Update on baking research at SWQL

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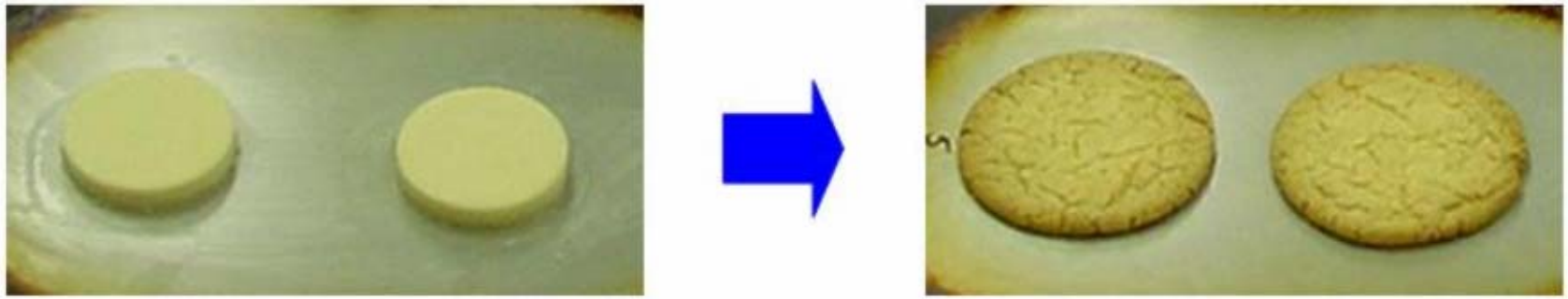
Objectives of the baking projects

- Cookie – Revise the current AACC macro and micro sugar-snap cookie methods
- Cake – Revise the current AACC cake baking method to improve leavening system and to replace hydrogenated shortening by zero-trans oil
- Cracker – Develop a bench-top baking method to predict contribution of gluten functionality to flour performance for chemically-leavened crackers

Sugar-Snap Cookie Baking



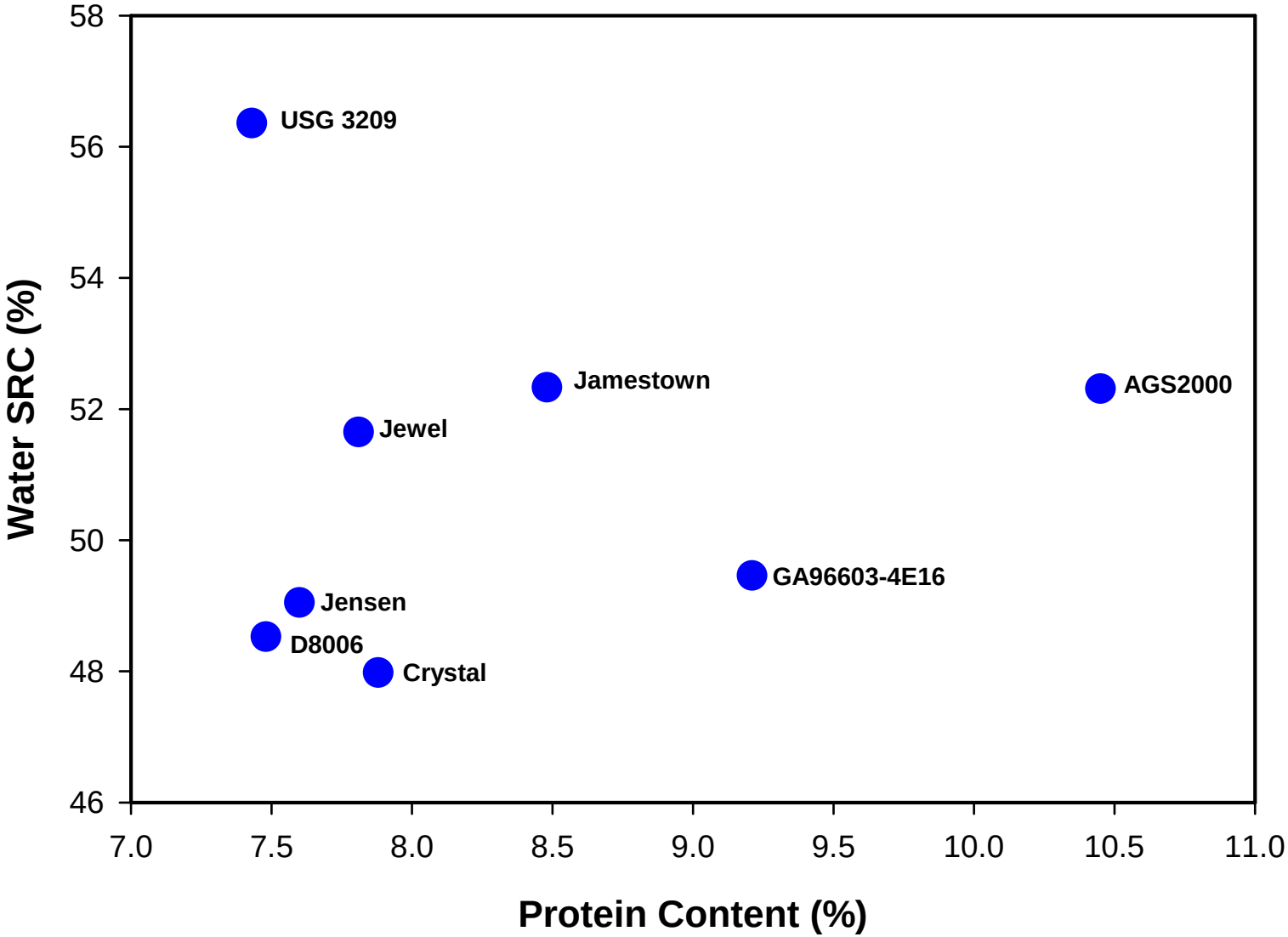
Why do the AACC methods need revision?

- Differences in the formulas of current macro and micro sugar-snap methods in sugar concentration, total solvent, and leavening system
- Water adjustment based on flour protein in the current micro AACC 10-52 sugar-snap cookie baking method
- Different modifications of cookie baking methods across labs

SRC values of the flour samples used for the sugar-snap cookie baking collaborative

Cultivar	State	Moisture	Protein	SRC			
				Water	LA	SC	Suc
AGS 2000	GA	14.1	10.5	52.31	106.84	67.42	100.87
GA96603-4E16	GA	14.2	9.2	49.46	113.58	64.23	92.11
USG 3209	VA	14.3	7.4	56.36	98.10	76.06	108.79
Jamestown	VA	14.1	8.5	52.33	99.68	66.41	95.99
Jensen	NY	14.5	7.6	49.05	81.26	63.77	85.96
D8006	MI	14.7	7.5	48.53	97.73	63.17	81.87
Crystal	MI	14.3	7.9	47.98	91.06	60.38	81.25
Jewel	MI	14.2	7.8	51.65	103.26	64.91	89.41

Water absorption vs total protein content of flour



Ingredients and formulas for sugar-snap cookie baking trials

Ingredients	Weights (g)				
	Scaled Macro AACC 10-50D	Micro AACC 10-52	Modified 1	Modified 2	Modified 3
Flour	40.0	40	40	40	40
Sucrose	23.1	24	24	24	24
Nonfat dry milk		1.2	1.2	1.2	1.2
NaCl	0.18				0.18
NaCl (in soln B)		0.18	0.18	0.18	
Sodium bicarbonate	0.44	0.40	0.40	0.40	0.40
Sodium bicarbonate (in soln A)		0.32 (in 4 mL)	0.32 (in 4 mL)	0.32 (in 4 mL)	
Ammonium chloride (in soln B)		0.20 (in 2 mL)	0.20 (in 2 mL)	0.20 (in 2 mL)	
Shortening	11.4	12.0	12.0	12.0	12.0
Dextrose solution	5.87 (5.55 g water)				
Added water	2.84	0.7-1.1	4.0	2.7	8.7
Total water	8.4	6.7-7.1	10.0	8.7	8.7
Calculated TS	78.7	76.8-77.8	85.0	81.8	81.8
Calculated % S	73.4	77.2-78.2	70.6	73.4	73.4

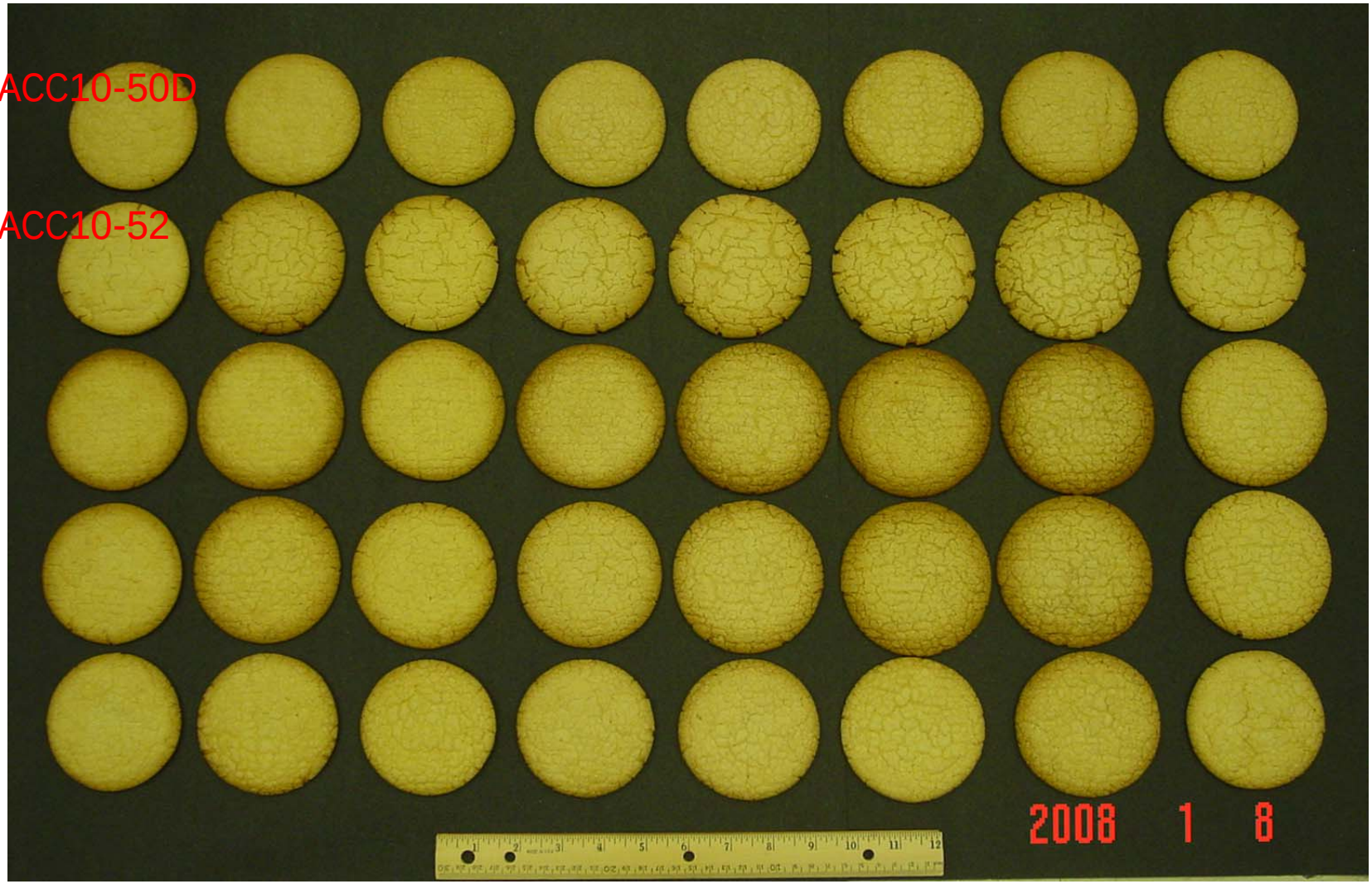
Cookie photos (SWQL)

Different flour samples

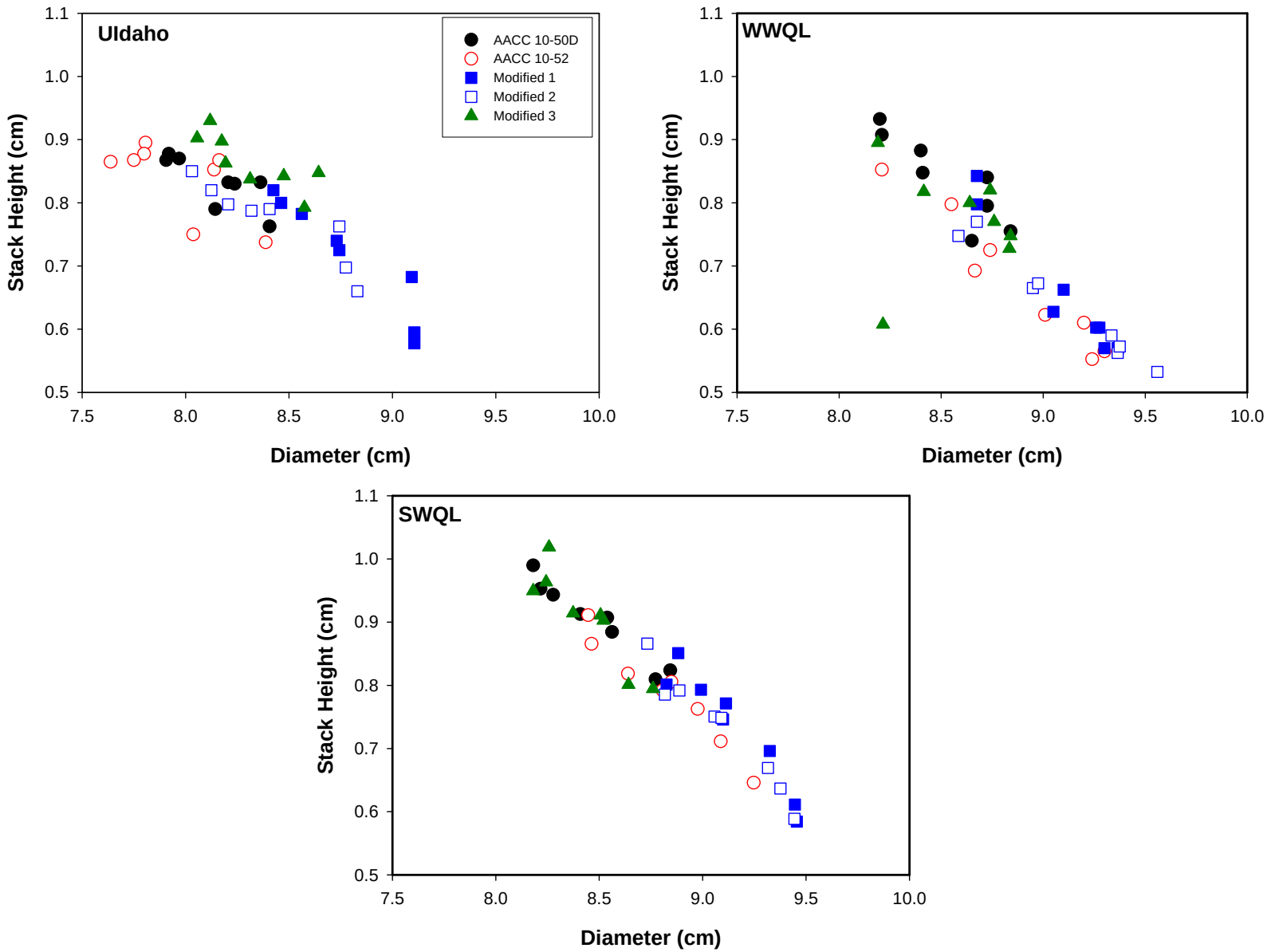
Different baking methods

AACC10-50D

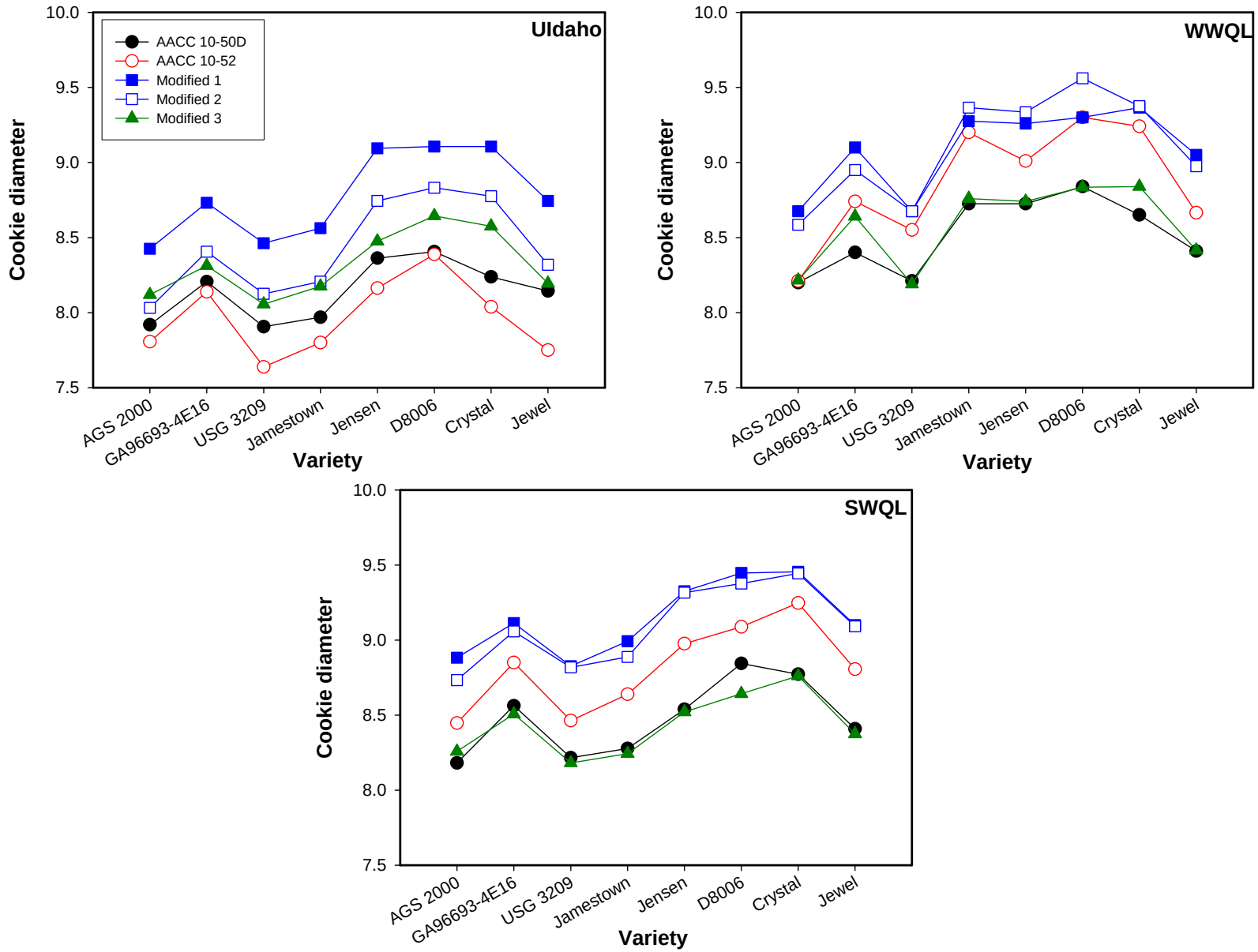
AACC10-52



Cookie diameter and stack height (three labs)



Cookie diameter and wheat varieties (three labs)

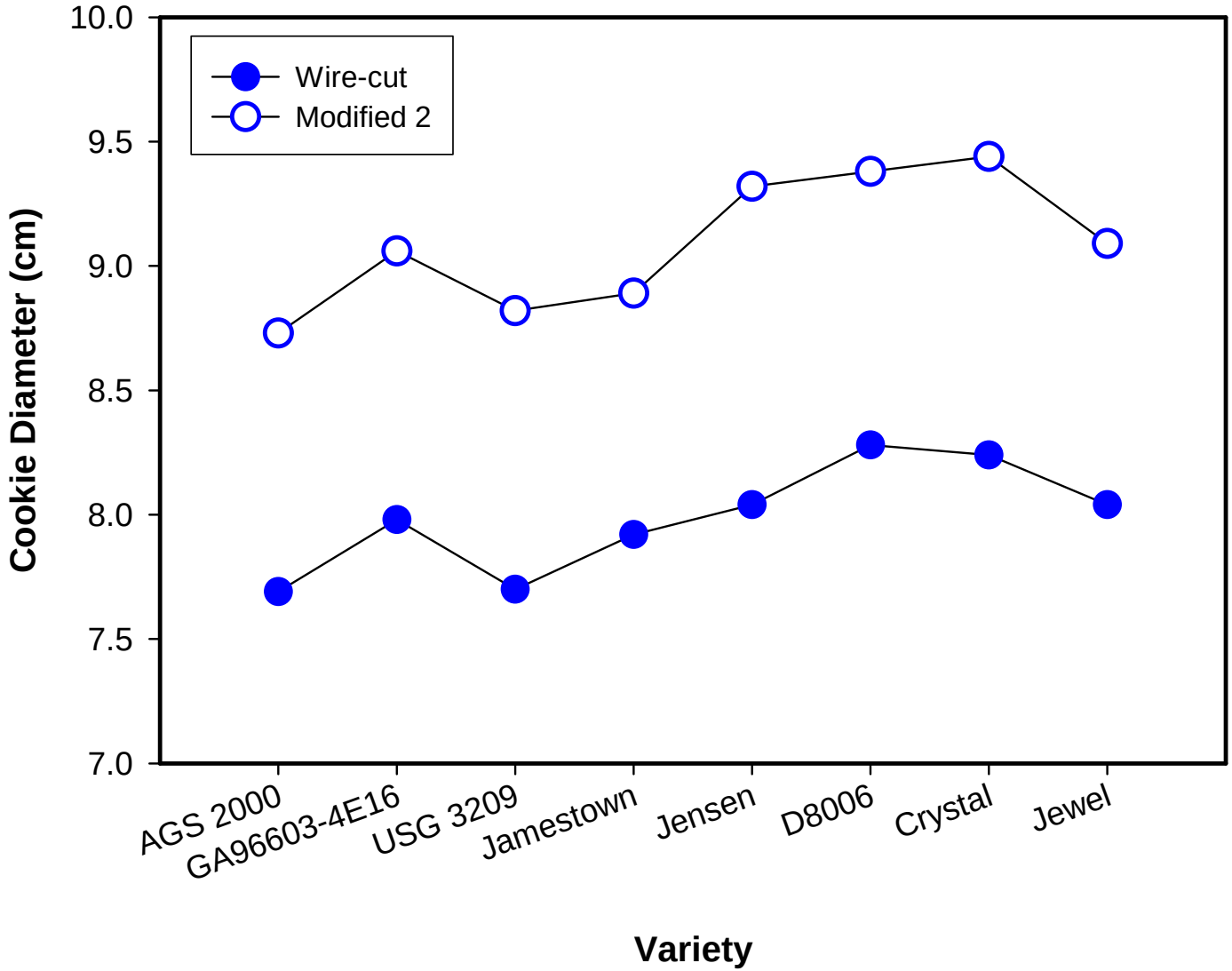


Ranking of cookie diameters for 8 cultivars

(Labs:1, UIdaho; 2, WWQL; 3, SWQL)

	Macro AACC 10-50D			Micro AACC 10-52			Modified 1			Modified 2			Modified 3		
	Lab 1	Lab 2	Lab 3	Lab 1	Lab 2	Lab 3	Lab 1	Lab 2	Lab 3	Lab 1	Lab 2	Lab 3	Lab 1	Lab 2	Lab 3
AGS 2000	7	8	8	5	8	8	8	8	7	8	8	8	7	7	6
GA96693-4E16	4	6	3	3	6	4	5	5	4	4	6	5	4	5	4
USG 3209	8	7	7	8	7	7	7	7	8	7	7	7	8	8	8
Jamestown	6	3	6	6	3	6	6	3	6	6	3	6	6	3	7
Jensen	2	2	4	2	4	3	3	4	3	3	4	3	3	4	3
D8006	1	1	1	1	2	2	2	2	2	1	1	2	1	2	2
Crystal	3	4	2	4	1	1	1	1	1	2	2	1	2	1	1
Jewel	5	5	5	7	5	5	4	6	5	5	5	4	5	6	5

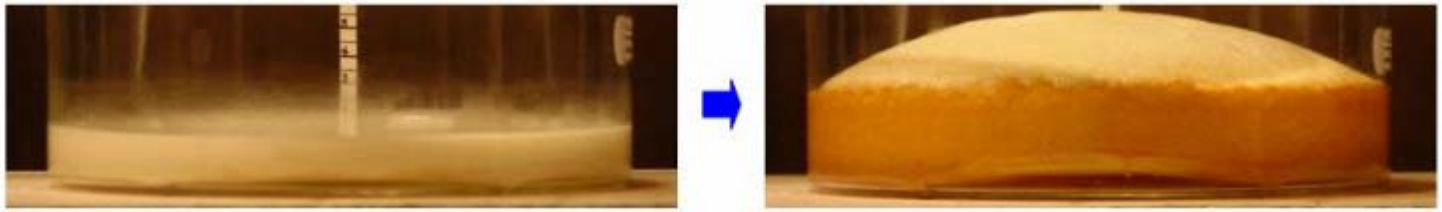
Wire-Cut and Modified 2 cookie baking methods



Conclusions

- The baking results in all labs for the current macro AACC 10-50D and micro AACC 10-52 sugar-snap cookie methods were very different with respect to cookie geometry, color, and pH.
- The baking results of the current macro AACC 10-50D and micro AACC 10-52 at high altitude (UIdaho) were not acceptable. The macro method resulted in very pale cookies with higher pH due to underbaking. The micro method resulted in ugly, non-uniform cookies, due to the higher sugar concentration.
- Among the five methods, Modified 2 was most acceptable in all three labs. Modified 2 will be evaluated further in a follow-up collaborative.

High-ratio cake baking



Why does the AACC method need revision?

- The current AACC Method 10-90
  - Requires multiple test bakes to select the formula water level for each flour, because the sugar level in the formula is held constant, but the water level is allowed to vary, in an attempt to improve cake geometry and texture
  - Creates hidden variation in the sugar-water solvent that controls gluten development and pentosan swelling during mixing, and gelatinization/pasting of starch and setting of egg white and whey proteins during baking
  - Impairs diagnostic evaluation of cake flour quality by the allowed ranges (49.1-52.8 %S and 265-285 TS)
- Reformulation from trans fat to zero-trans oil
  - Most of the baking industry has switched from trans fats to zero-trans oils, and now reformulation of the official baking method with zero-trans oil is needed by the industry.

Findings from the AACCI Collaborative in 2007

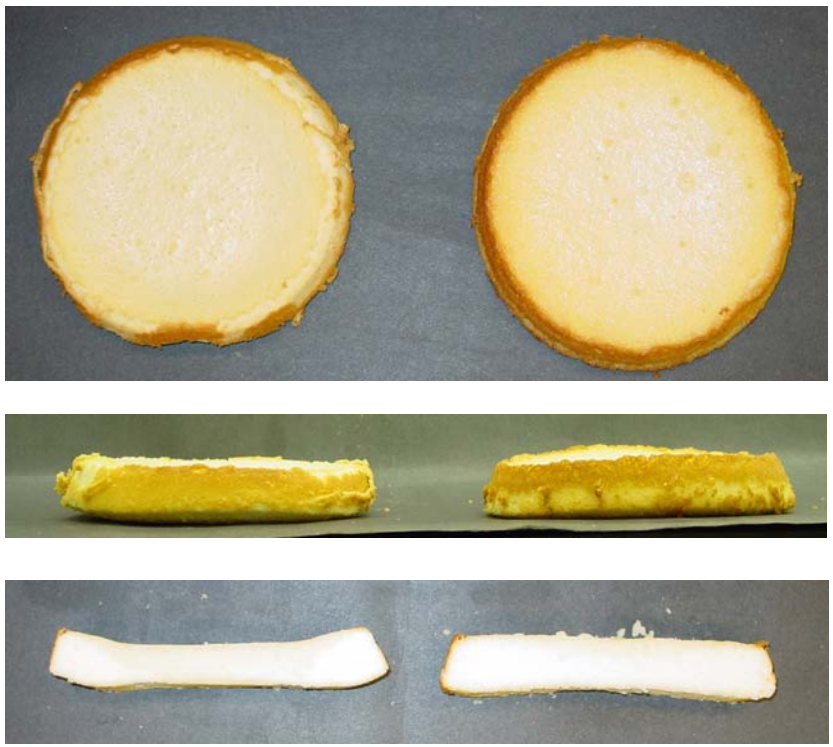
The AACC 10-90 cake baking method is too sensitive to:

- Fat type (trans/zero-trans fats and oils)
- Oven temperature variation
- Altitude

Effect of fat type on cake baking

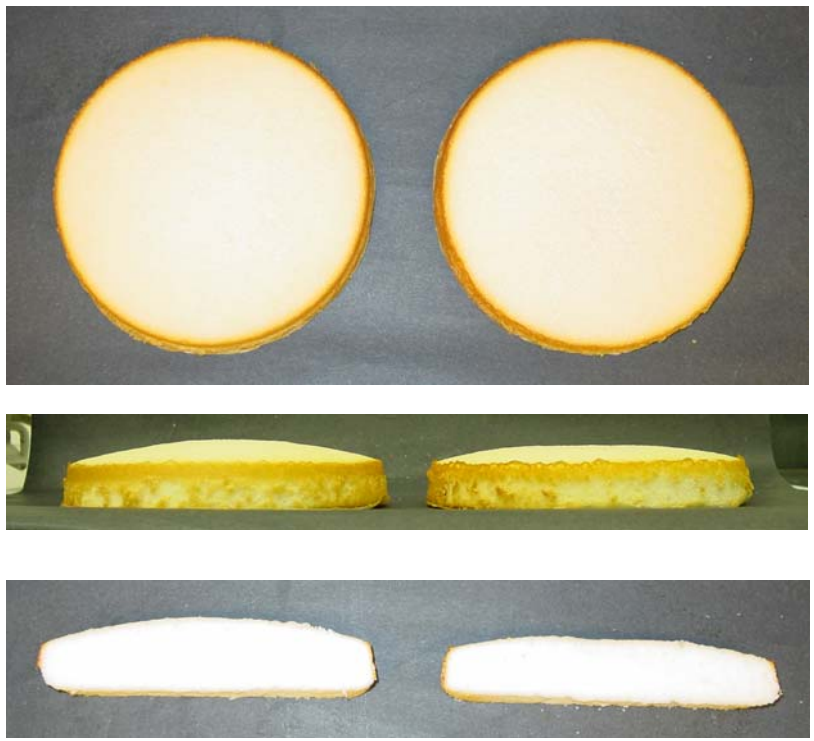
Unchlorinated flour

Trans fat | Zero-trans fat



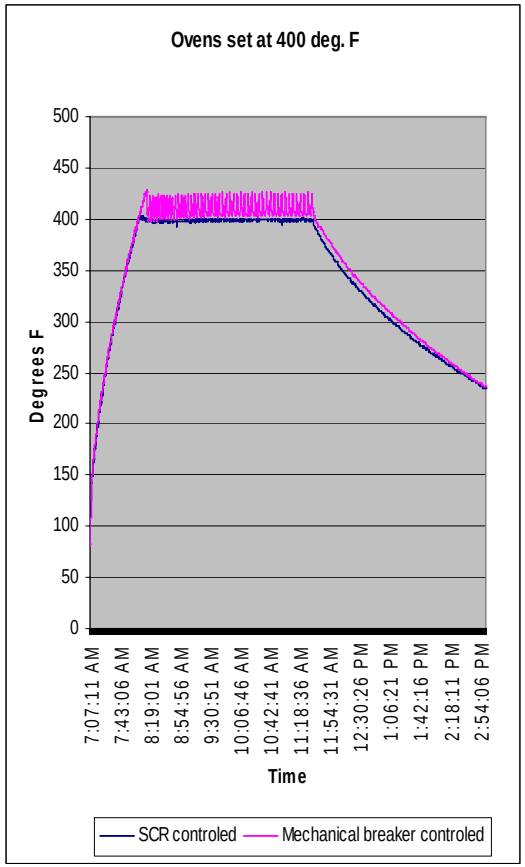
Chlorinated flour

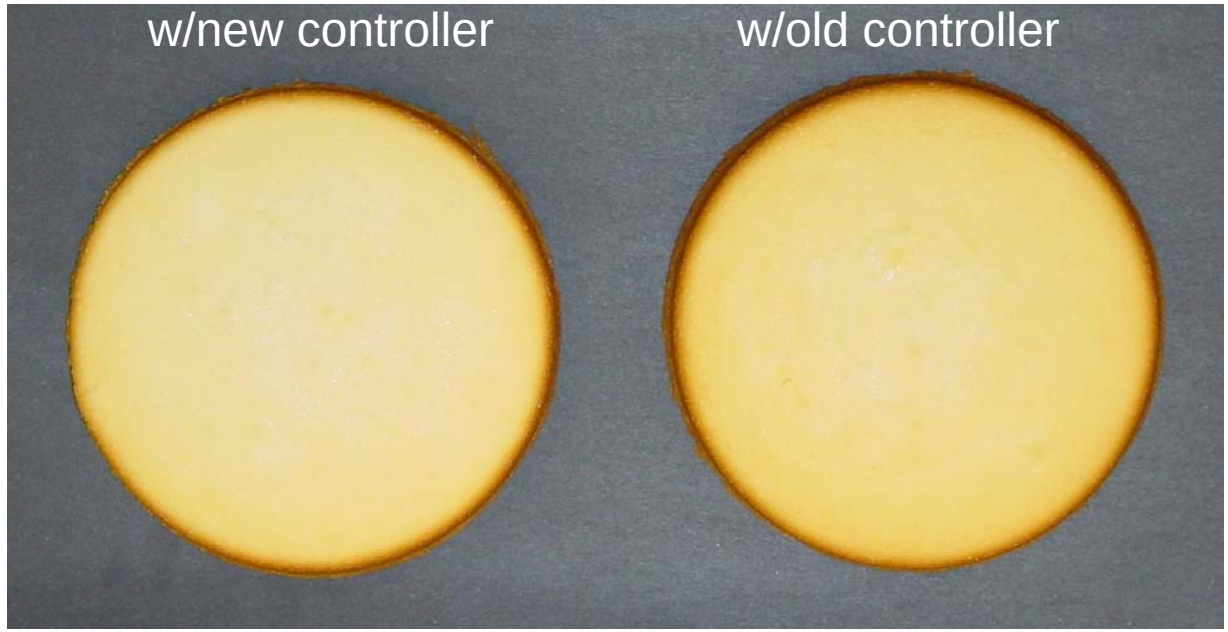
Trans fat | Zero-trans fat

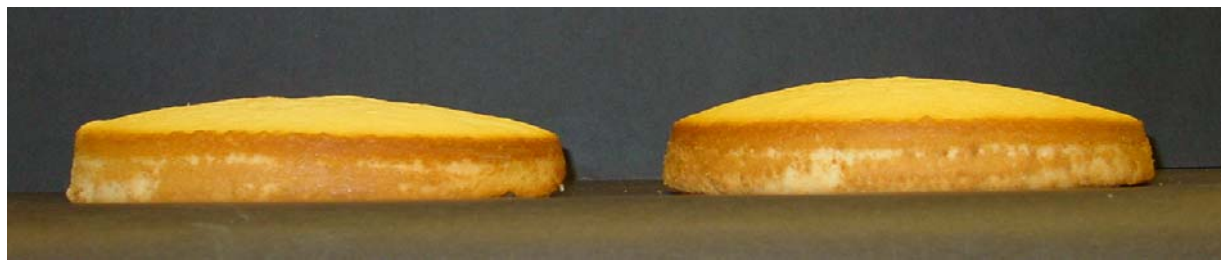


Cakes baked with two ovens

(340 ^{O}F setting with different fluctuation cycles)

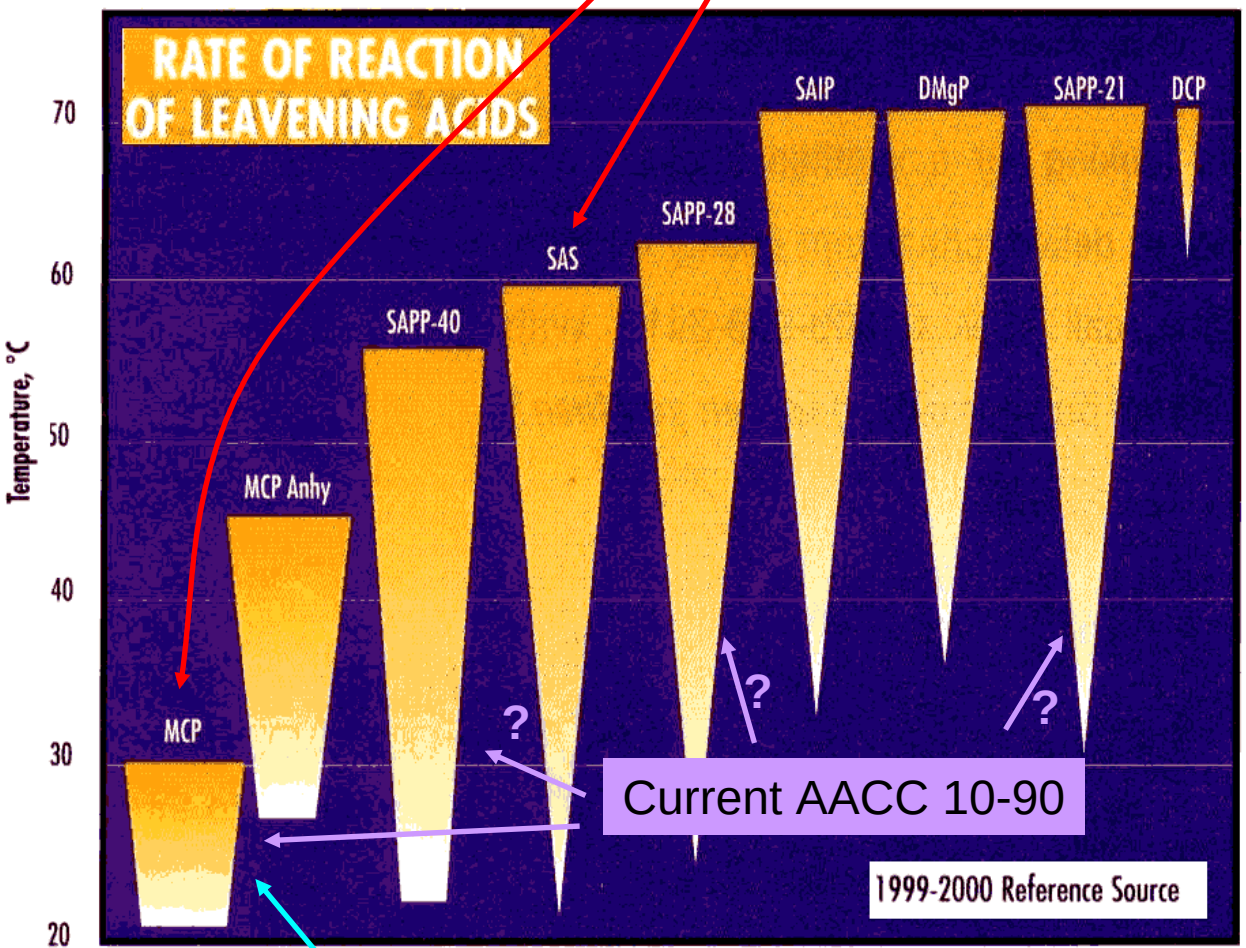






Rate of reaction of leavening acids

Commercial BP (e.g. Clabber Girl and Kraft Calumet)



Current AACC 10-90

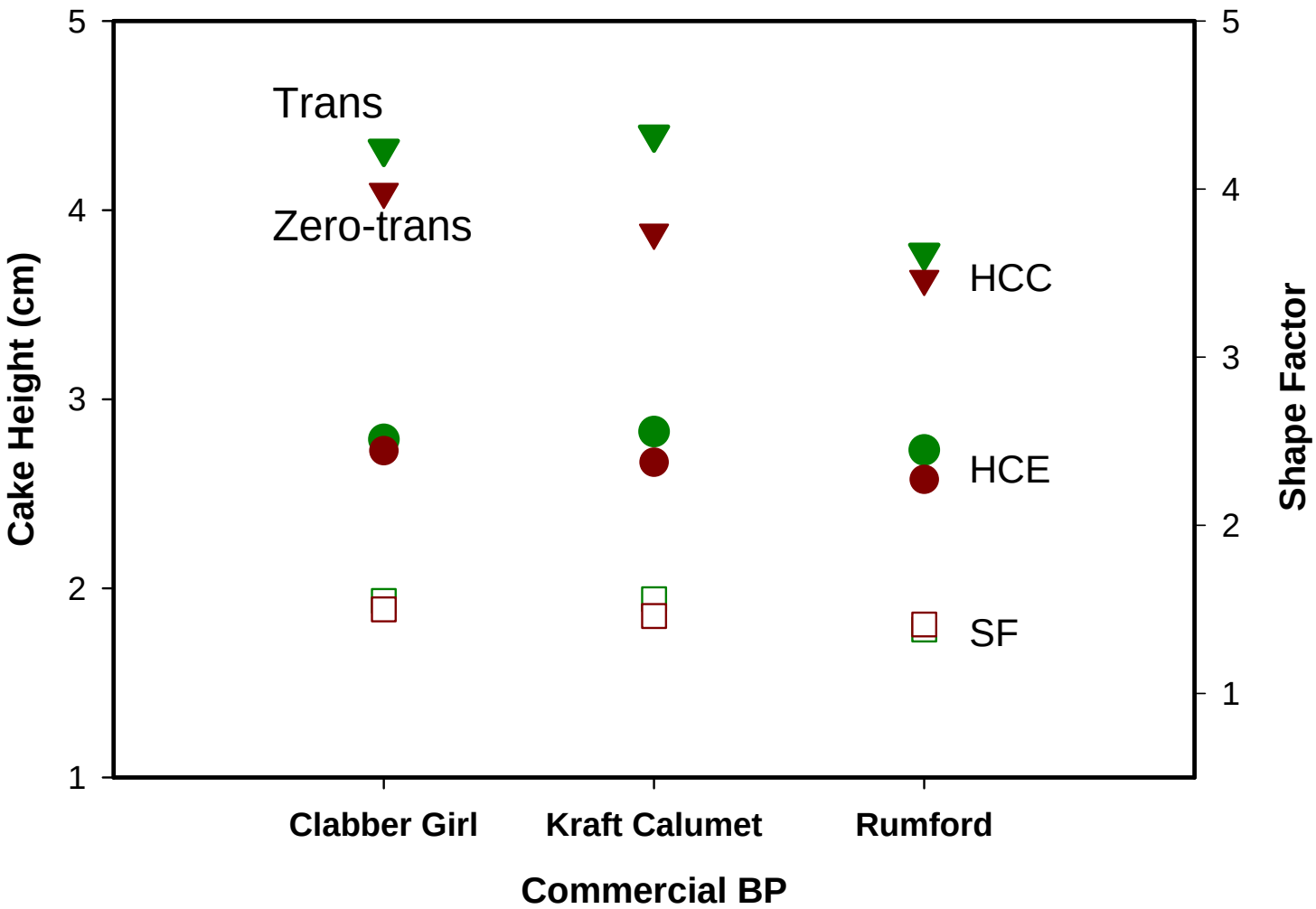
Commercial BP (e.g. Rumford)

LEAVENING BALANCE

ACID	Molecular Weight Relative to Soda = 1
Dicalcium phosphate, dihydrate (DCP)	2.86
Dimagnesium phosphate (DMgP)	2.50
Glucono-delta-lactone (GLD)	2.22
Monocalcium phosphate, monohydrate (MCP)	1.25
Coated monocalcium phosphate, anhydrous (AMCP)	1.20
Potassium acid tartate	2.22
Sodium aluminum sulfate (SAS)	0.96
Sodium acid pyrophosphate (SAPP)	1.39
Sodium aluminum phosphate (SALP)	1.00

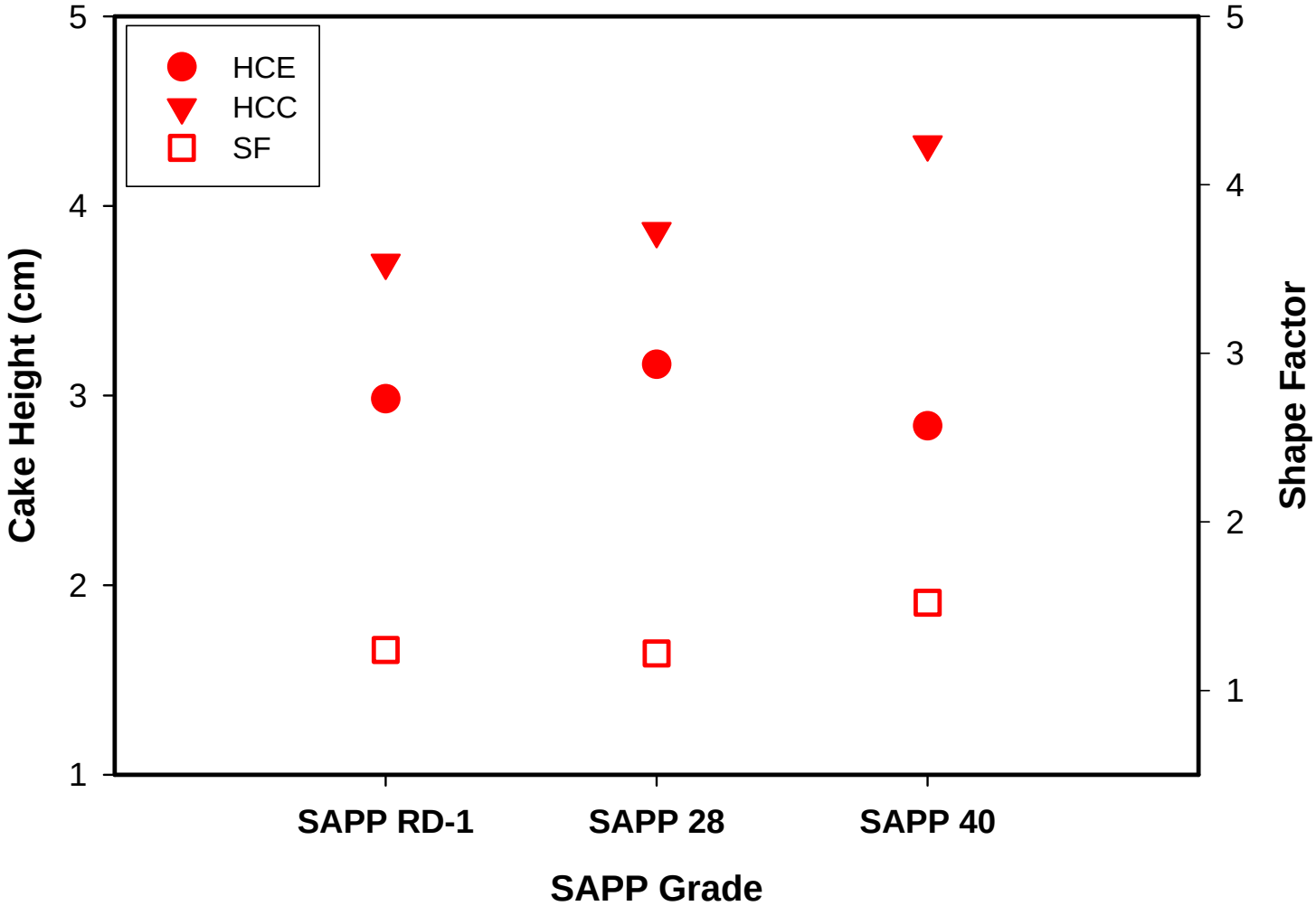
Cake baking with commercial BP

(Swans Down flour)

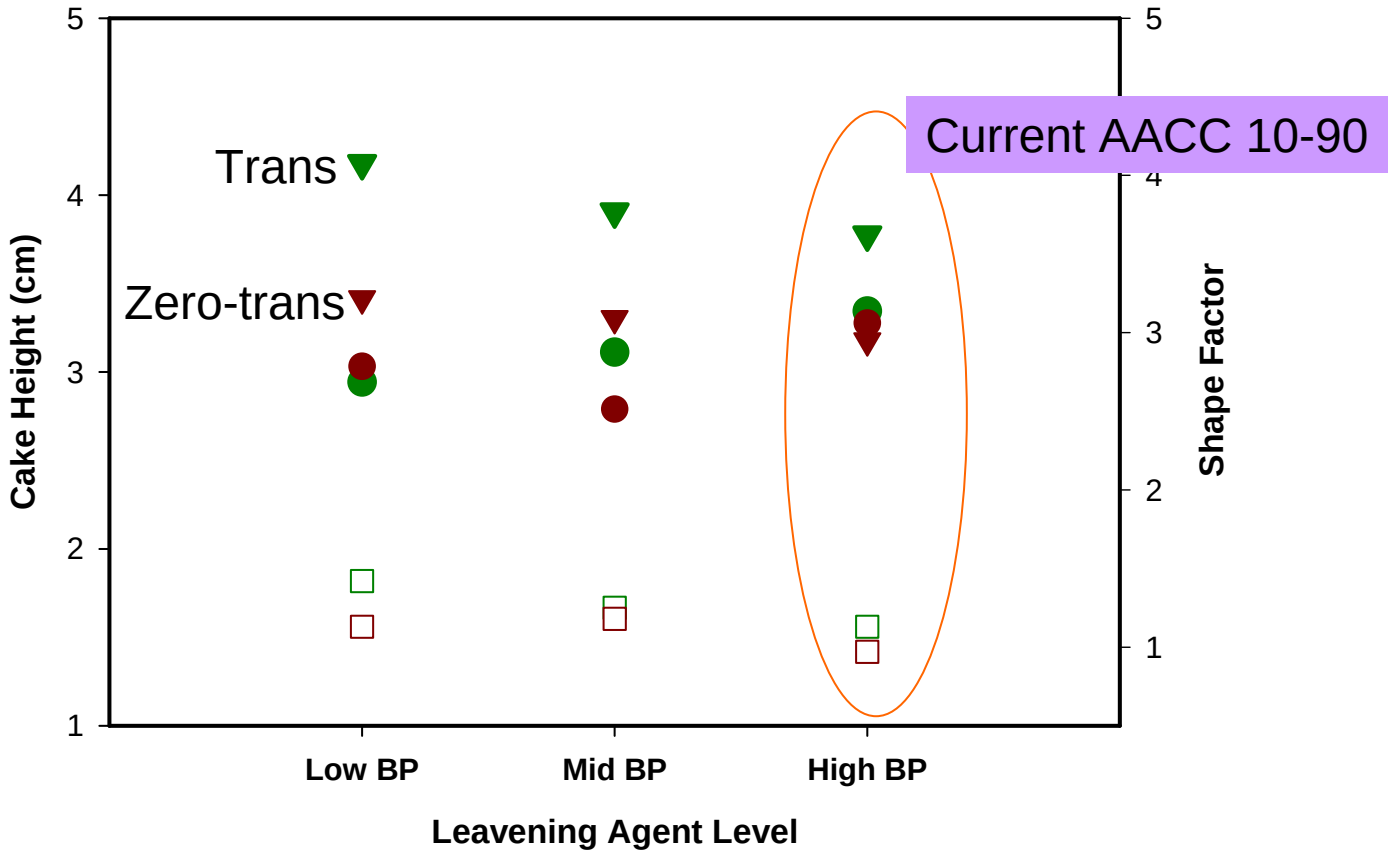


Effect of SAPP grade

(Swans Down flour with trans fat)



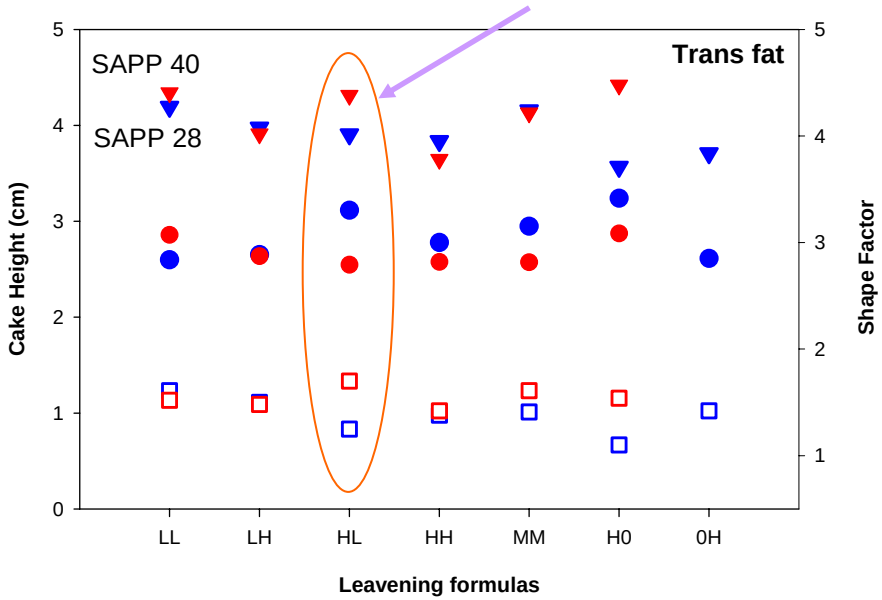
Effect of leavening agent level

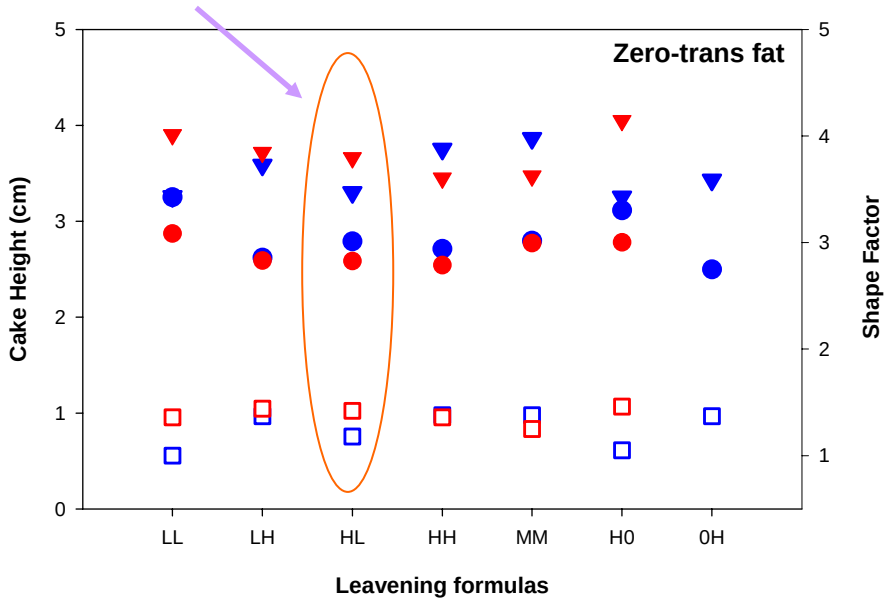


Leavening Agent	Soda	SAPP 28	MCP
Low BP	1.80	1.58	0.22
Mid BP	1.95	2.05	0.29
High BP	2.10	2.52	0.35

Effect of leavening acids and fat type

Current AACC 10-90: Mid BP



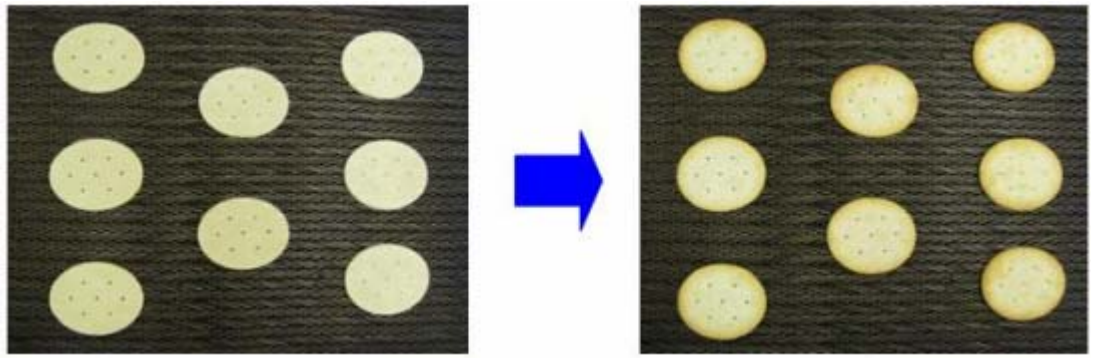


Leavening formulas	Soda	SAPP	MCP
LL	1.95	0.29	0.29
LH	1.95	0.29	2.05
HL	1.95	2.05	0.29
HH	1.95	2.05	2.05
MM	1.95	1.17	1.17
H0	1.95	2.34	0.00
0H	1.95	0.00	2.34

Next steps for cake baking research

- Study effect of sodium aluminum sulfate
- Select appropriate emulsifiers
- Establish a robust cake formula to tolerate oven temperature fluctuation

Chemically-leavened cracker



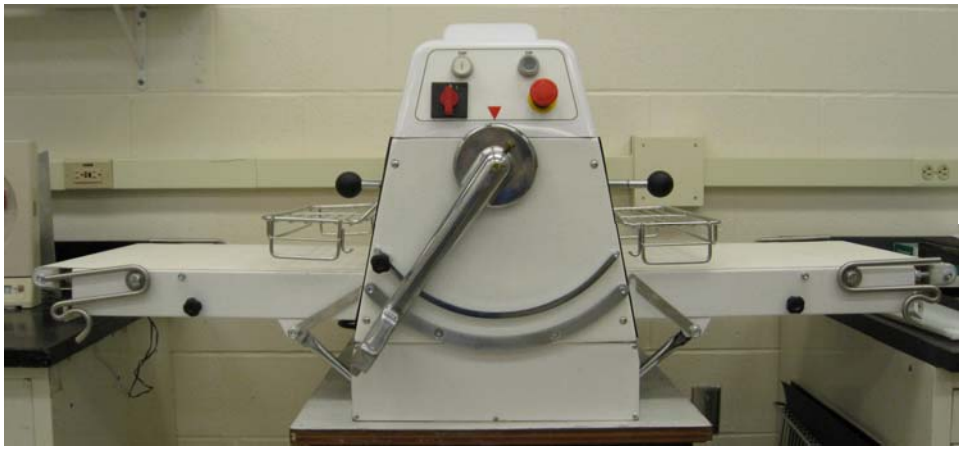
Hurdles in developing a cracker baking method

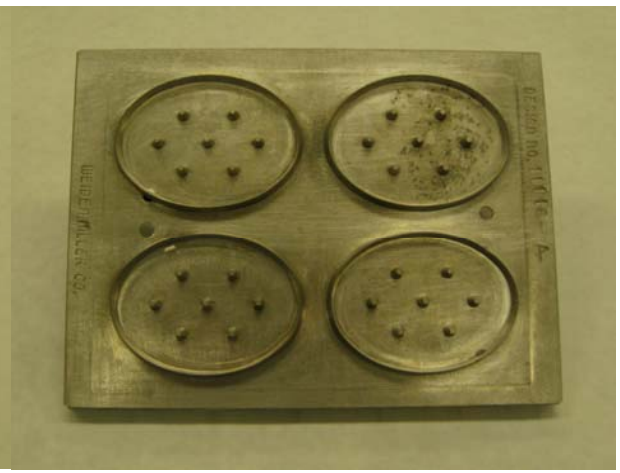
- Difficulty to find ideal diagnostic flours that differ only in gluten functionality (same SRC values, except SRC-LA)
- Absence of a suitable two zone bench-top oven.
- Absence of a powerful bench-top mixer like a commercial plant-scale cracker mixer to enable gluten development with low TS and %S formulas.
- Absence of a powerful 2-4 roll sheeter and reduction system to enable gluten development during machining.

Equipment used for experiments

- Mixer: Pin mixer with 100g mixing bowl
- Sheeter: Univex sheeter
  (similar to Rondo-type sheeter)
- Oven: Standard National lab baking oven
- Baking rack: wire-mesh
- Cutter: Oval shape hand cutter
  (2.25 x 1.65 inch, 7 docker pins)

Equipment used for experiments





Basic ingredients and formulas

Ingredient	Formula (g)
Flour	100.0
FG Sugar	9
Salt	0.75
Sodium bicarbonate	1.25
Ammonium bicarbonate	1.25
Monocalcium phosphate	1.25
Shortening	12.0
Water	28.0
TS	37
% S	24.3

Notes:

1. **~ 80-87 C water was used, and the shortening was melted before use.**
2. **Mixing bowl was warmed up in 63 C water bath for 5 min before mixing was started.**
3. **Mixing time was 5-10 min.**
4. **Dough was sheeted 5 times. Roll gap was decreased from 5.59 to 0.54mm, without folding and rotation of sheet between passes.**

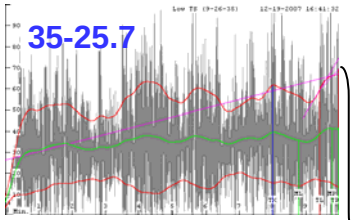
Flour samples used for developing the formula and method

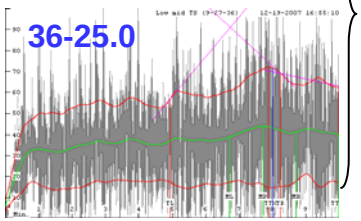
Flour	SRC			
	Water	LA	SC	Suc
Standard cookie	46.5	82.7	61.3	83.7
Pioneer 25R26	50.6	99.6	70.2	96.9
Relative Increment	100	110	105	106

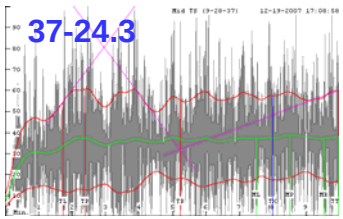
Glutenin functionality is only marginally increased beyond functional contributions from damaged starch and pentosans.

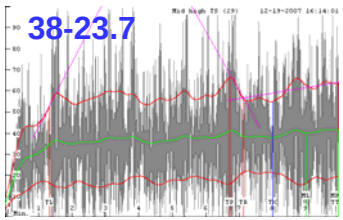
Mixograph of standard cookie flour

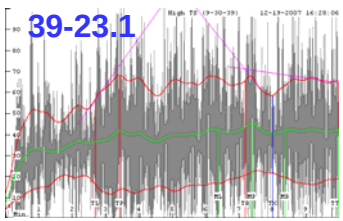
Various TS and %S



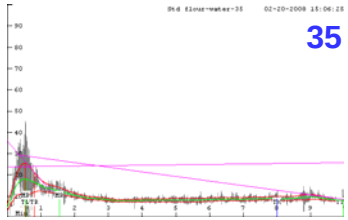


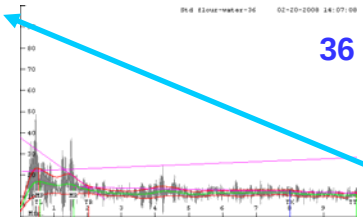


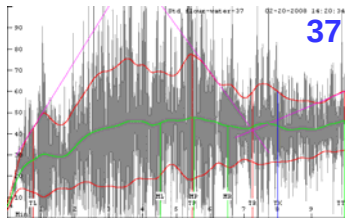


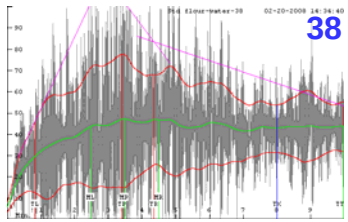


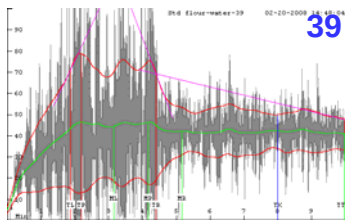
Various TS with water



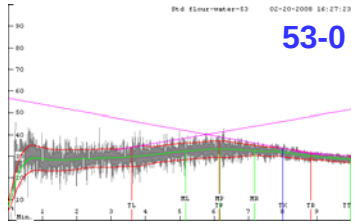


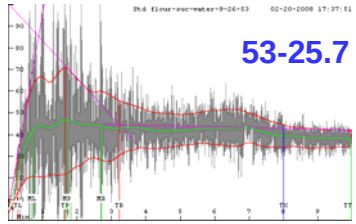


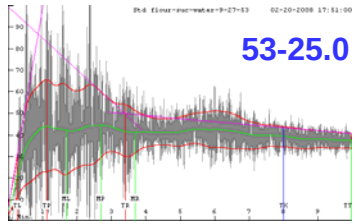


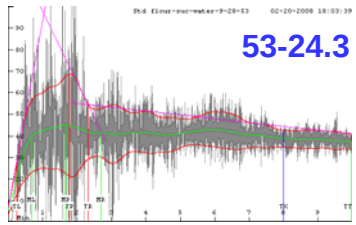


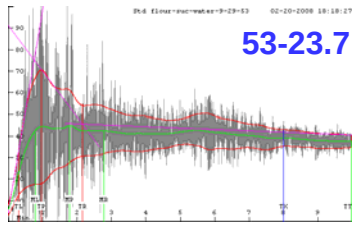
53 TS with water or various % S

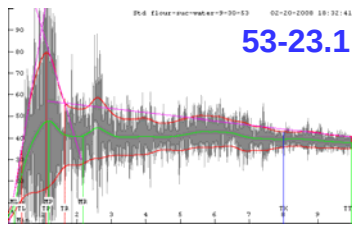










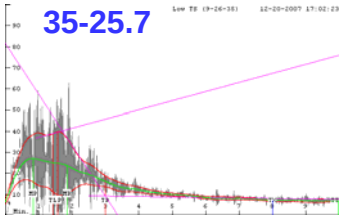


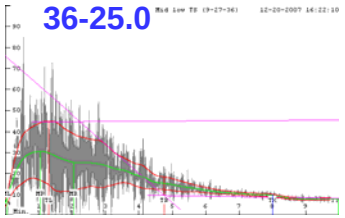
At limited TS (< 37), sugar-water acted as a better solvent for swelling and viscosity development of flour polymers, compared to water.

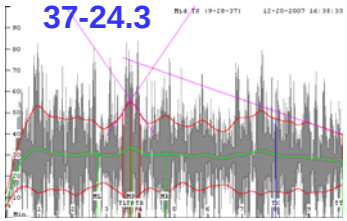
This shows that pentosans dominate the initial phase of the mixogram, not gluten.

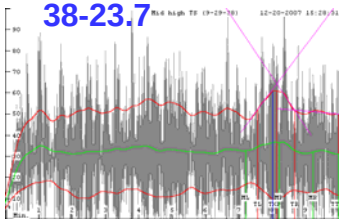
Mixograph of Pioneer 25R26

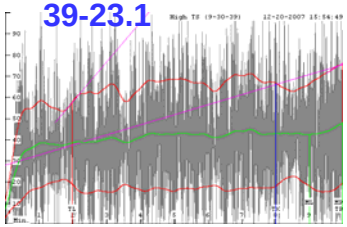
Various TS and %S



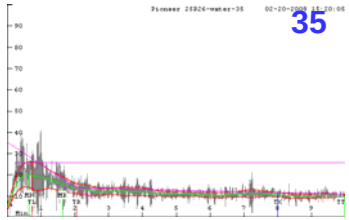


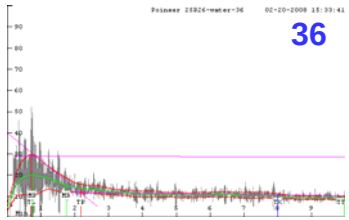


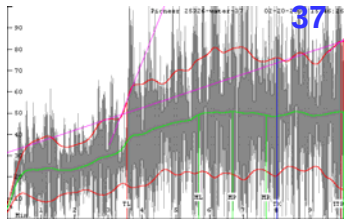


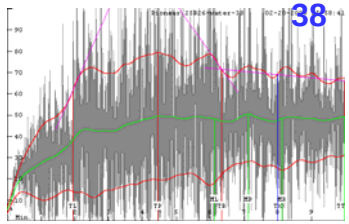


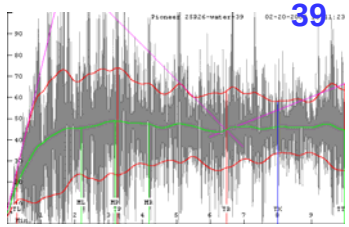
Various TS with water



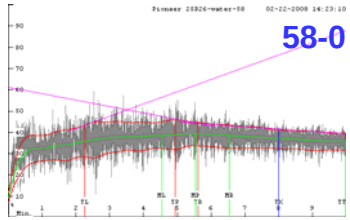


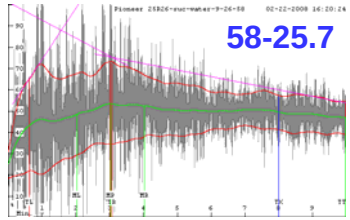


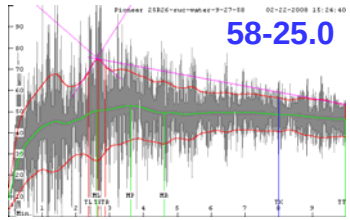


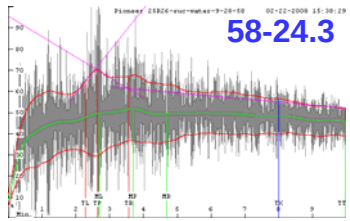


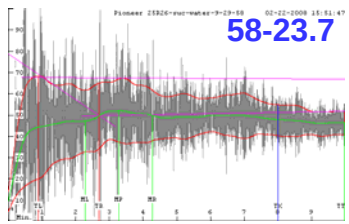
58 TS with water or various % S

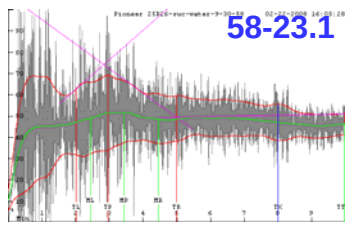












Pioneer 25R26 (higher damaged starch and pentosans) required much higher TS for swelling and viscosity development during mixing, compared to standard cookie flour.

Effect of Total Solvent and Sugar Concentration

(7 min mixing, mixing bowl warmed at 45C)

Flour	TS	% S	Dough/piece		Moisture loss	Cracker/piece	
			Weight	Thickness		Weight	Thickness
Standard cookie	36	25.0	3.83	0.17	26.07	2.83	0.46*
	37	24.3	3.83	0.17	26.26	2.83	0.46**
	38	23.7	3.63	0.15	27.25	2.64	0.45**
	39	23.1	3.26	0.14	27.60	2.36	0.44***
Pioneer 25R26	36	25.0	4.33	0.19	25.40	3.23	0.48
	37	24.3	4.24	0.19	26.13	3.13	0.47
	38	23.7	4.06	0.18	26.54	2.99	0.45
	39	23.1	3.94	0.18	27.50	2.86	0.45

* Blisters

Effect of mixing time

(Standard cookie flour: 36TS, 25% S & 37TS, 24.3% S)

TS	% S	Mixing time	Dough/piece		Moisture loss	Cracker/piece			
			Weight	**Thickness**		**Weight**	**Length**	**Width**	**Thickness**
37	24.3	5	3.09	0.125	27.24	2.25	5.15	4.34	0.429*
		7.5	2.92	0.118	26.86	2.14	5.26	4.27	0.446**
		10	2.91	0.115	26.35	2.14	5.29	4.19	0.426*
36	25.0	5	3.44	0.138	26.57	2.53	5.13	4.35	0.488
		7.5	3.39	0.136	26.58	2.49	5.21	4.33	0.444
		10	3.24	0.131	26.23	2.39	5.27	4.27	0.425

* Blisters

Effect of mixing time

(Pioneer 25R26 flour: 24.3% S, 37 TS)

5 min

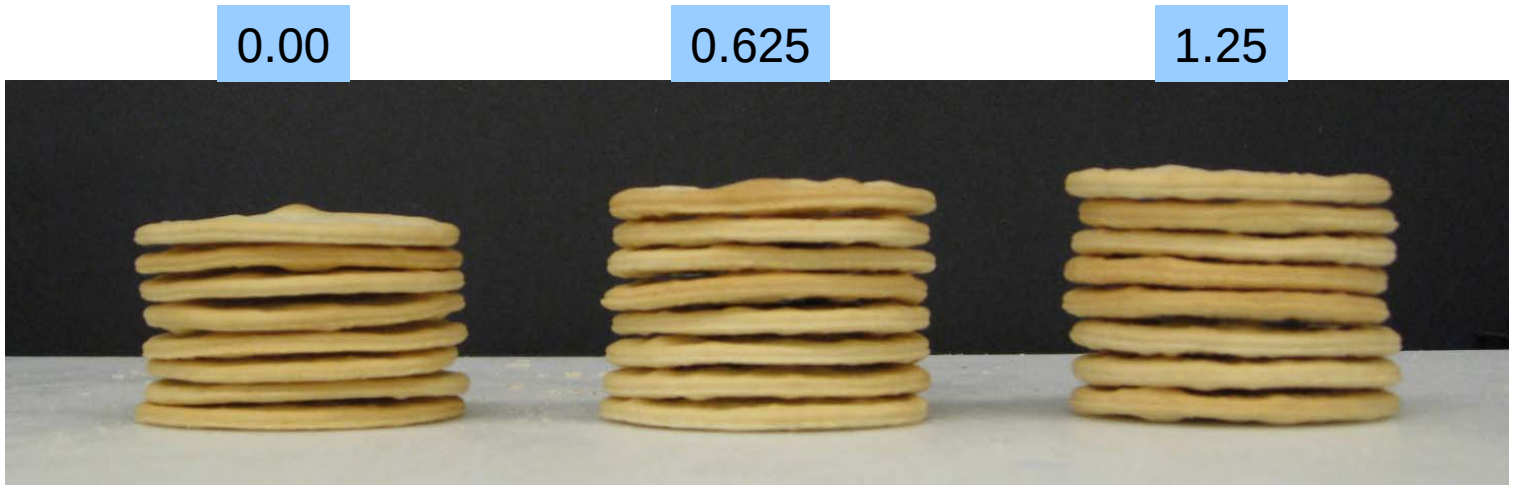
7.5 min

10 min

Mixing time (min)	Dough/piece		Moisture loss	Cracker/piece			
	Weight	Thickness		Weight	Length	Width	Thickness
5	4.29	0.168	25.88	3.17	5.13	4.28	0.493
7.5	3.99	0.161	26.22	2.94	5.04	4.33	0.443
10	3.74	0.156	25.94	2.77	4.85	4.32	0.429

Effect of ammonium bicarbonate

(Standard cookie flour: 25% S, 36 TS, 7min mixing)



ABC	Dough/piece		Moisture loss	Cracker/piece			
	Weight	Thickness		Weight	Length	Width	Thickness
0	3.60	0.139	26.75	2.64	5.21	4.16	0.412
0.625	3.68	0.141	25.74	2.74	5.14	4.21	0.450
1.25	3.68	0.142	26.69	2.70	5.12	4.29	0.500

Ratio of SRC LA/(SC+Suc) of flour samples

Cultivar	SRC				LA/(SC+Suc)
	Water	LA	SC	Suc	
GA96603-4E16	49.5	113.8	64.4	92.3	0.726
Caledonia	48.2	101.1	63.3	84.4	0.685
D 8006	48.8	97.8	63.1	82.3	0.673
Jewel	51.6	103.2	65.0	89.8	0.666
Crystal	48.1	92.3	60.3	81.5	0.651
AGS 2000	52.4	107.1	67.7	101.2	0.634
Jamestown	52.4	99.4	66.7	96.4	0.609
Jensen	49.2	80.9	63.6	86.2	0.540
USG 3209	56.4	98.1	76.1	109.0	0.530
MPV 57	49.5	80.8	63.7	91.4	0.521

Baking with various flour samples

(37 TS, 24.3% S, 10min mixing)

Flour	Dough	Dough/piece		Moisture loss	Cracker/piece				
		Wt.	Thk.		Wt	L	W	Thk	Blister #
GA96603-4E16	Soft	3.89	0.163	25.98	2.88	5.12	4.31	0.416	0
Caledonia	Soft	3.41	0.148	26.23	2.52	5.23	4.32	0.451	4
D 8006	Very soft	3.79	0.160	26.50	2.78	5.08	4.30	0.418	0
Jewel	Crumbly	3.91	0.161	25.58	2.91	4.88	4.30	0.451	Ugly top
Crystal	Soft	3.80	0.160	26.06	2.81	5.21	4.26	0.418	0
AGS 2000	Hard	3.71	0.160	25.68	2.76	5.22	4.30	0.528	8
Jamestown	Soft	3.80	0.161	25.90	2.82	5.09	4.32	0.401	2
Jensen	Soft	3.14	0.142	26.85	2.30	5.25	4.26	0.393	2
USG 3209	Crumbly	3.68	0.157	25.52	2.74	5.04	4.21	0.396	0
MPV 57	Very soft	2.73	0.106	26.59	2.01	5.29	4.17	0.418	8

Challenges and future work

- **Challenges:**
  - What are satisfactory criteria (e.g. cracker thickness) to distinguish differences in gluten functionality and flour performance for chemically-leavened crackers?
  - If mixing time, water level, and water temperature are adjusted to compensate for variations in flour functionality, a statistical model will be required to deconvolute the role of flour, because of the dominance of process variables.
- **Future work:**
  - Rheological test to evaluate extent of gluten development during mixing, and subsequently, during machining.
  - Correlate predictions from rheological testing with criteria used to distinguish differences in gluten functionality and flour performance for chemically-leavened crackers.
  - Use alpha-amylase and pentosanase enzymes to compensate for differences in SRC SC and Suc values, so that flours differ ONLY in SRC LA values.

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Lone Star Geyser in Yellowstone in 2007