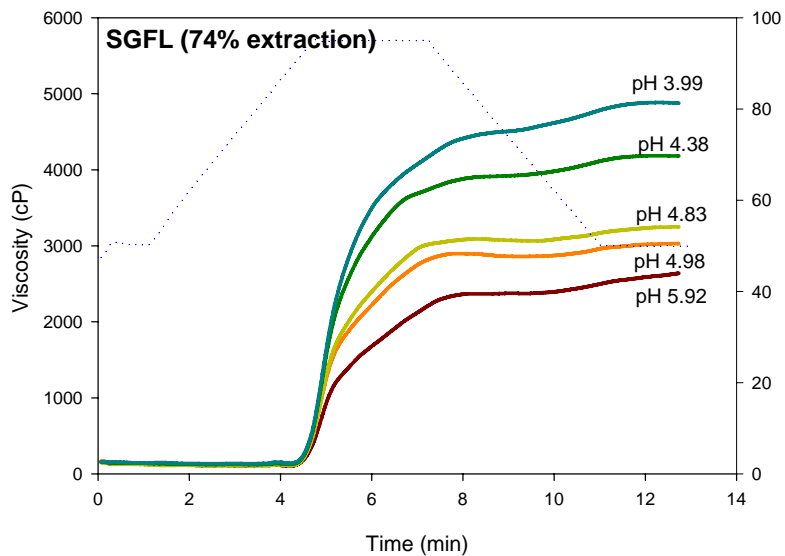
DSC thermograms of flour samples in sucrose



RVA of flour samples in water



RVA of flour samples in 50% w/w sucrose



Time Lapse Photography for cake baking with 55% extraction flour

Unchlorinated

Chlorinated

Baking time (min)

pH 5.70

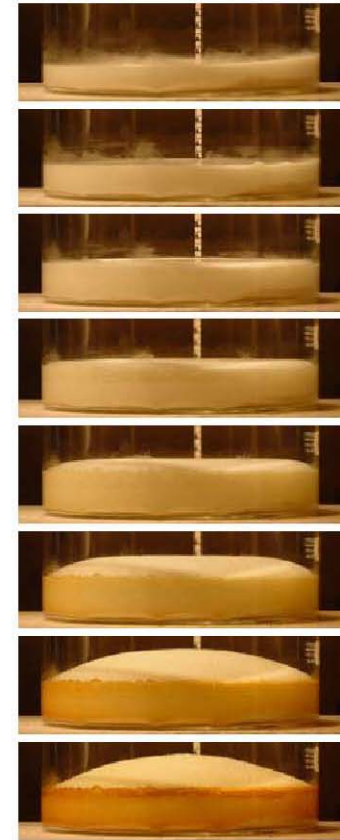
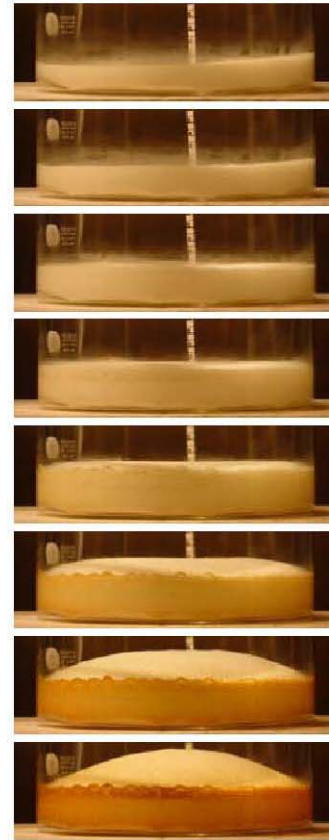
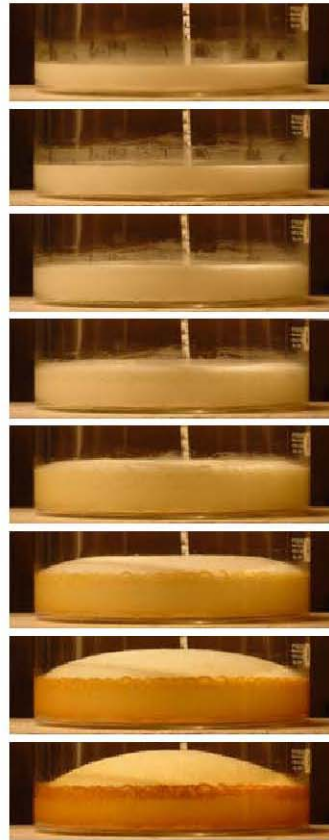
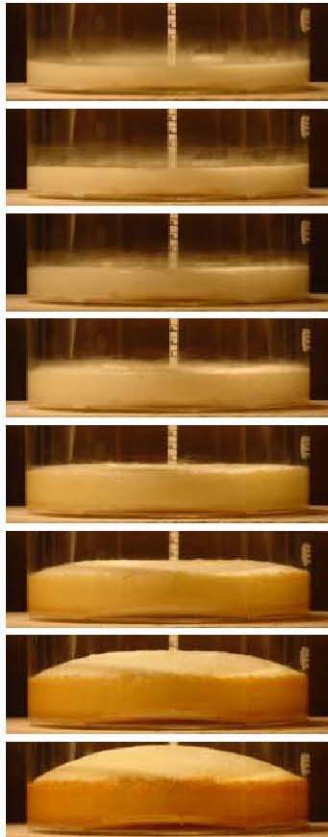
pH 4.85

pH 4.59

pH 4.04

Baking time (min)

1
5
10
15
20
25
30
35



1
5
10
15
20
25
30
35

Final cooled cake

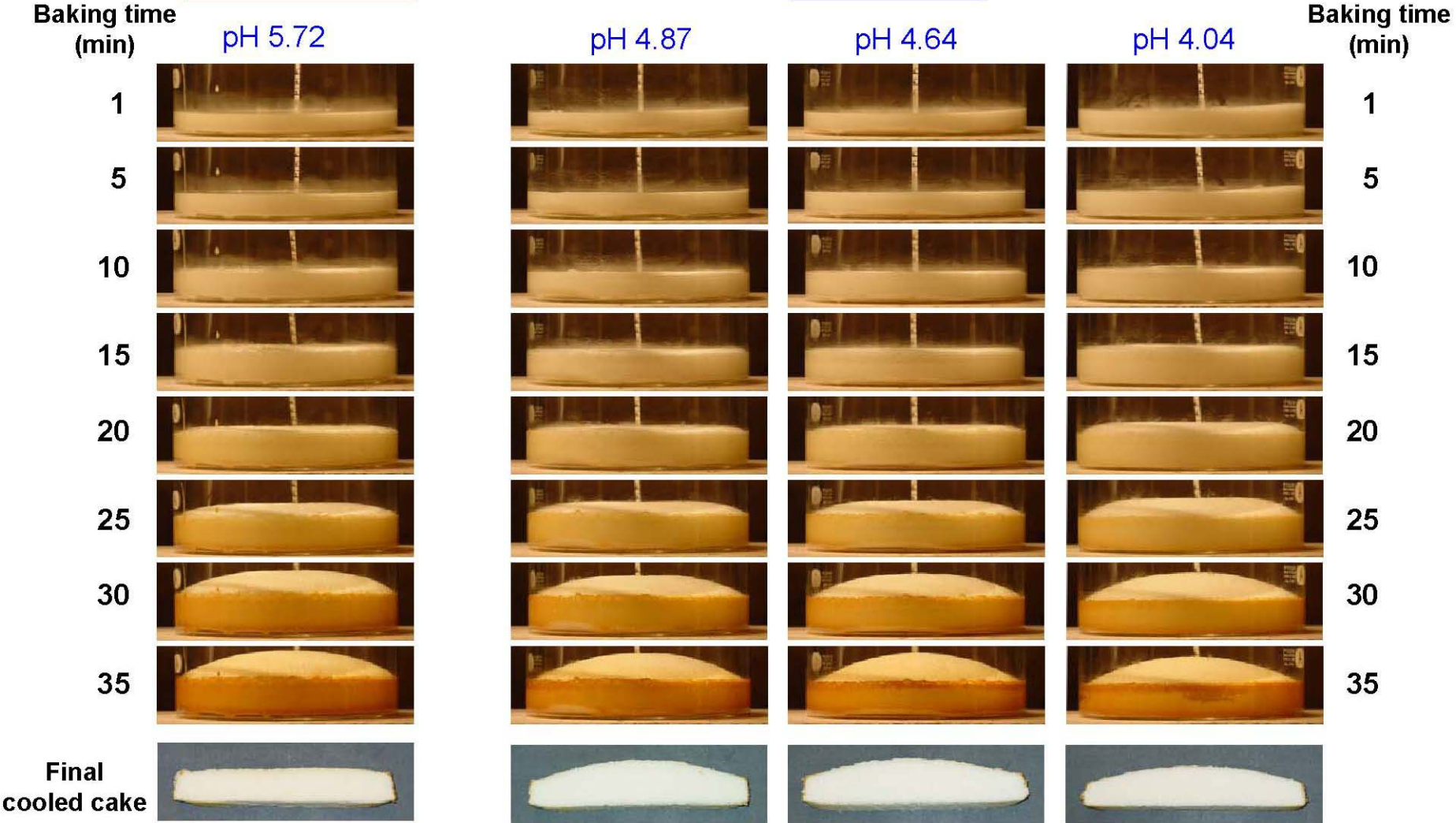


Cross sections of final cooled cakes show dramatic collapse for unchlorinated flour

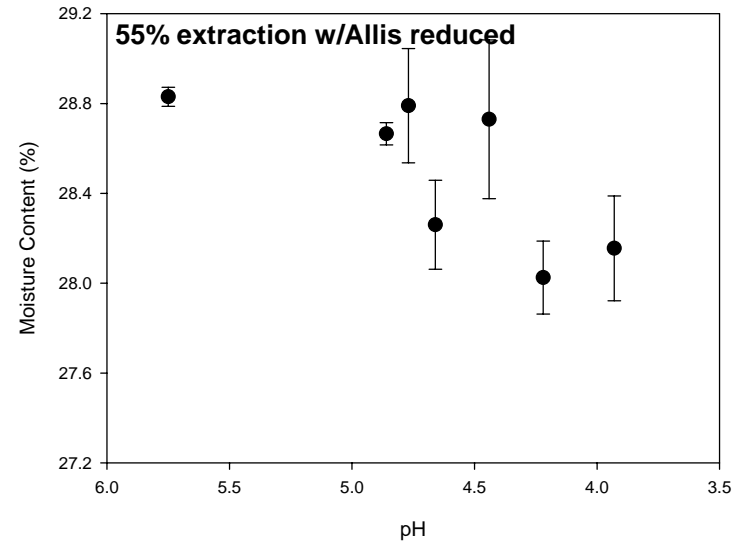
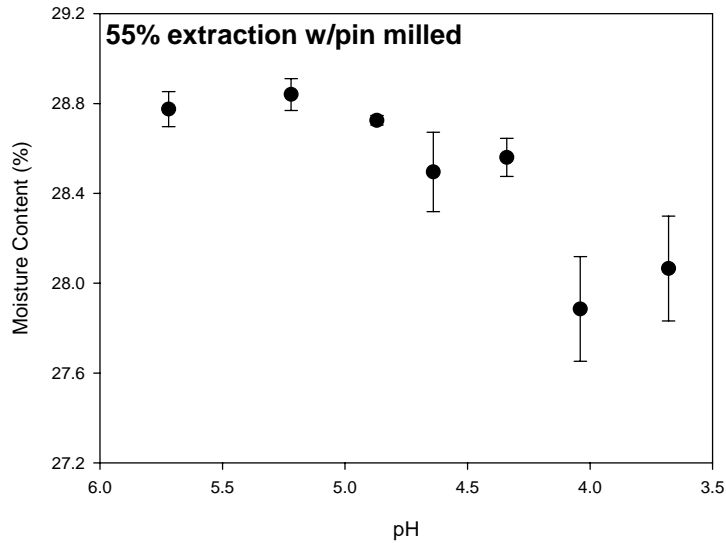
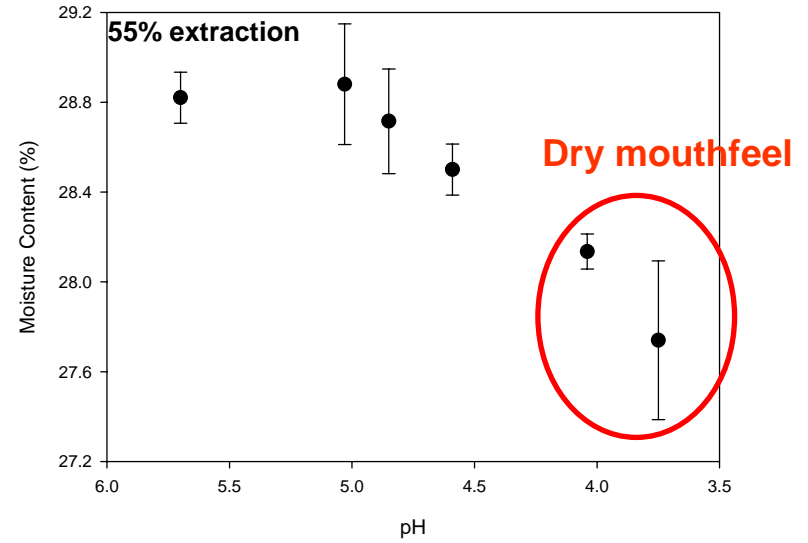
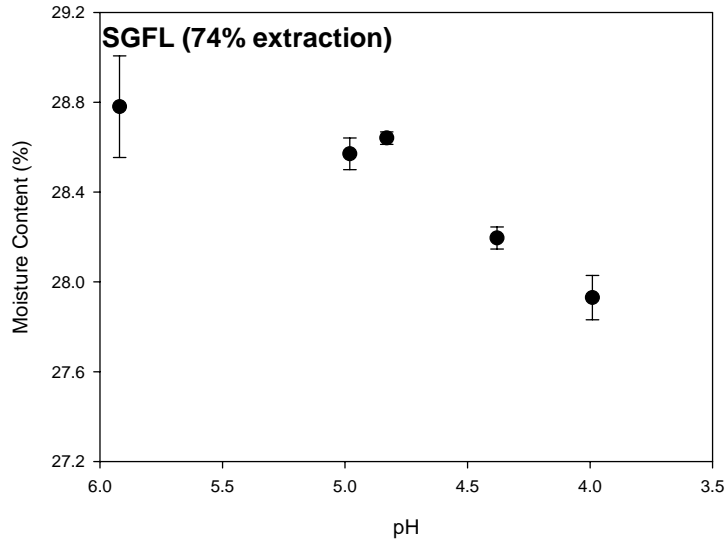
Time Lapse Photography for cake baking with 55% extraction w/pin milled flour

Unchlorinated

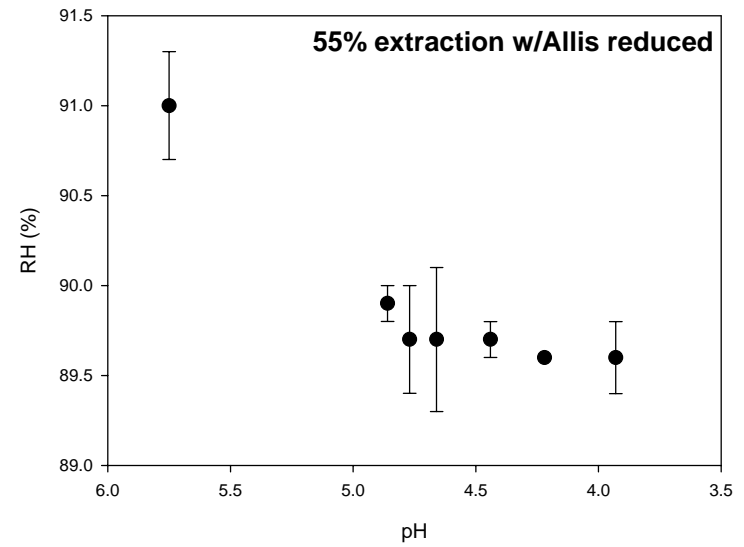
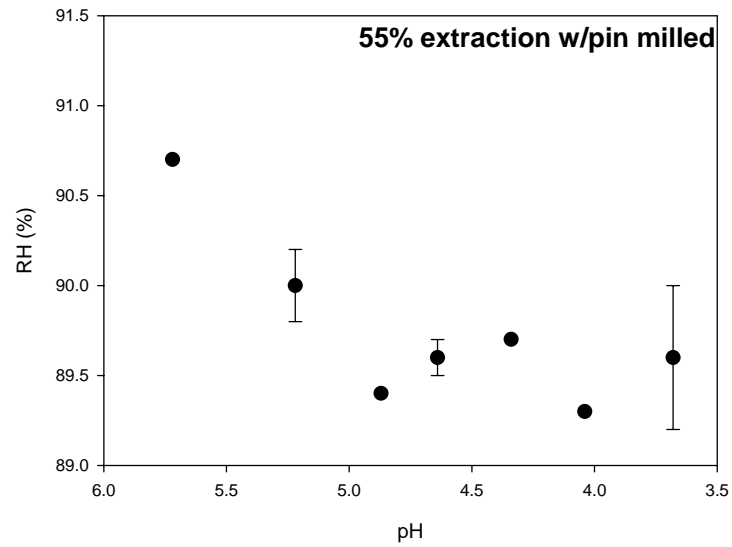
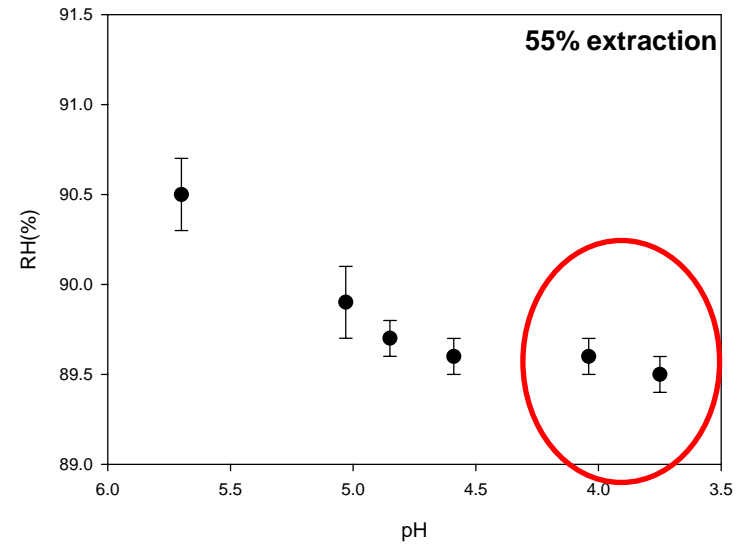
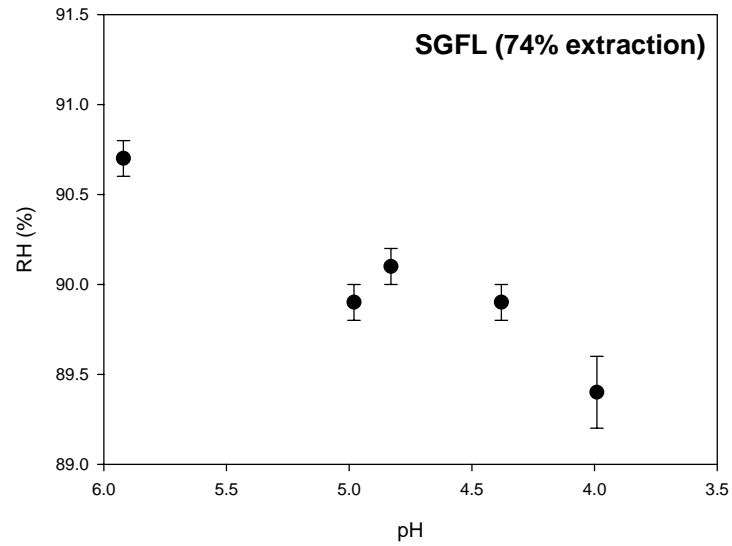
Chlorinated



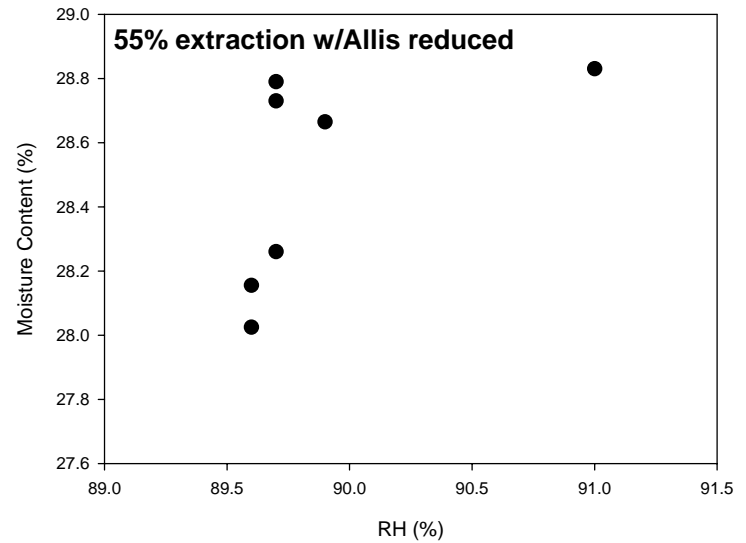
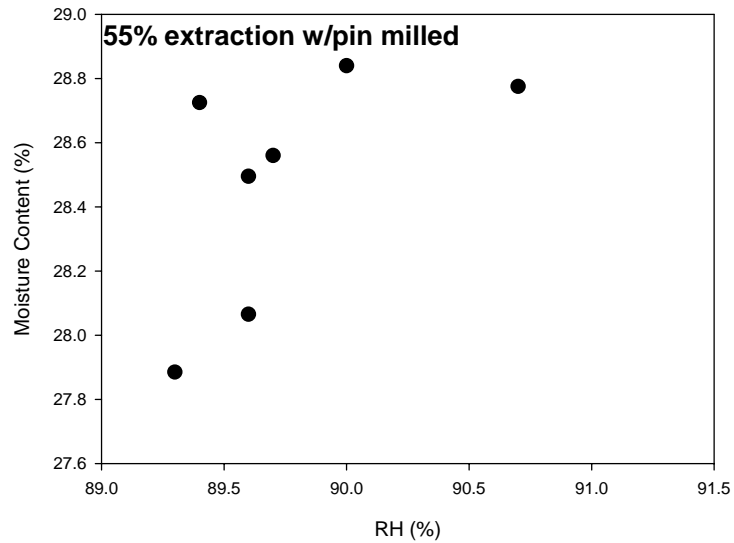
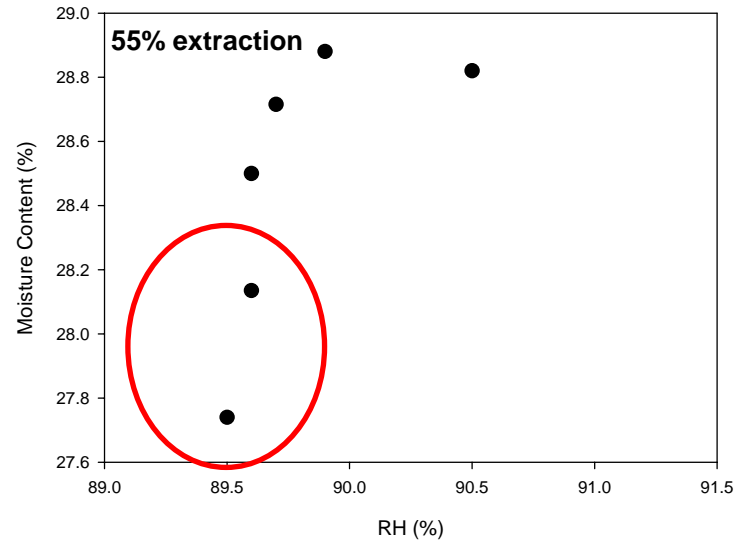
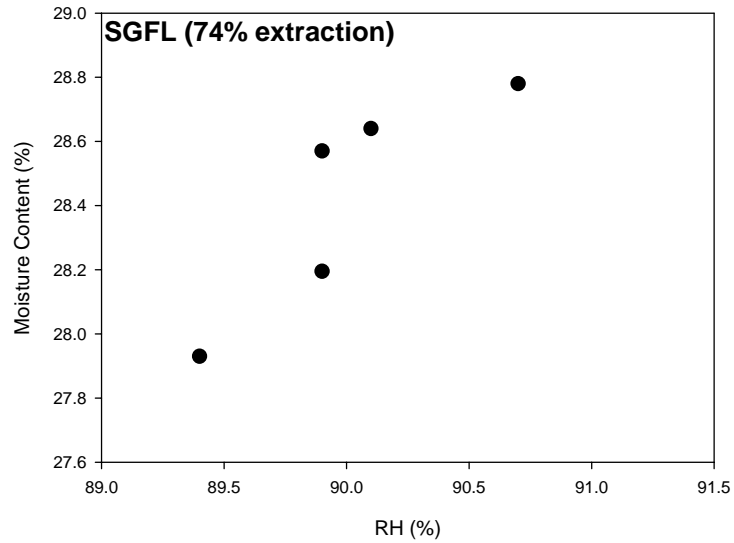
Moisture content of cake (calculated from weight loss during baking)



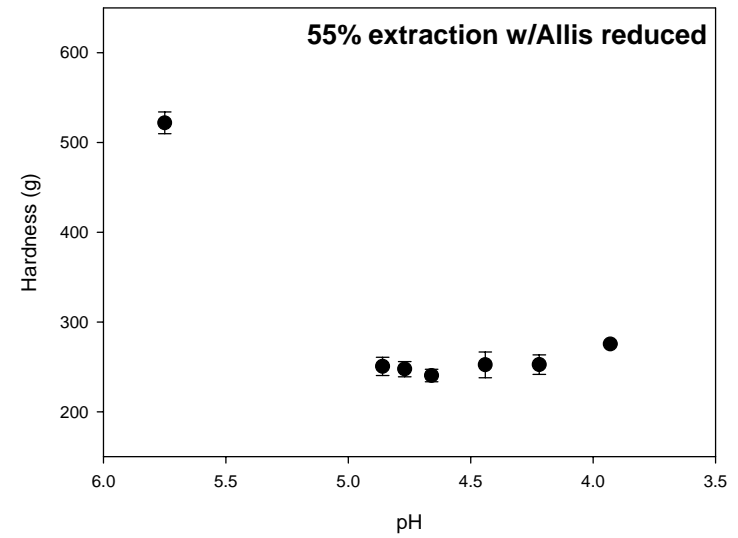
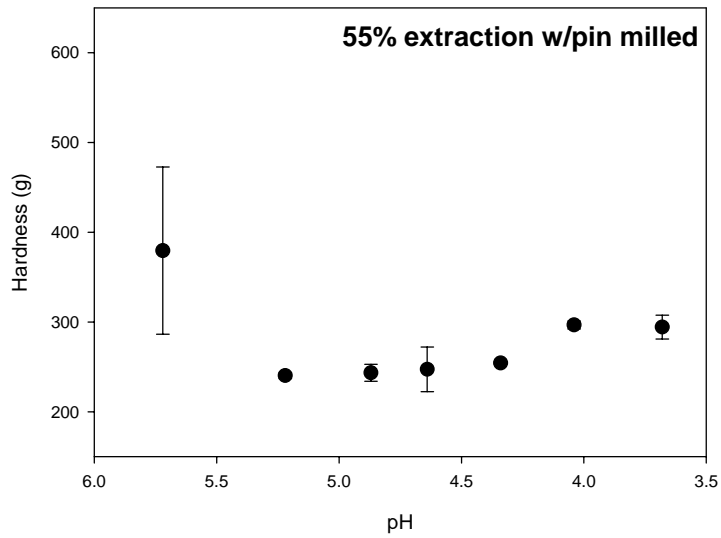
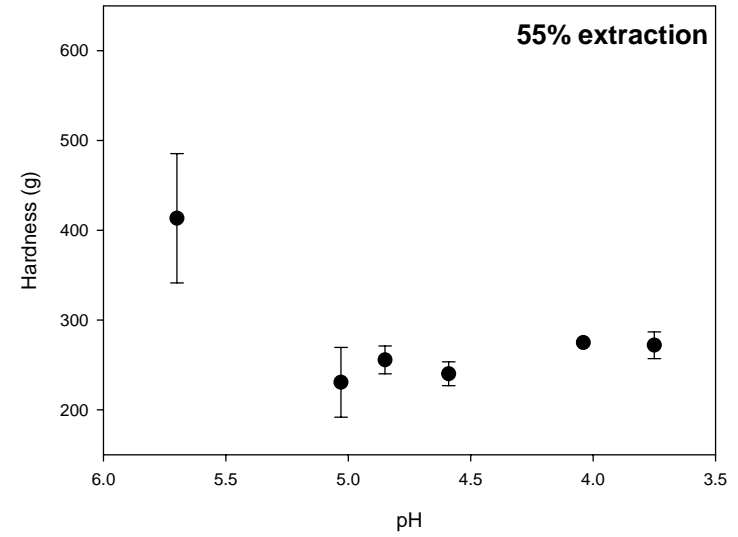
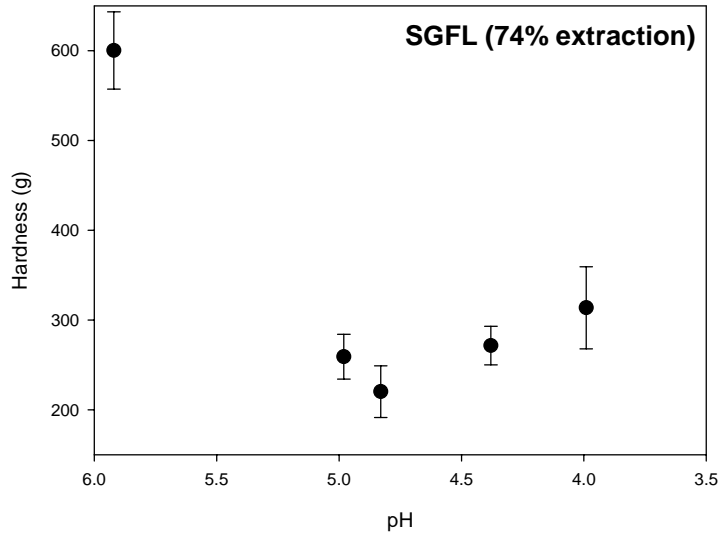
RH % of cake



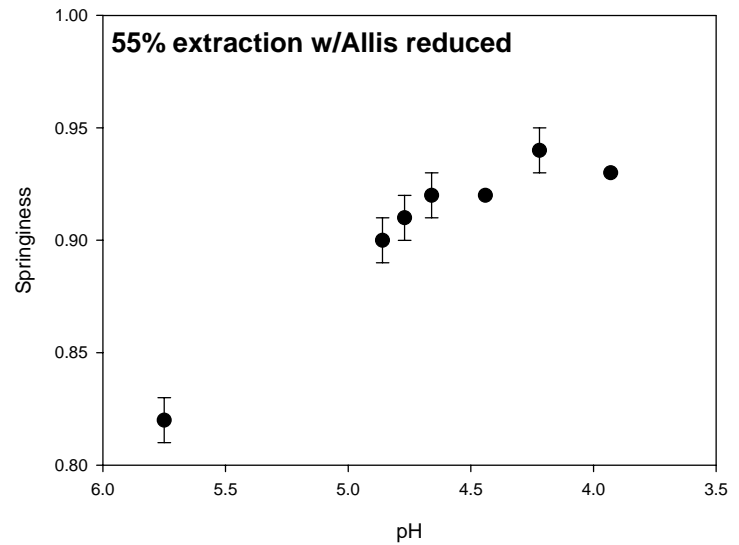
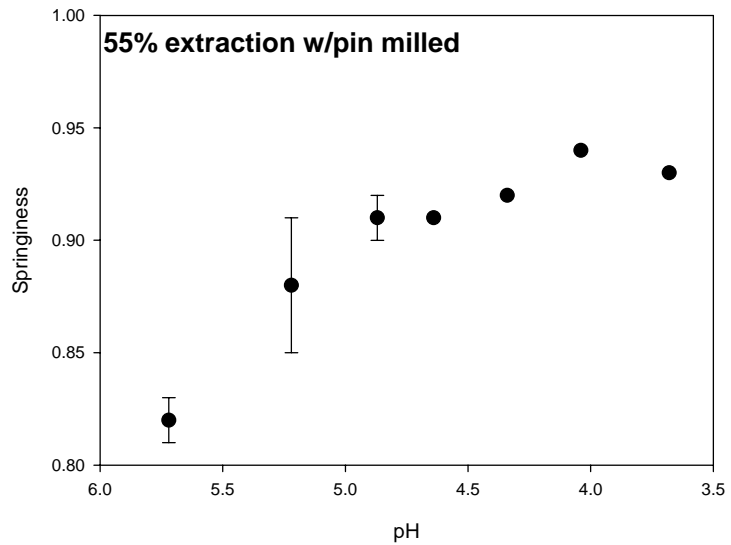
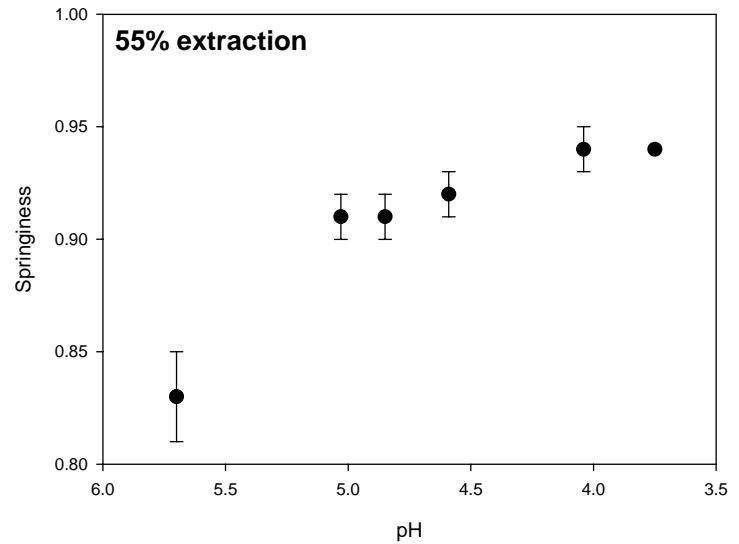
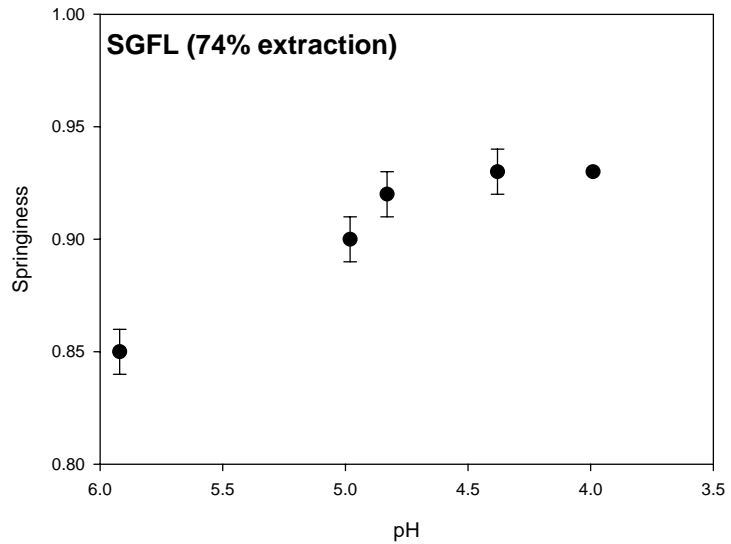
Moisture content vs RH % of cake



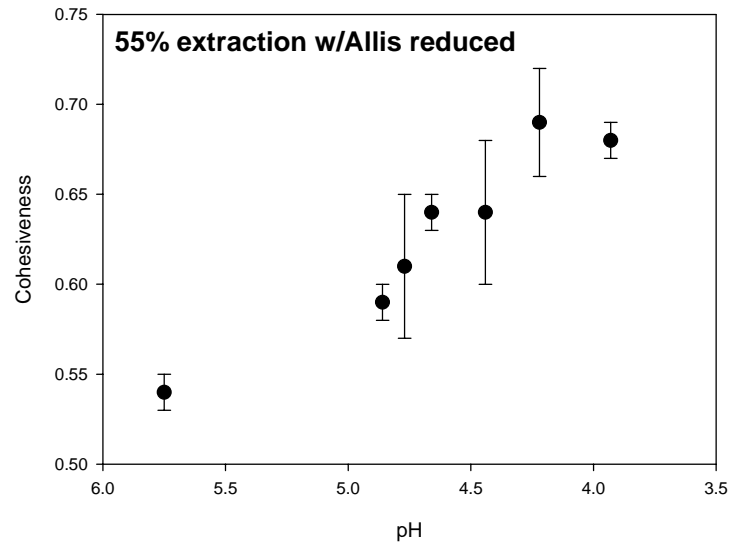
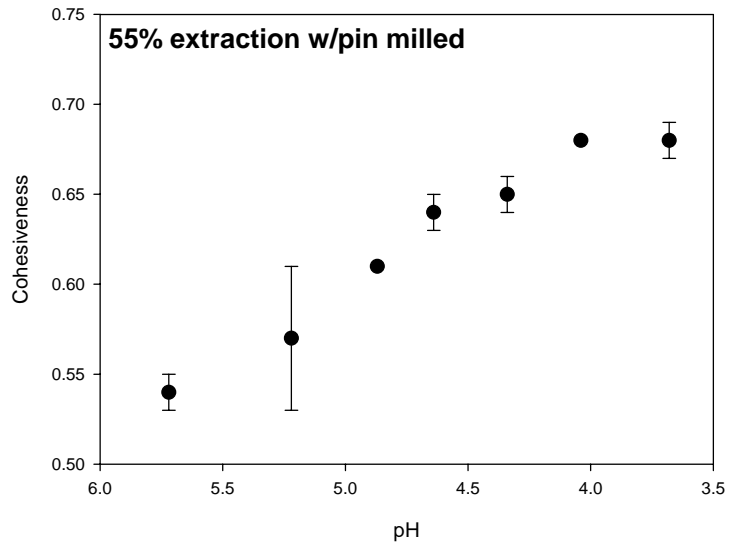
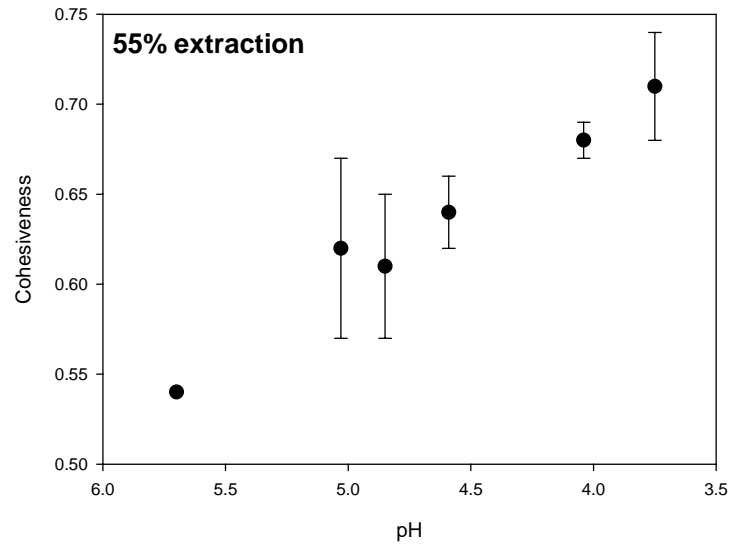
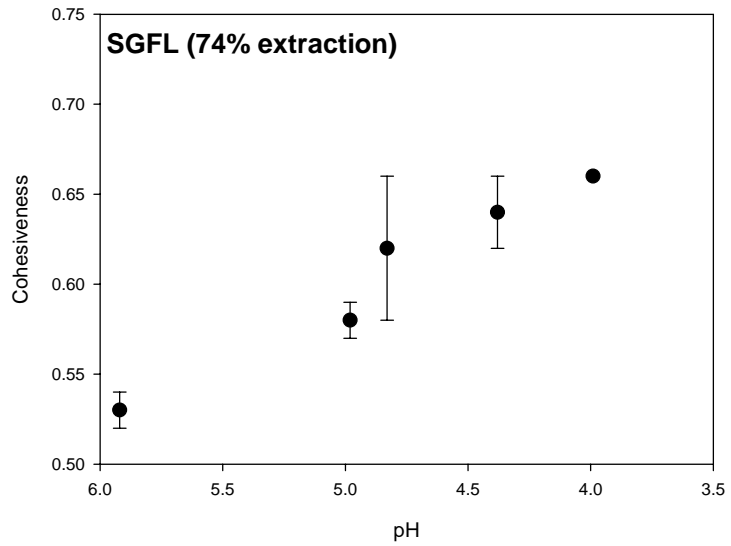
Hardness of cake by TAXT2



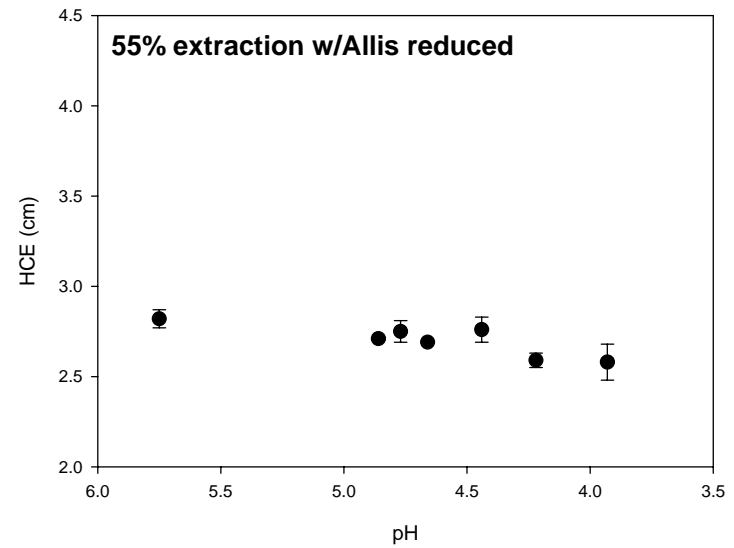
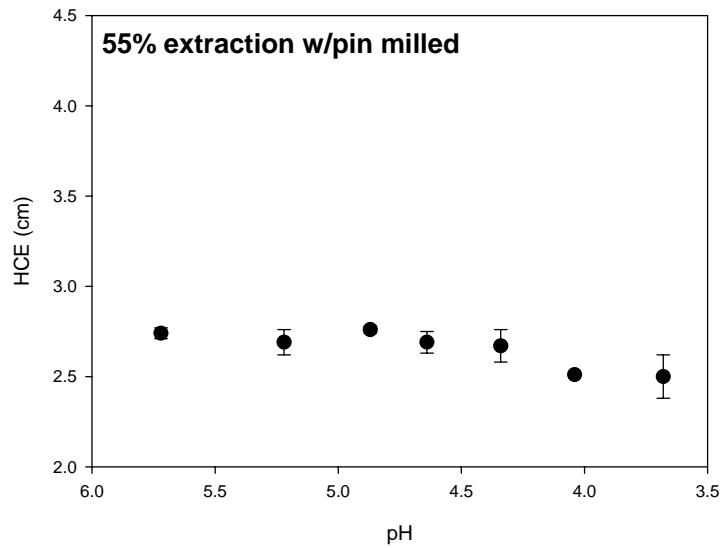
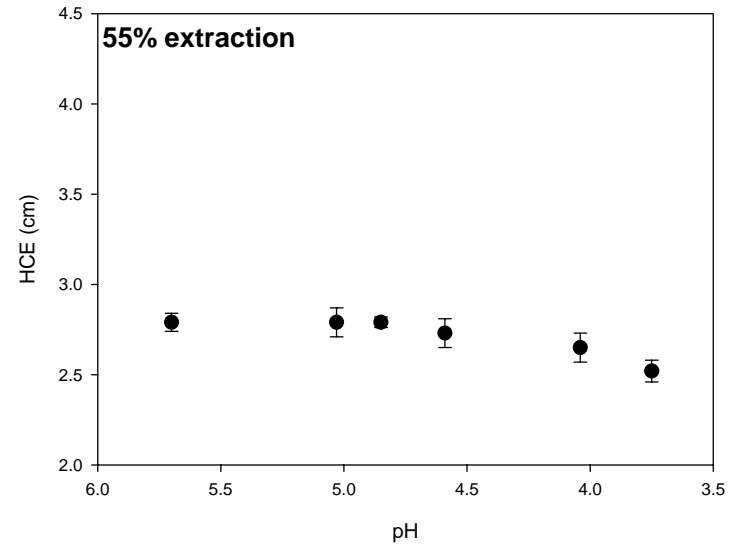
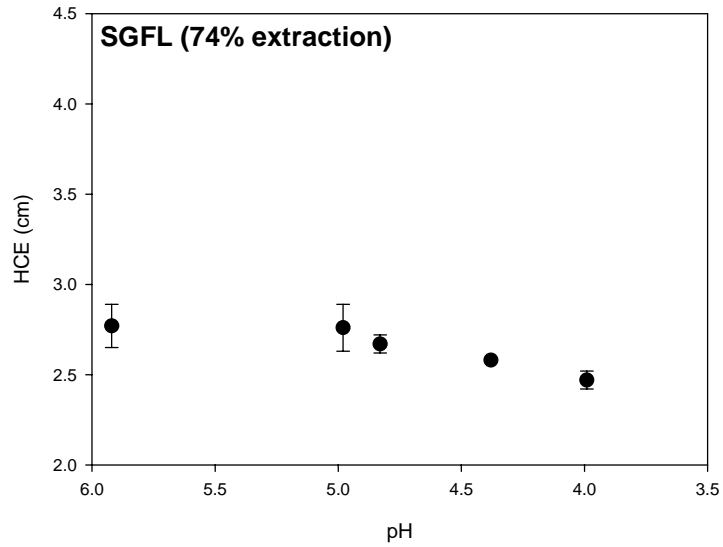
Springiness of cake by TAXT2



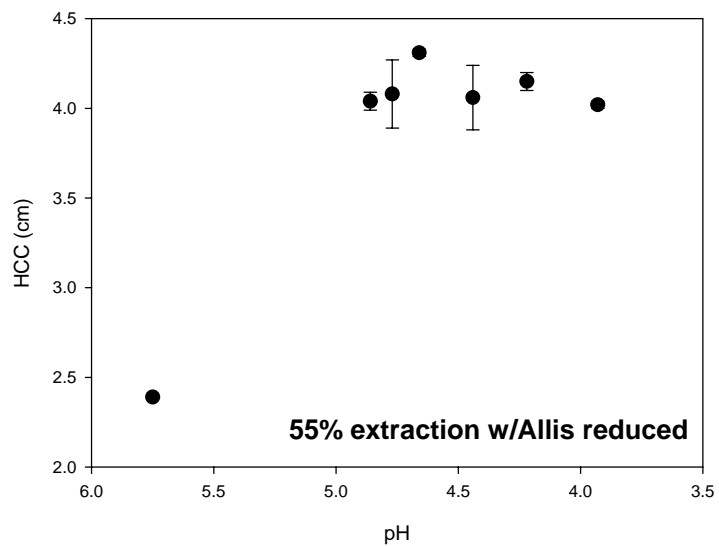
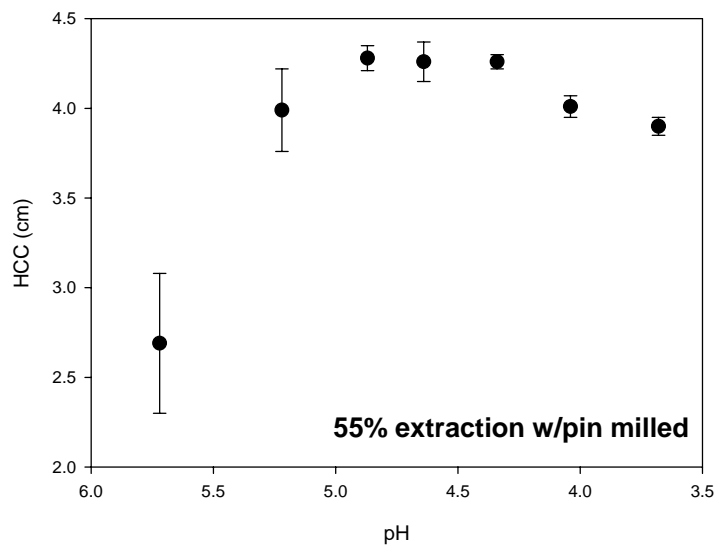
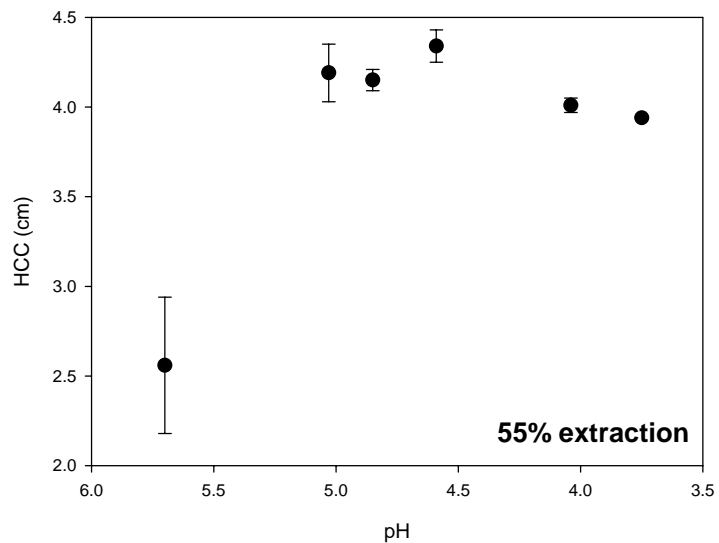
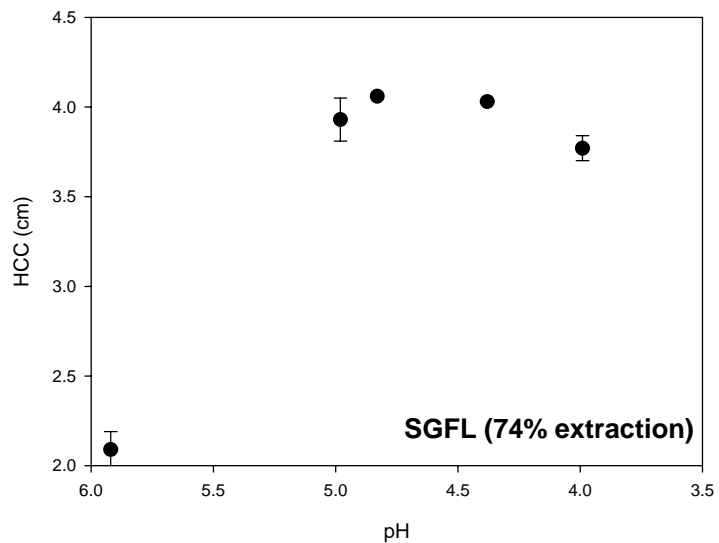
Cohesiveness of cake by TAXT2



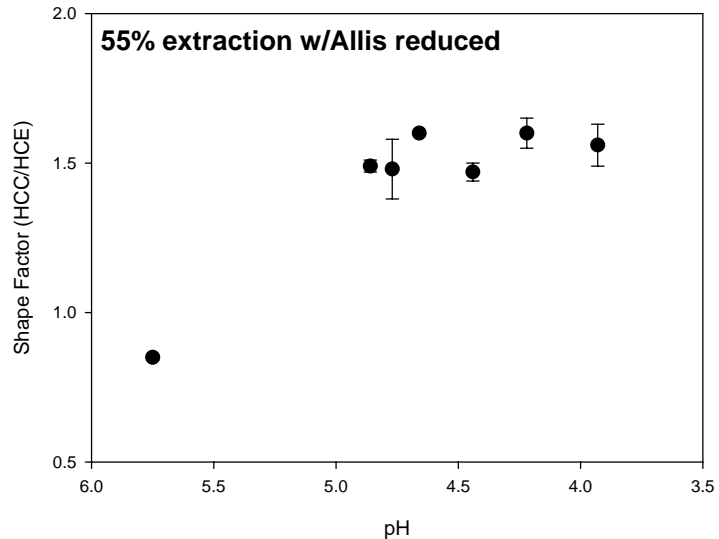
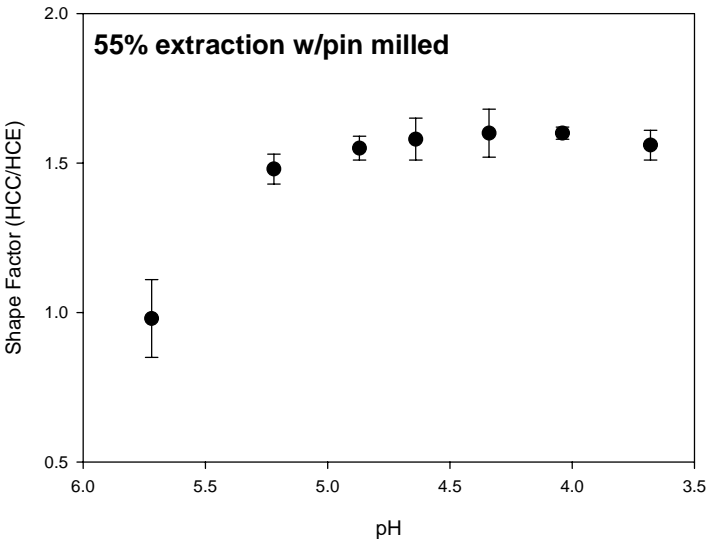
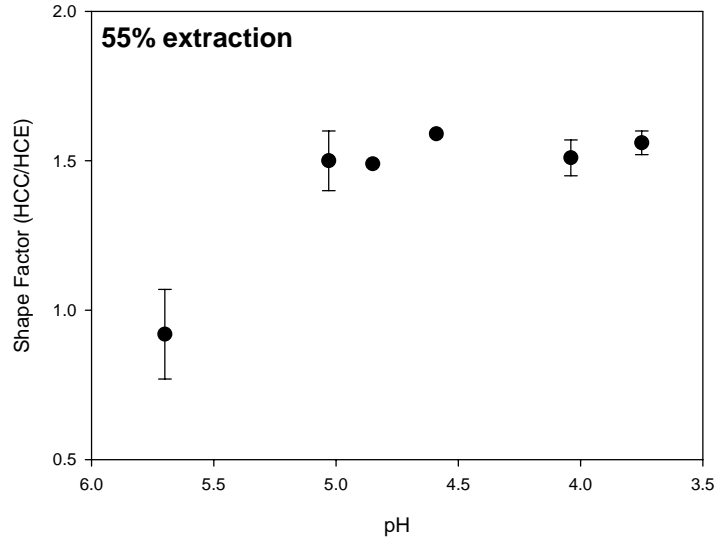
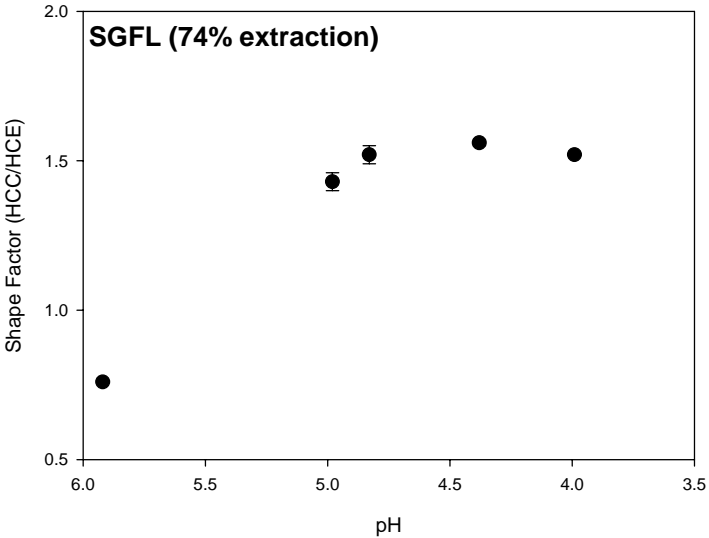
Height of cake edge (HCE)



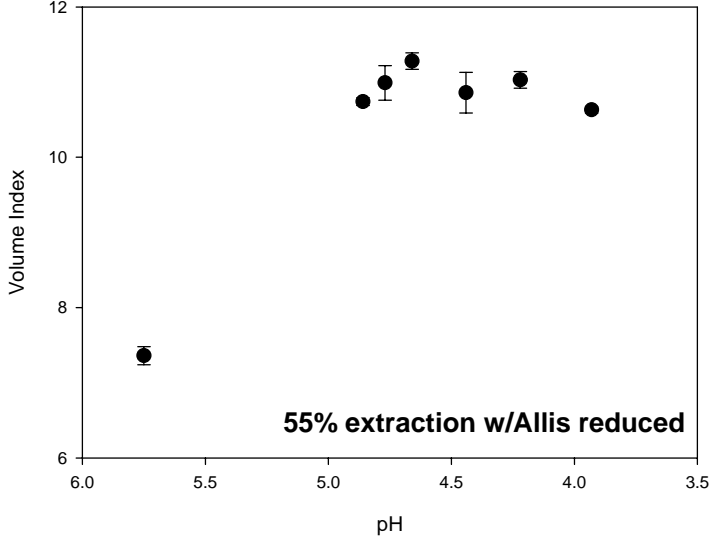
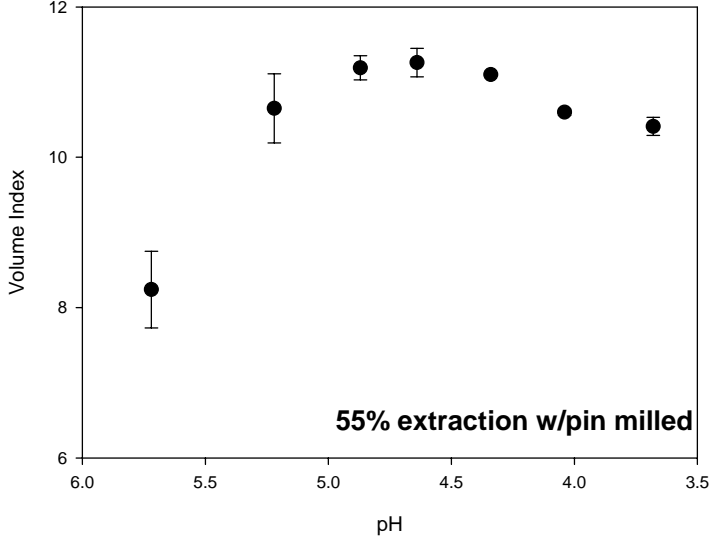
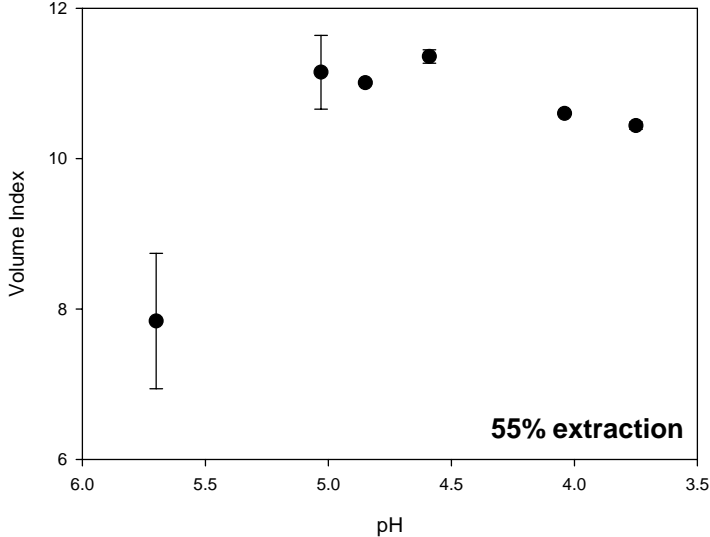
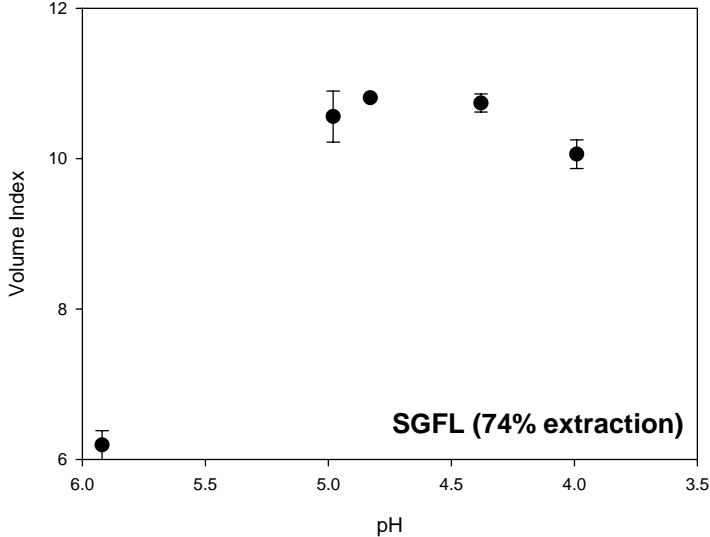
Height of cake center (HCC)



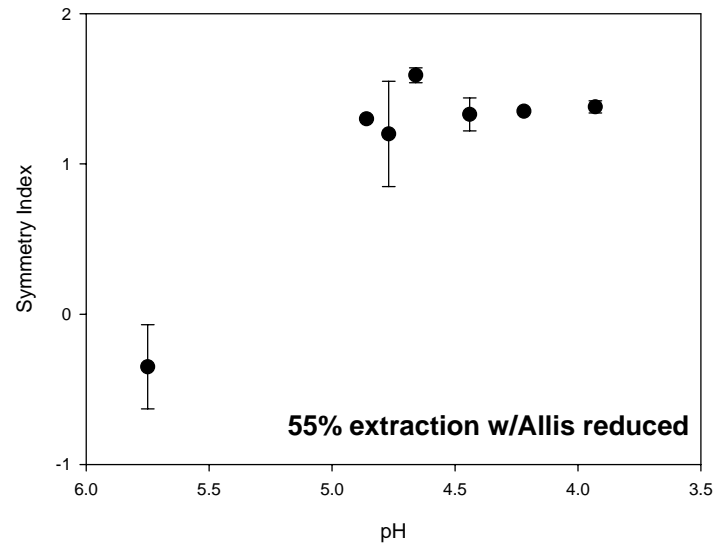
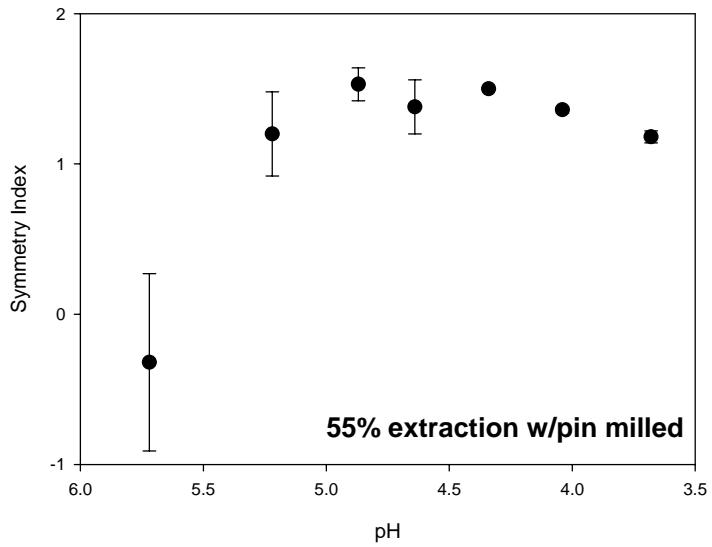
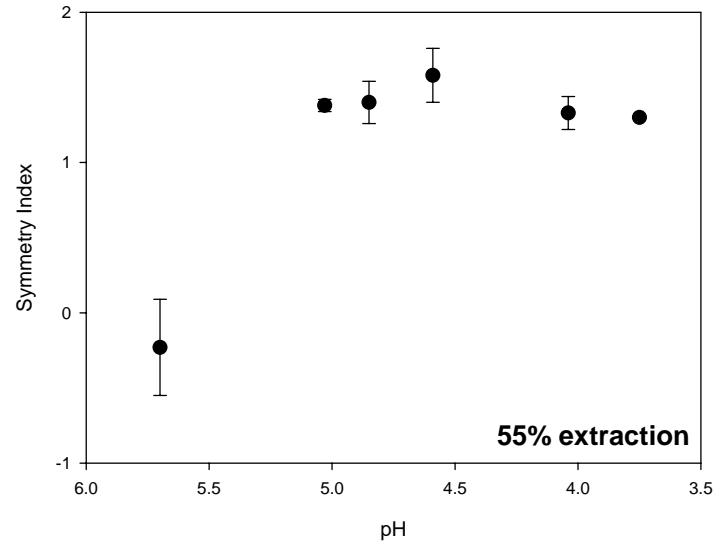
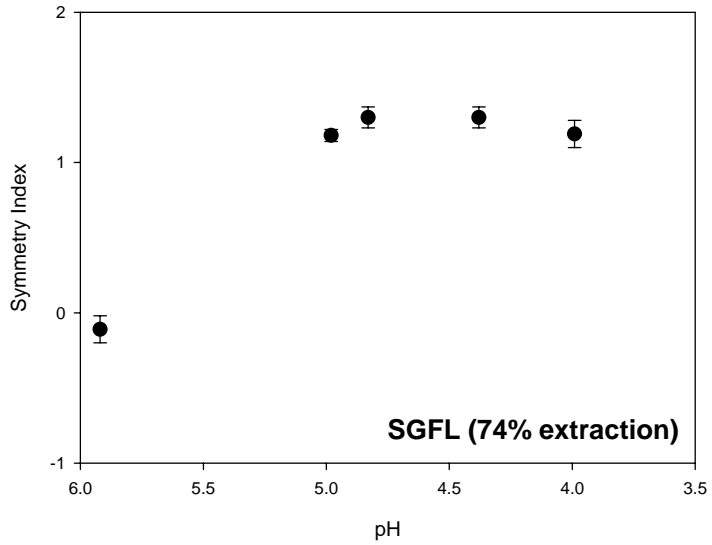
Cake shape factor (HCC/HCE)



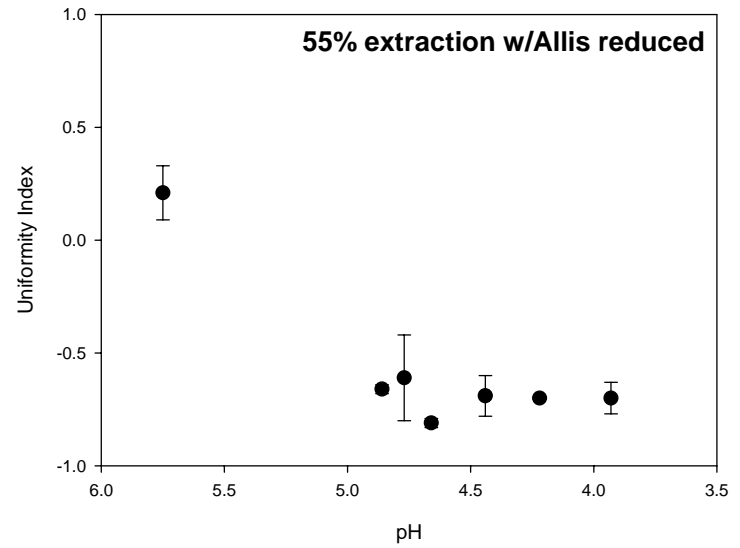
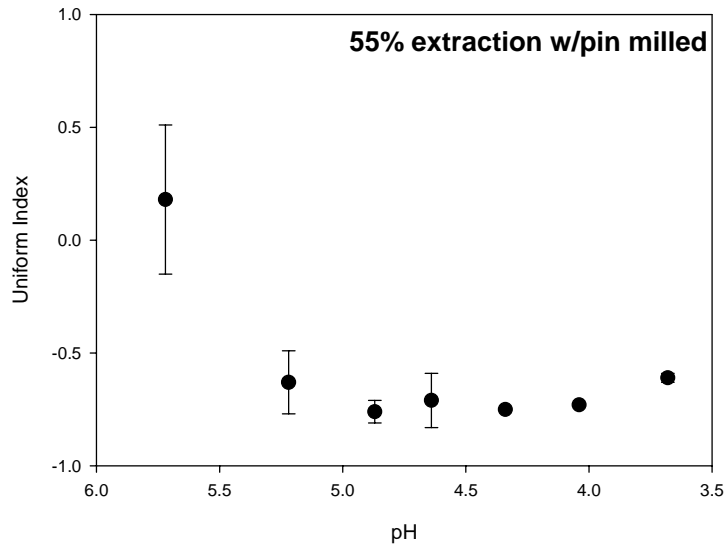
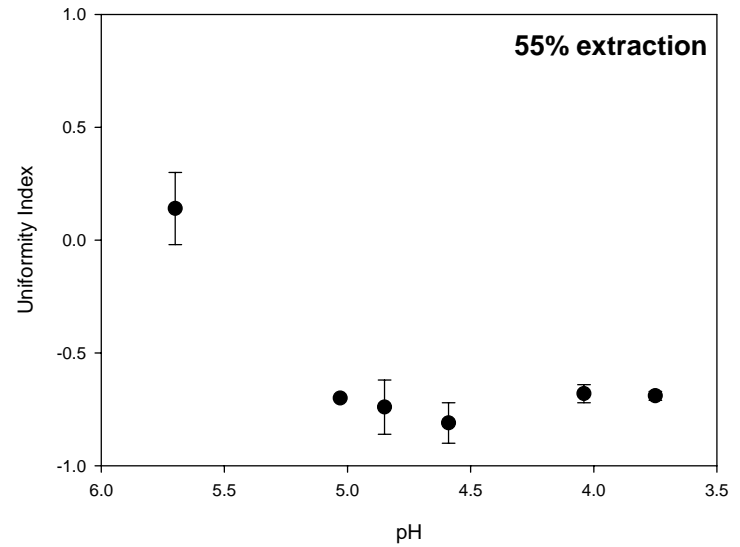
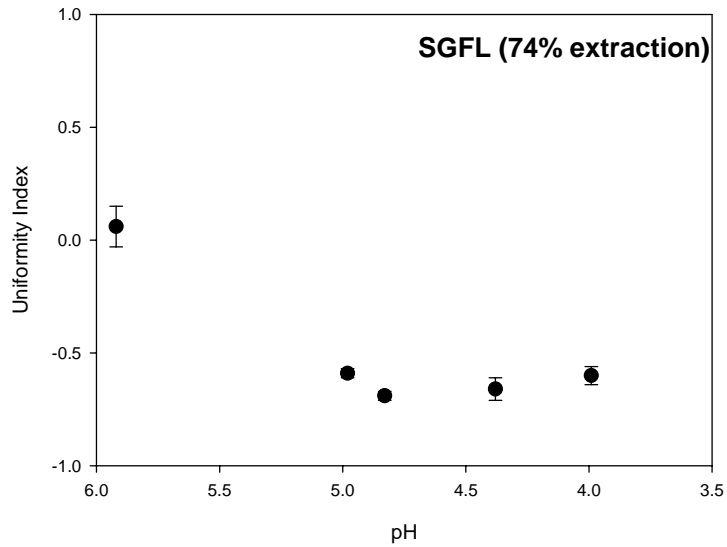
Volume index



Symmetry index



Uniformity index





Conclusions

- Three factors were explored by SRC, DSC, RVA, and cake baking. Milling extraction rate and chlorination extent showed dramatic effects, but additional milling to reduce particle size was a less significant factor
- SRC showed increases in water, sodium carbonate, and sucrose SRC values, but a decrease in lactic acid SRC values with increasing extent of chlorination.
- DSC showed that chlorination did not affect starch gelatinization in water and 50% sucrose regardless of extraction rate and particle size, until the extent of chlorination was sufficient to decrease flour pH to ~4.6 or below, where a slight increase in gelatinization temperature was observed.
- RVA showed that chlorination had a large effect on starch pasting. Starch pasting occurred earlier, and both peak viscosity and set-back viscosity were increased, with increasing extent of chlorination. The effects of extent of chlorination were dramatic in high sugar concentrations relevant to cake baking, such as 50% sucrose, compared to the effects in water.

Conclusions (cont'd)

- Cake baking with chlorinated flours, 50%S, and 275 TS showed that:
 - As the extent of the chlorination increased, moisture loss during baking increased and cake edge height decreased. Cake center height and shape factor were curvilinear with a maximum near pH 4.6.
 - Collapse occurred dramatically for cakes baked with unchlorinated flour samples due to delayed starch pasting, as documented by time-lapse photography, and comparison to the geometry of the final cooled cakes.
 - Starch pasting and egg white setting occurred too early for the cakes with excessively chlorinated flour (\leq pH 4.0), but too late for the cakes with unchlorinated or insufficiently chlorinated flour (\geq pH 4.9), compared to the ideal performance with appropriately chlorinated flours (below pH 4.9 and above pH 4.0). The effects of extent of chlorination showed the impact of starch pasting on collapse.
- Cake texture:
 - Sensory mouthfeel was related to cake moisture content and the relationship between moisture content and RH. Excessive chlorination resulted in unacceptably dry mouthfeel.
 - The effects of extent of chlorination showed the impact of gluten strength on cake hardness. (in addition to the effects of cake volume and moisture content). Lower values of SRC lactic acid were linked to lower cake hardness. Chlorination and the increased values of SRC sucrose may be related to increased cake springiness and cohesiveness.



Acknowledgements

- Lonnie Andrews
- Ron Martin
- Tom Donelson
- Ed Souza
- Louise Slade
- Harry Levine
- CJ Lin
- Gang Guo

