PACIFIC NORTHWEST WHEAT QUALITY COUNCIL
PNW SECTION AACC
24 JANUARY 2007

COOKIE vs CRACKER BAKING -- WHAT'S THE DIFFERENCE ?

FLOUR FUNCTIONALITY REQUIREMENTS EXPLORED BY SRC AND ALVEOGRAPHY

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PRODUCT CATEGORIES ILLUSTRATE FORMULA **DESIGN**

THE SAME FLOUR CAN BE USED TO MAKE VERY DIFFERENT PRODUCTS BY CONTROLLING SUGAR LEVEL, WATER LEVEL, AND WATER TEMPERATURE

OR

DIFFERENT FLOURS CAN BE USED TO MAKE THE SAME PRODUCT BY CONTROLLING SUGAR LEVEL, WATER LEVEL, AND WATER TEMPERATURE

Oreo	High sugar	Hot water temperature	Low water level
HMG	Medium sugar	Hotter water temperature	”
Ritz	Low sugar	Hotter water temperature	”
Premium	No/low sugar	Medium water temperature	Low water level
Maria	Med/low sugar	Hottest water temperature	”
CA!	Med sugar	Cold water temperature	”
Chewy*	High sugar	Cold water temperature	”
Cake*	High sugar	Cold water temperature	High water level
Wafers	No/low sugar	Cold water temperature	High water level

***** Benefit from “bleached flour”, chlorinated to pH 4.6

HOW TO DESCRIBE THE FUNCTIONALITY OF SUGAR AND WATER IN THE FORMULA

THE INDIVIDUAL LEVELS OF SUGARS AND WATER ARE *NOT* PREDICTIVE, BECAUSE THE SUGARS DISSOLVE IN THE WATER AT VARYING RATES TO VARYING EXTENTS AT EACH TIME POINT IN THE PROCESS, DEPENDING ON SOLUBILITY, PARTICLE SIZE, INITIAL WATER TEMPERATURE, AND OVEN/PRODUCT PROFILE.

TS = **Total Solvent => Controls CREEP**
= Total Syrup = Sum of Sugars + Water

% S = **Solvent Concentration => Controls COLLAPSE,**
via gluten development and starch gelatinization/pasting
= Concentration of Syrup Made by Sugars + Water
= Sugars / (Sum of Sugars + Water)
= Sugars/TS

S/W = Sugar/Water Ratio (alternative for concentration)
= Ratio of Sugars to Water

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ALL low water level

Rotary mold cookie	High sugar	Hot water temperature	74-80 %S
AACC 10-50D	High sugar	Room temperature water	
Graham cracker *	Medium sugar	Hotter water temperature	62-66 %S
Rich snack cracker	Low sugar	Hotter water temperature	~ 25 %S
Lean cracker	No/low sugar	Medium water temperature	~ 0 %S
AACC 10-53	Medium sugar	Room temperature water	~ 67 %S
Wire-cut cookie	Medium sugar	Cold water temperature	

***** Cookie/Cracker Dilemma***

Test Baking Research

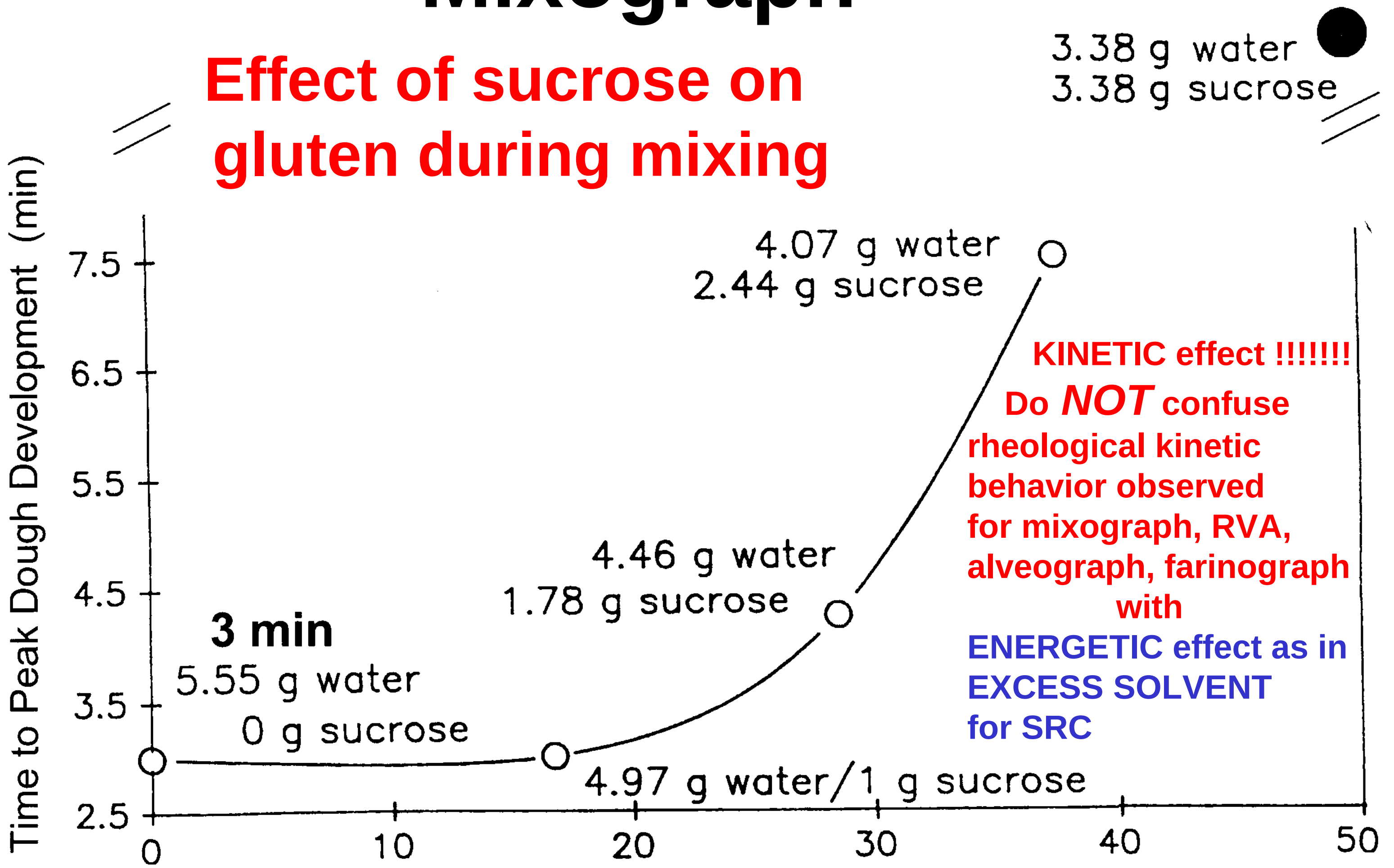
Rationale

18 min

Mixograph

50 w%

Effect of sucrose on gluten during mixing



Sucrose weight % in Constant Volume (5.5 ml solution) with 5 g Climax Flour

One Sugar Type: Different Concentrations

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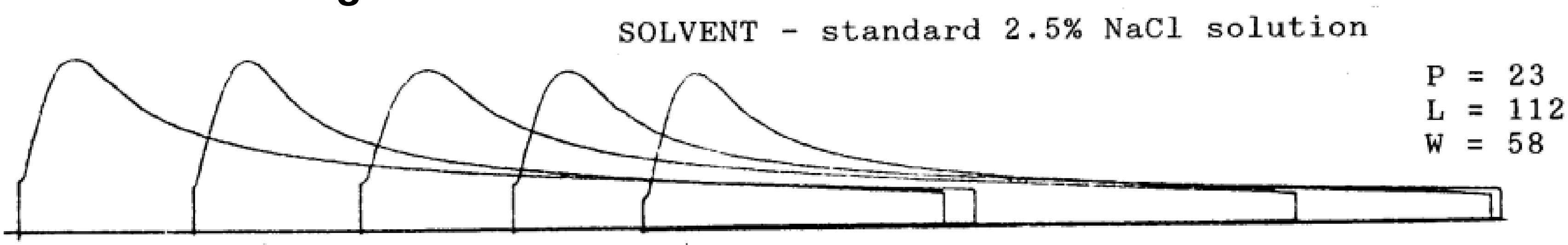
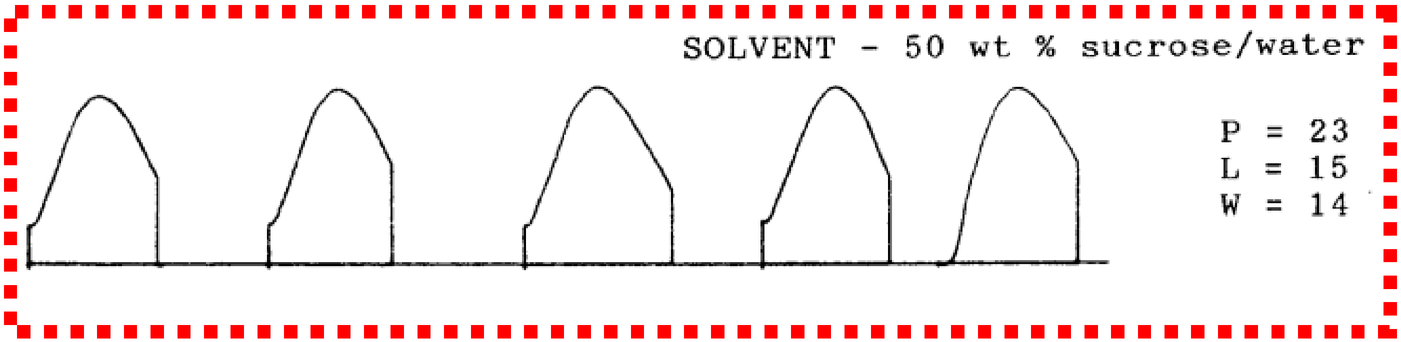
Alveograph TOO MUCH SUGAR IN A FORMULA MAKES A FLOUR *LOOK* "WEAK"

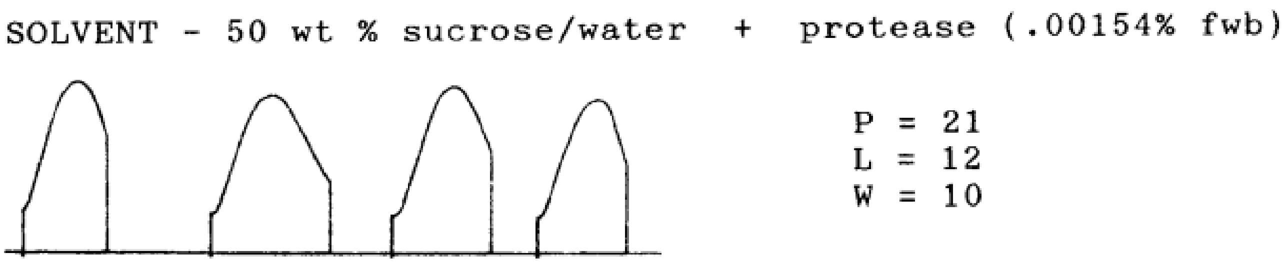
Standard alveogram for Ohio SRW flour



When Sugar Concentration > 30%, gluten cannot develop in normal mixing time



Because gluten cannot develop, there is no effect of protease



CAUTION ! Do NOT compare SRC to rheology for sucrose solvent !!!

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Test Baking Research

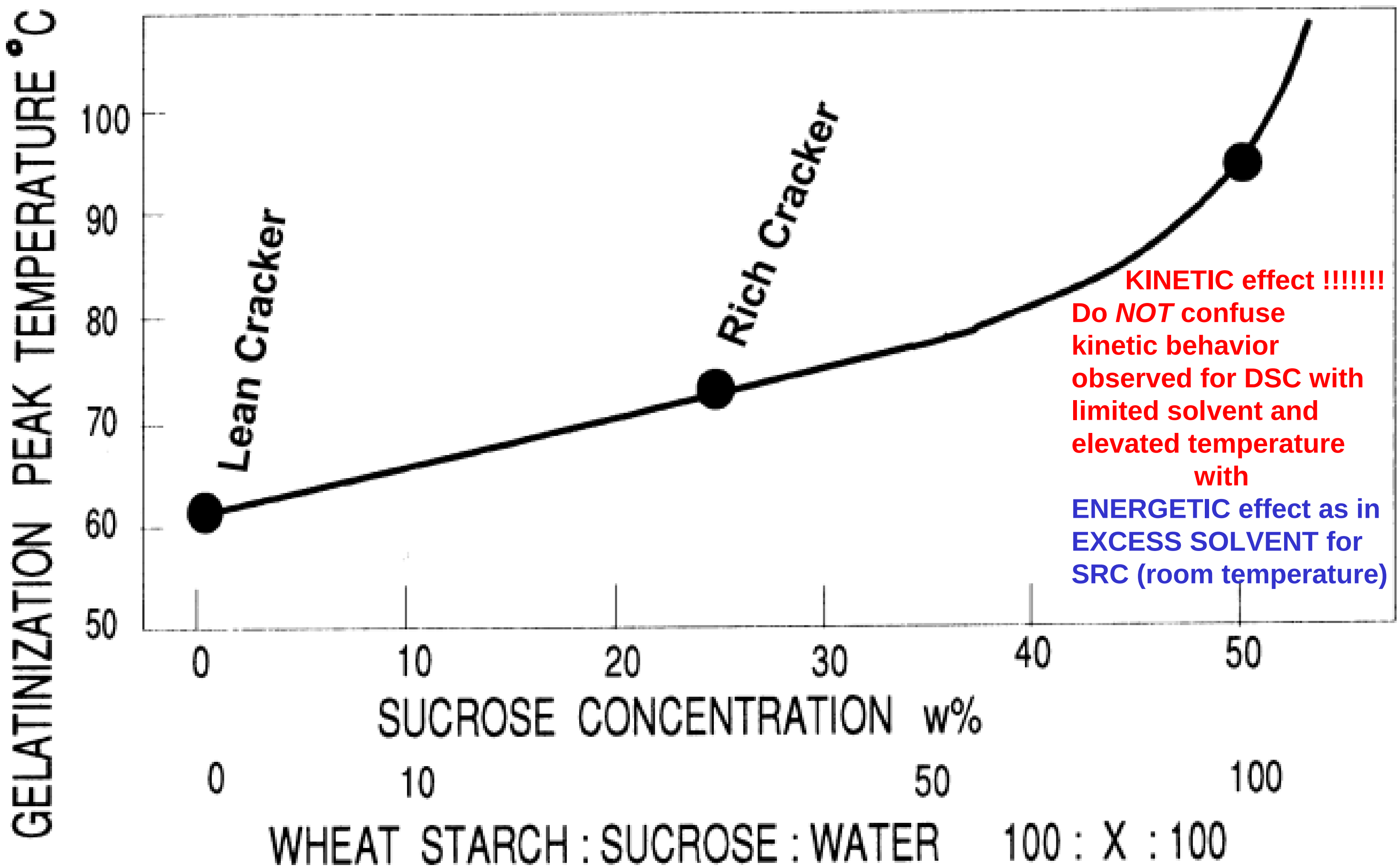
Rationale

74-80%
Sugar Snap Cookie

DSC — Effect of sucrose on starch during baking

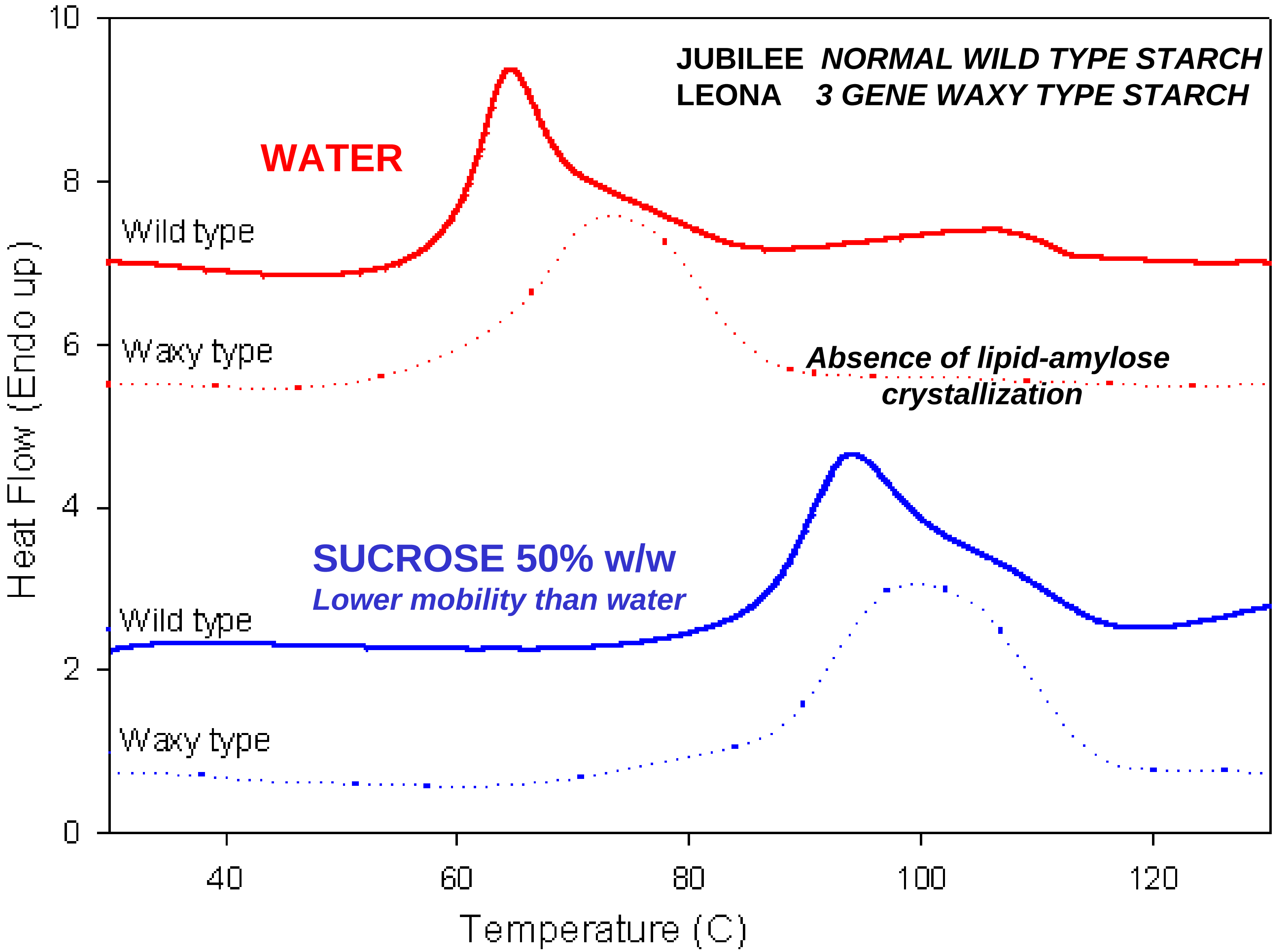
Wire-cut Cookie ~ 67%

Graham cracker 62-66%

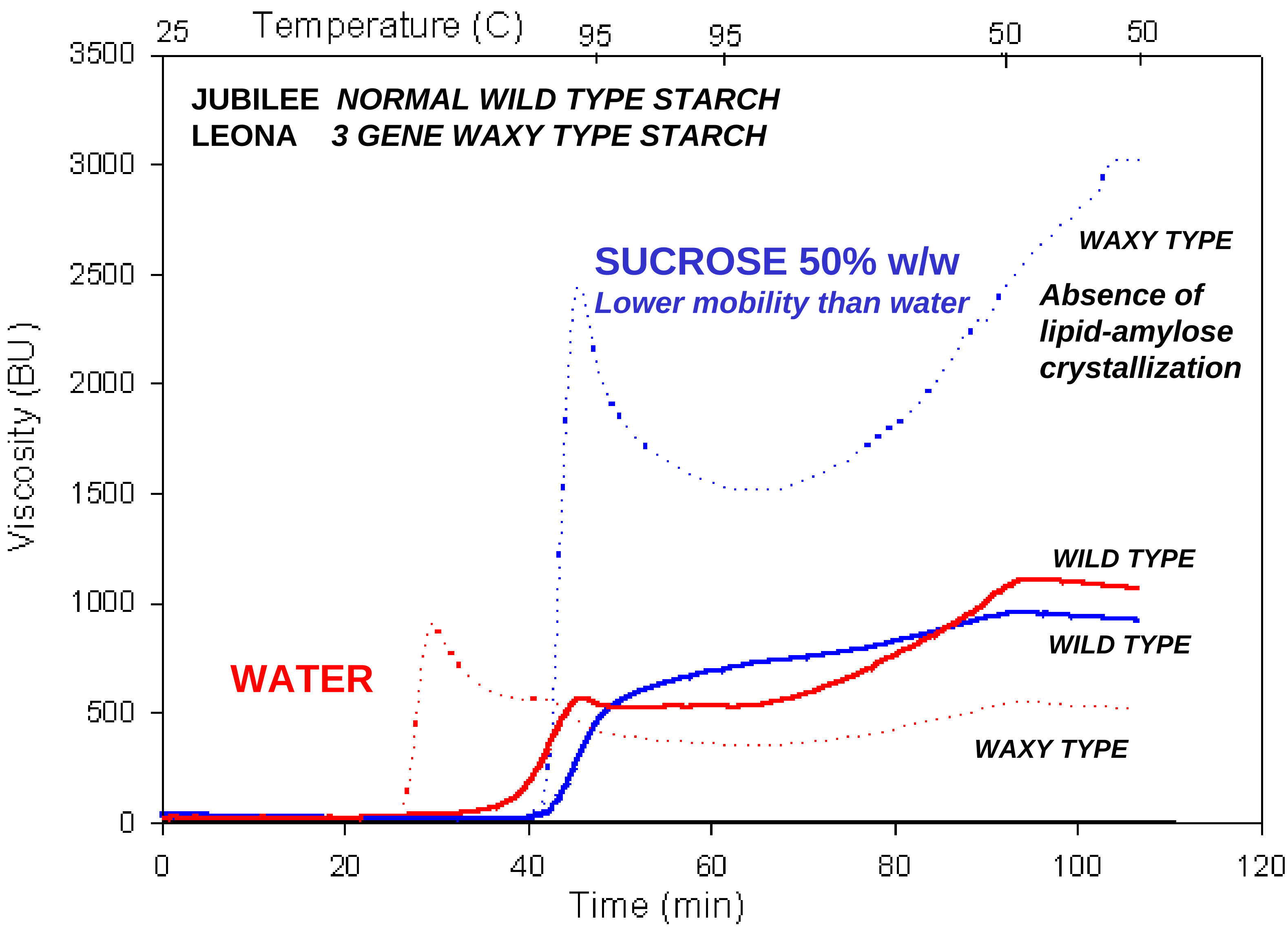


DSC

SHOWS ***GELATINIZATION*** OF STARCH
HEAT, ***NO SHEAR***, ~ 50% FLOUR



RVA SHOWS *PASTING* OF STARCH
HEAT, *SIGNIFICANT SHEAR*, ~ 12% FLOUR

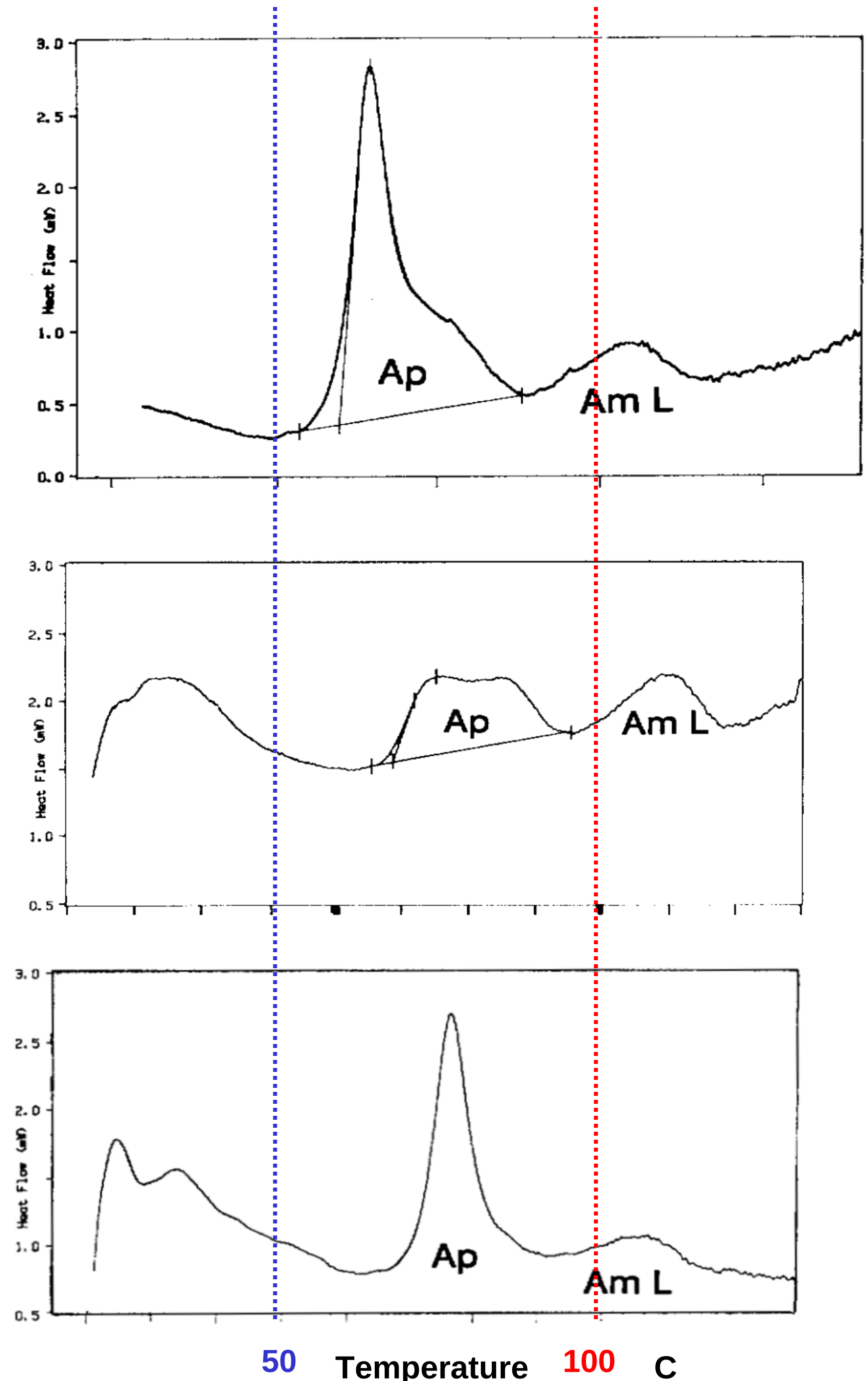


RAW COOKIE/CRACKER FLOUR

100% NATIVE AMYLOPECTIN
100% NATIVE AMYLOSE-LIPID

DIAGNOSTIC DSC PROFILES

SHOW EFFECT OF SUGAR CONCENTRATION %S ON STARCH GELATINIZATION DURING BAKING



BAKED LEAN CRACKER

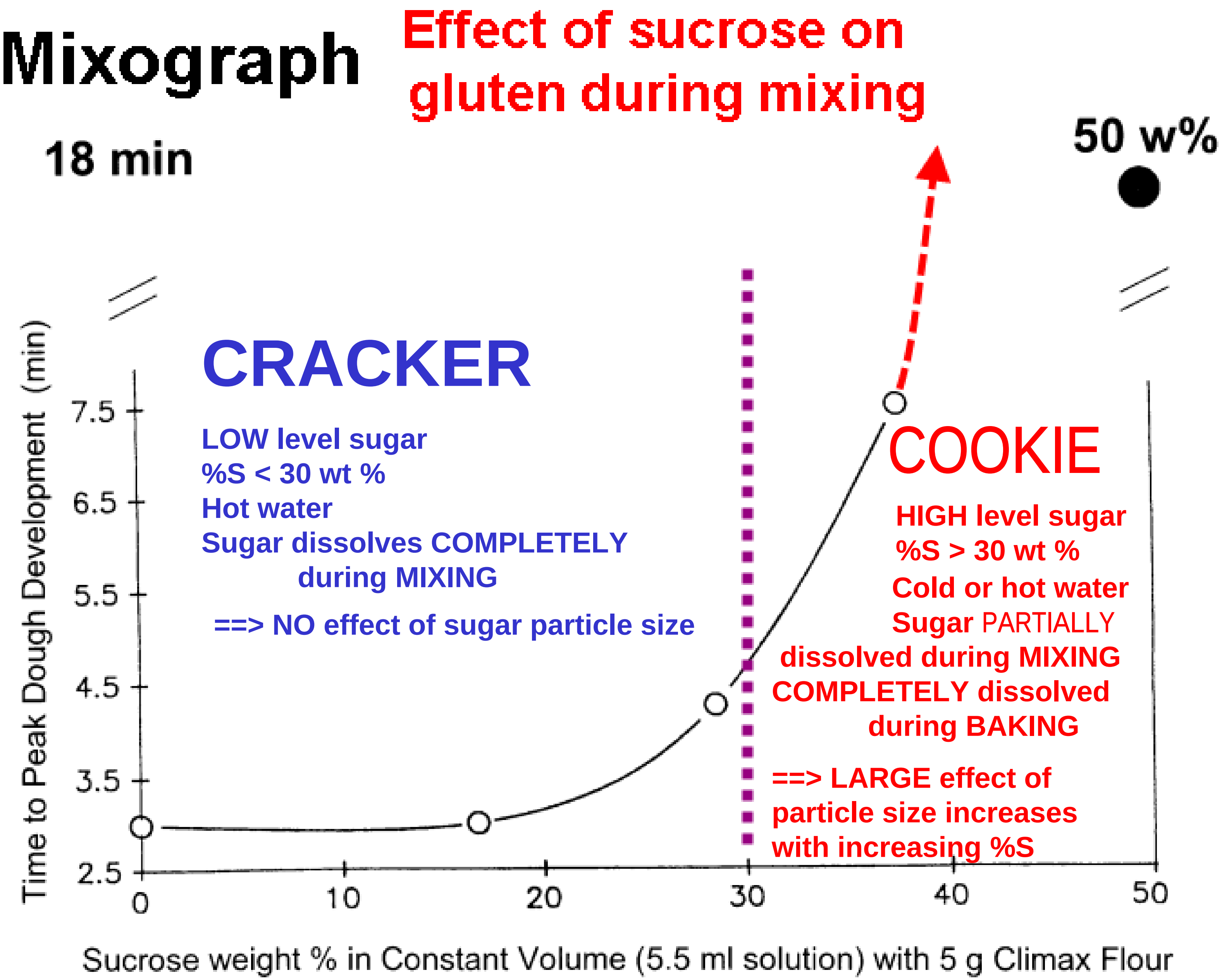
40% NATIVE AMYLOPECTIN
120% NATIVE AMYLOSE-LIPID

BAKED ROTARY MOLD COOKIE

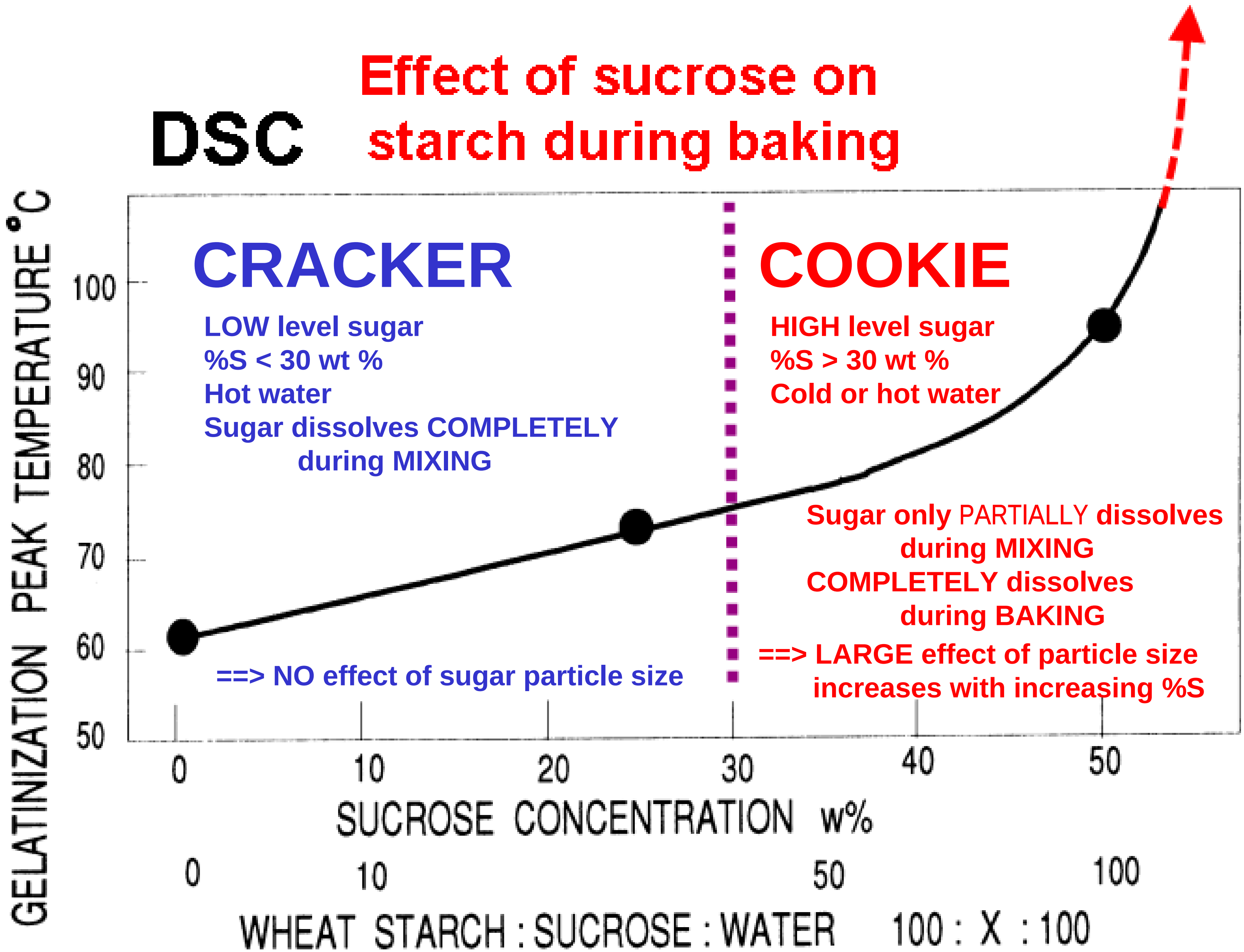
100% NATIVE AMYLOPECTIN
100% NATIVE AMYLOSE-LIPID

VERY HIGH %S PREVENTS STARCH GELATINIZATION DURING OPTIMUM BAKING TIME

DEFINE CRACKER vs COOKIE BY ~ 30 %S



DEFINE CRACKER vs COOKIE BY ~ 30 %S



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GLASS TRANSITION IN COOKIES AND CRACKERS

EFFECT OF MOISTURE CONTENT [FAT-FREE BASIS] AND FINAL COMPOSITION OF MATRIX ON Tg AND OBSERVED CRITICAL RH FOR PRODUCT QUALITY & SHELFLIFE PREDICTION

CRITICAL RH INCREASES WITH INCREASE IN HIGH MW STARCH / LOW MW SUGARS RATIO

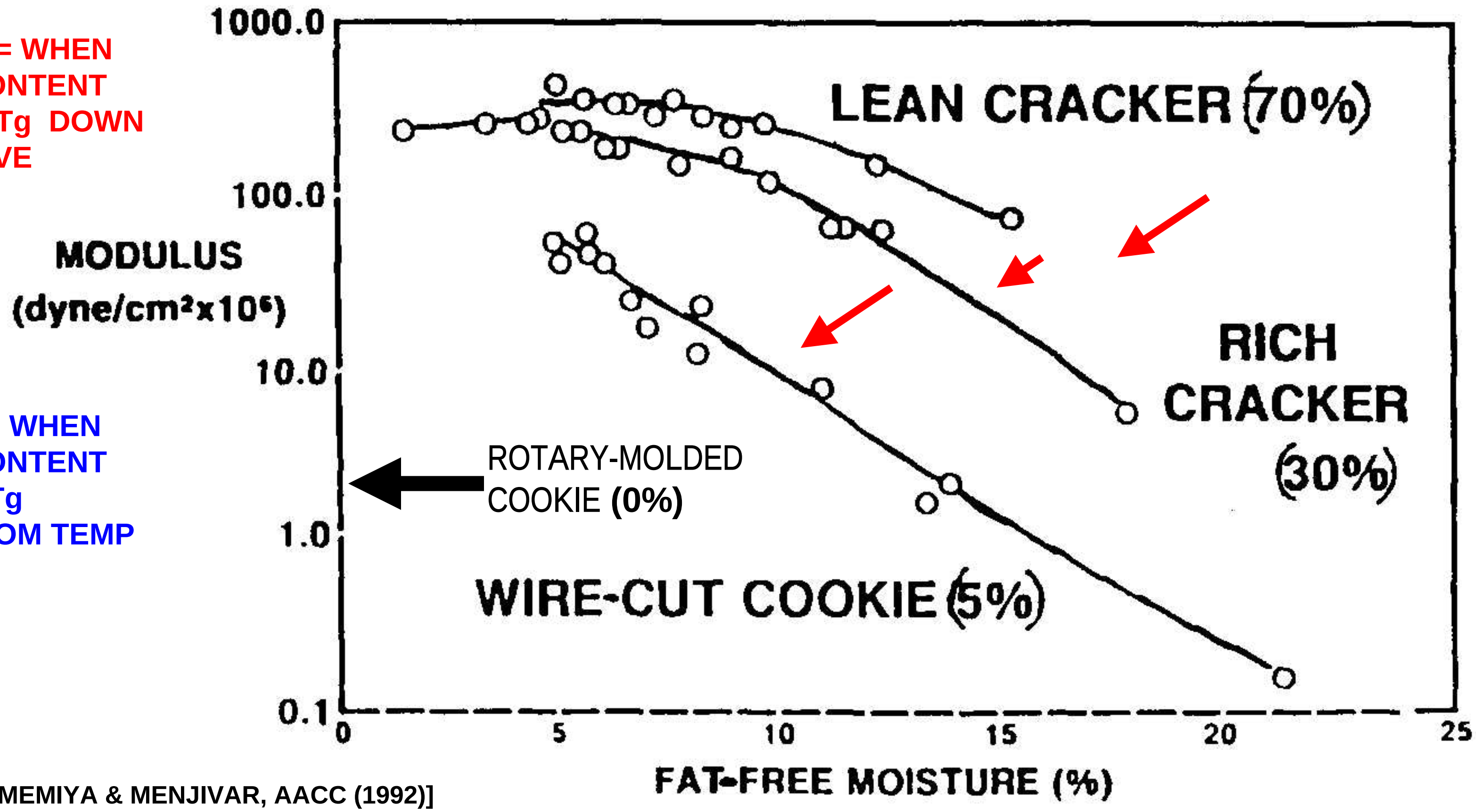
WATER IS A *SOFTENING* AGENT FOR BAKED PRODUCT TEXTURE:

PRODUCT HARDNESS DECREASES WITH INCREASING MOISTURE CONTENT

THREE-POINT-BEND TESTING AT ROOM TEMPERATURE (% GELATINIZED STARCH IN FAT-FREE DRY SOLIDS)

CRITICAL RH = WHEN MOISTURE CONTENT DEPRESSES Tg DOWN TO ~20C ABOVE ROOM TEMP

SOGGINESS = WHEN MOISTURE CONTENT DEPRESSES Tg DOWN TO ROOM TEMP



[AMEMIYA & MENJIVAR, AACC (1992)]

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EFFECT OF FAT CONTENT ON COOKIE TEXTURE

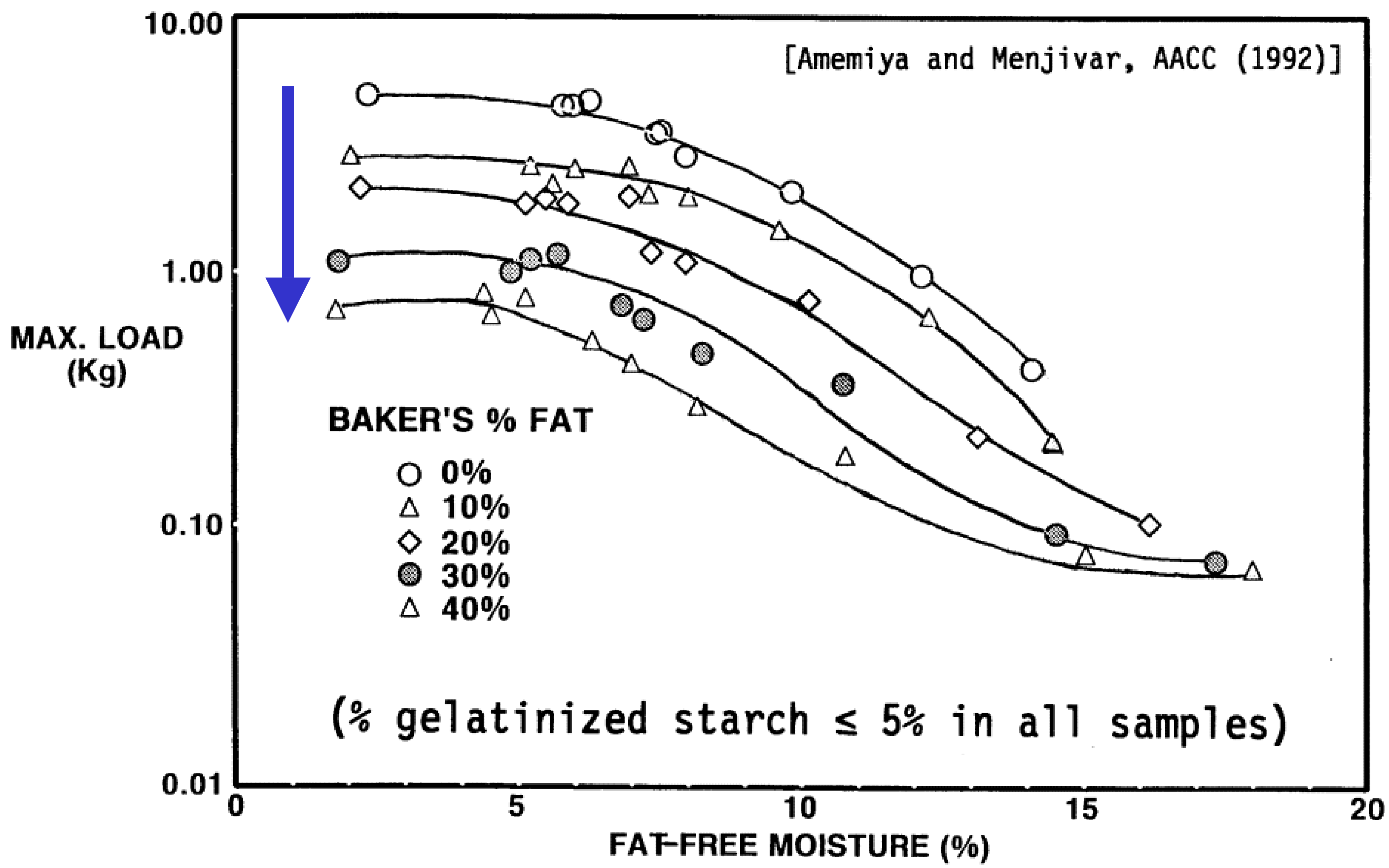
IN CONTRAST TO WATER,

FAT IS A *TENDERIZING* AGENT FOR BAKED PRODUCT TEXTURE

BUT FAT HAS NO EFFECT ON CRITICAL RH OR CRITICAL MOISTURE CONTENT:

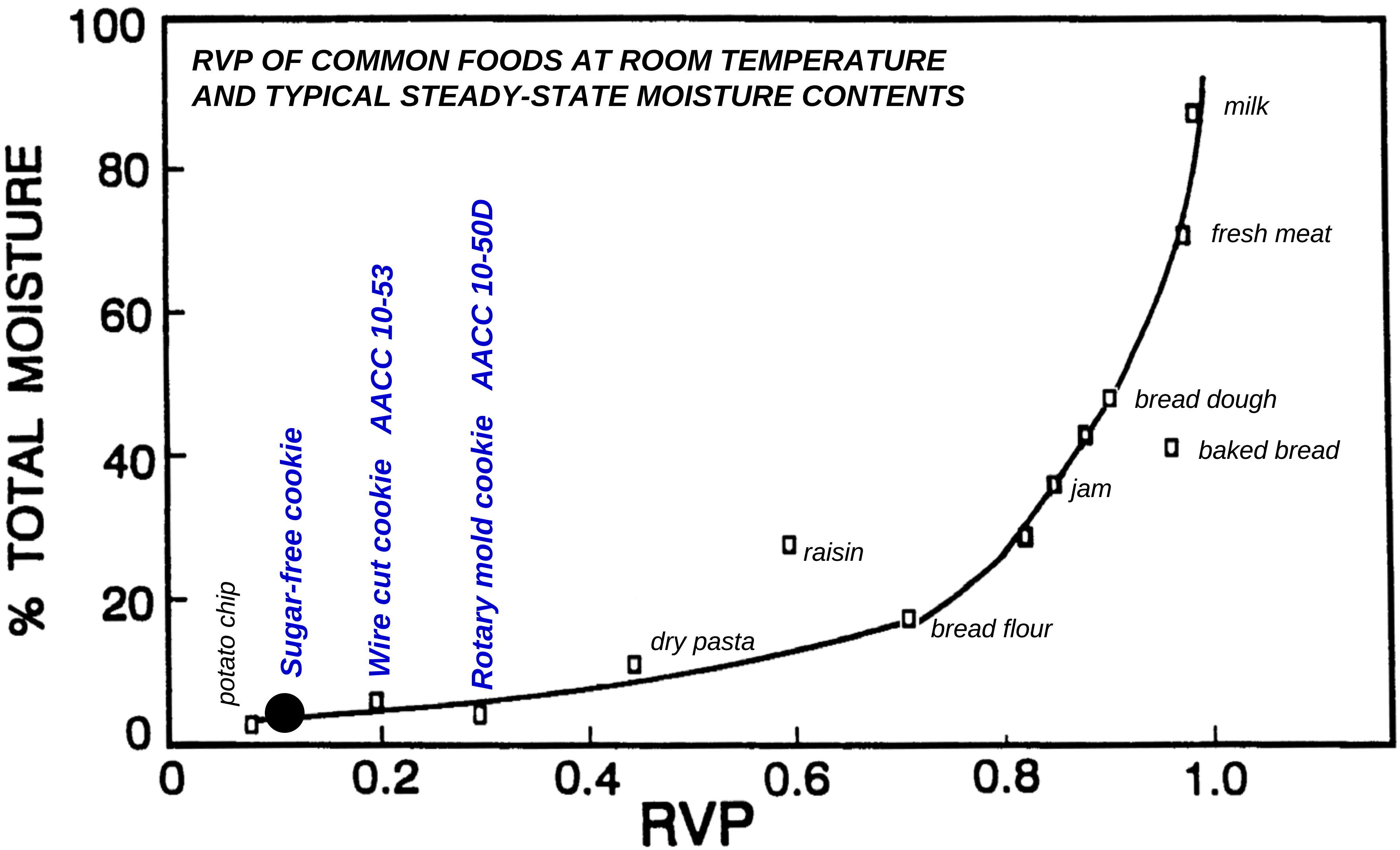
PRODUCT HARDNESS DECREASES WITH INCREASING FAT CONTENT,

BUT FAT DOES NOT AFFECT Tg OR THE WATER CONTENT AT WHICH DRAMATIC SOFTENING OCCURS



PRODUCT RELATIVE HUMIDITY VALUES FOR HIGH QUALITY COOKIES WITH EXTENDED SHELFLIFE

DEPEND ON FORMULATION %S & TS AND MOISTURE LOSS DURING BAKING



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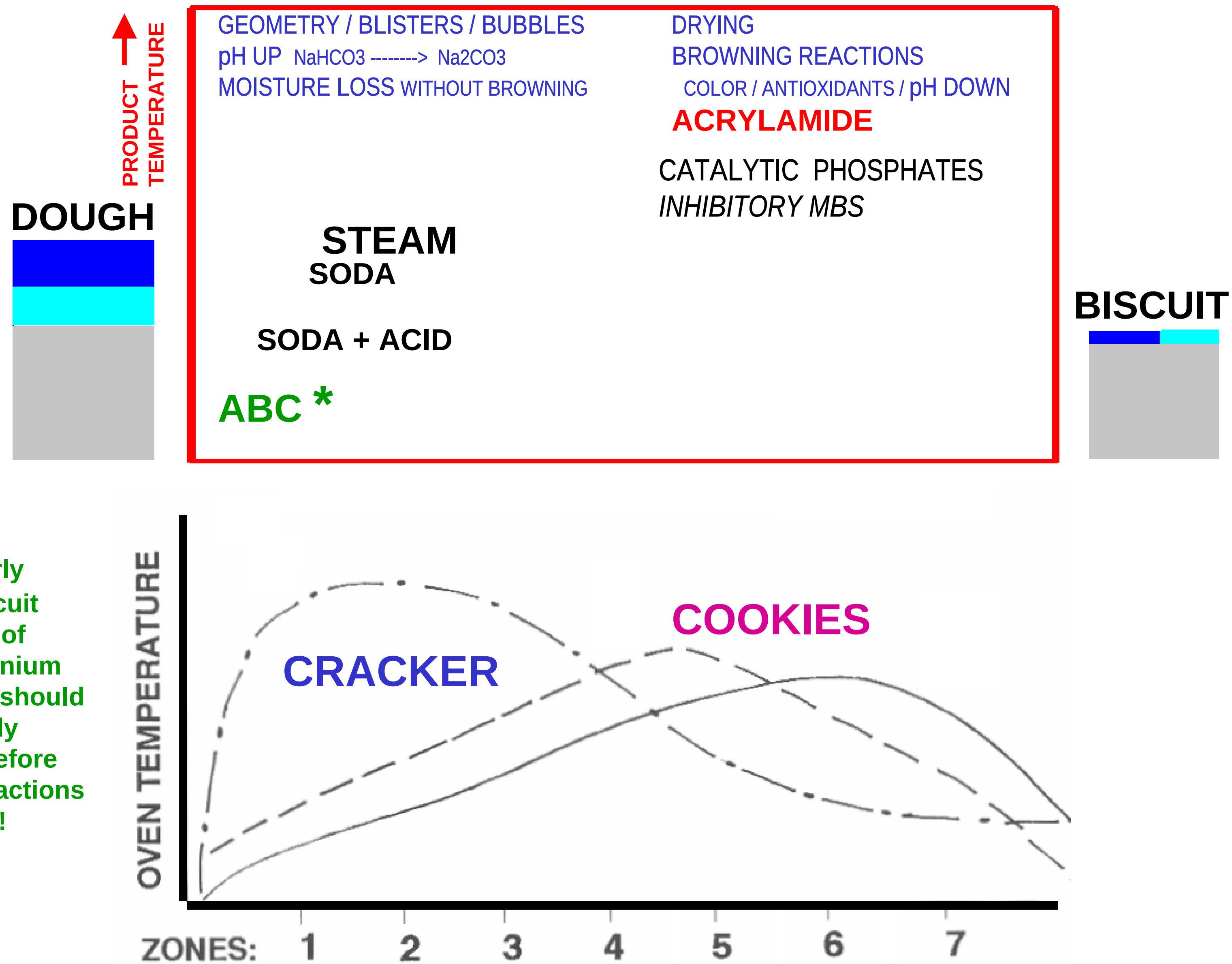
OVEN PROFILES AND BAKING REACTIONS

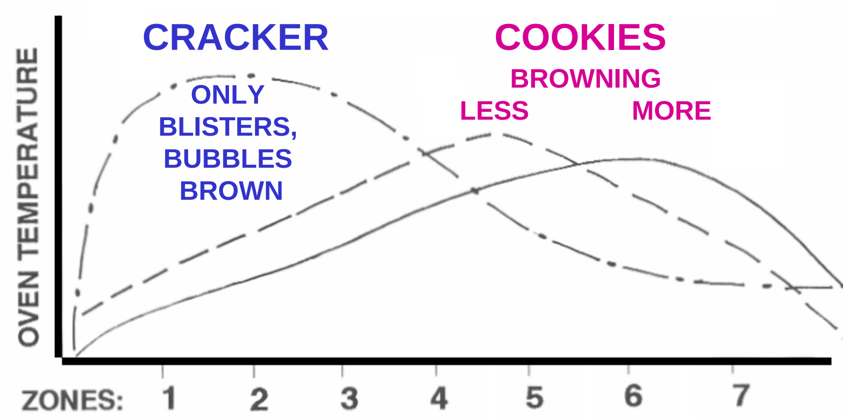


* When properly used for biscuit baking, ALL of of the ammonium bicarbonate should be completely volatilized before browning reactions are initiated !

OVEN PROFILES AND BISCUIT CATEGORY BAKING

ANIMAL CRACKER
BAKED AS A
CRACKER

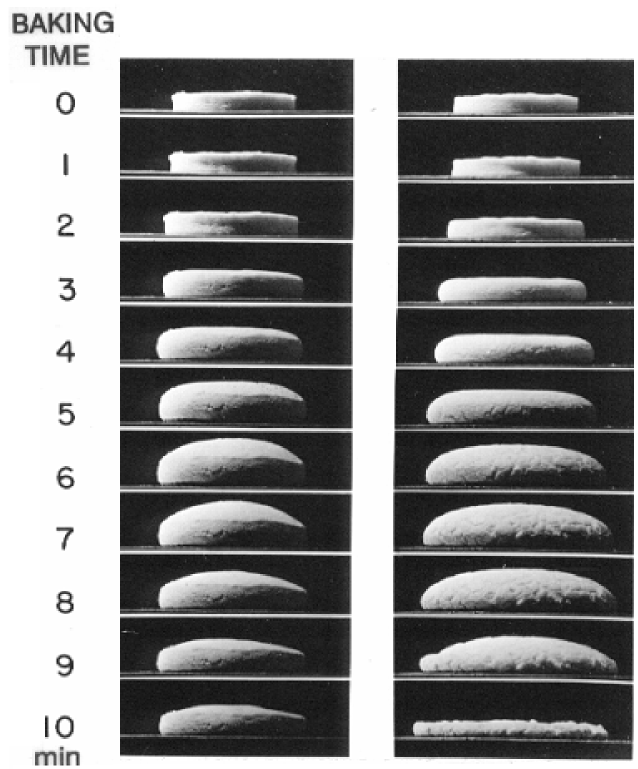
ACRYLAMIDE
70 ppb



ANIMAL CRACKER
BAKED AS A
COOKIE

ACRYLAMIDE
430 ppb

CRACKER BAKING MECHANISM



COOKIE BAKING MECHANISM

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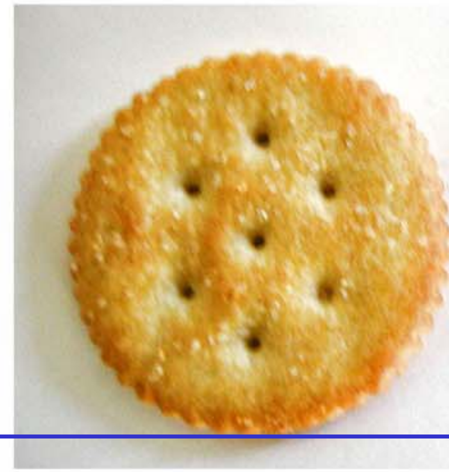
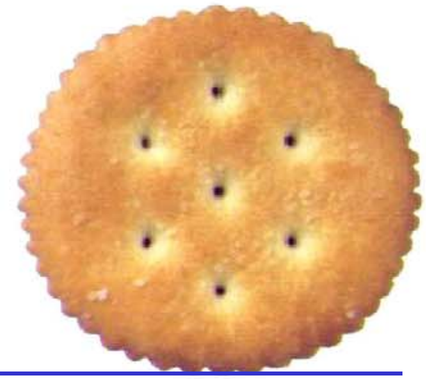
CRACKER BAKING PERFORMANCE
THE PROCESS IS A PRIMARY CRITICAL FACTOR !!

Cutter Length



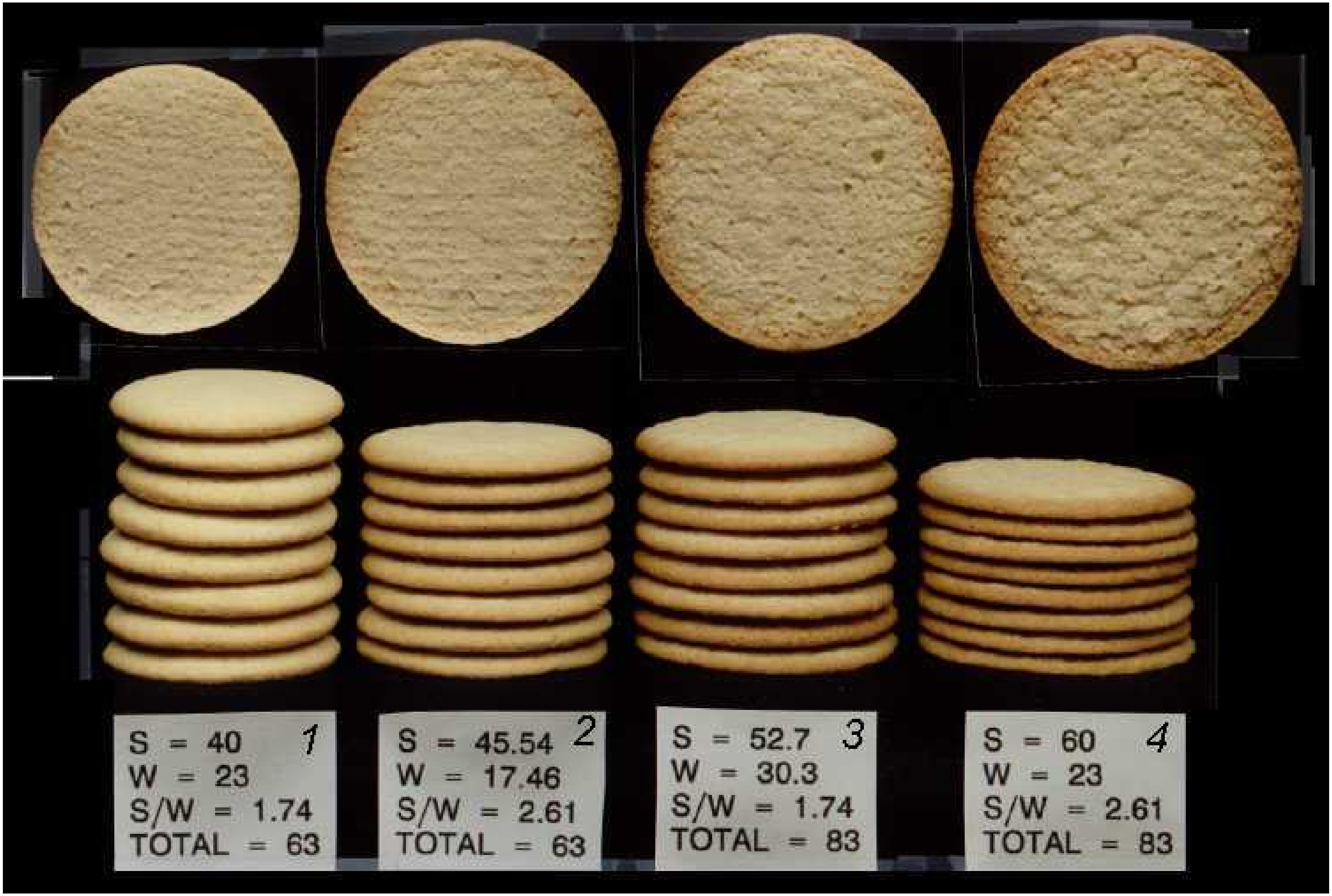


CONSTANT & OPTIMUM
Flour SRC & Alveo
Water temperature
Water level
Sugar level
~ 25%S 33 TS

ONLY VARIABLE IS MACHINING/ SHEETING ROLL GAP SETTINGS

STACK HEIGHT IS DIRECTLY RELATED TO SNAP-BACK CONTROLLED BY UNIAXIAL PULL ON DOUGH SHEET CAUSING EXTENSION OF GLUTENINS

Experimental design: ONLY sugar & water levels varied, from ~ 10-53 Wire-Cut to ~ 10-50D Sugar-Snap



Sucrose conc w/w	**63.5%**	**72.3%**	**63.5%**	**72.3%**
Dough firmness	**240**	**308 firmest**	**94 softest**	**156**

2 x 2 FACTORIAL DESIGN
% SUGAR CONCENTRATION vs TOTAL SOLVENT

3
W = 30.3
S = 52.7
LFRA = 94

S/W = 1.74
SW% = 63.5
TS WT = 83

S/W = 2.61
SW% = 72.3
TS WT = 83
Model for Sugar Snap

4
W = 23
S = 60
LFRA = 156

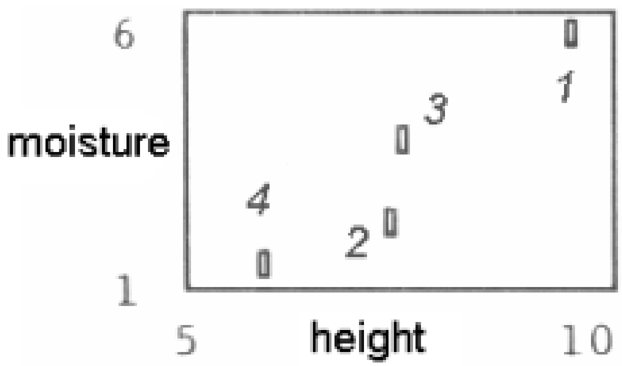
1
W = 23
S = 40
LFRA = 240

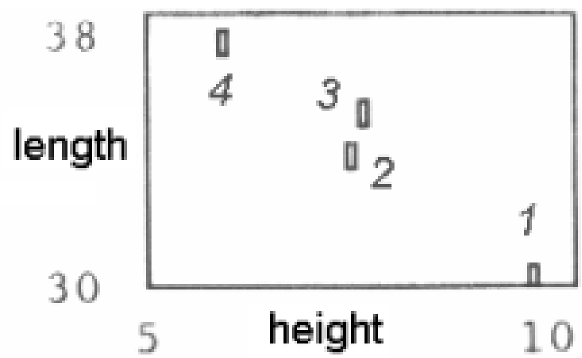
S/W = 1.74
SW% = 63.5
TS WT = 63
Model for Wire-Cut

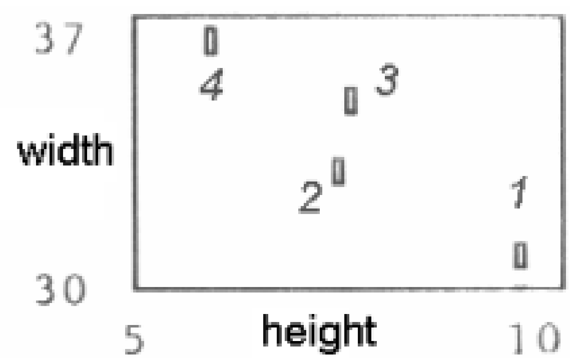
S/W = 2.61
SW% = 72.3
TS WT = 63

2
W = 17.46
S = 45.54
LFRA = 308

LFRA increases 3 4 1 2 BUT Diameter increases 1 2 3 4
Dough firmness does NOT predict product diameter !







All networks retain expansion volume and moisture content during baking.

SRC lactic acid predicts snap-back and height creation/retention.

Creep is related more to SRC sucrose & Na carbonate.

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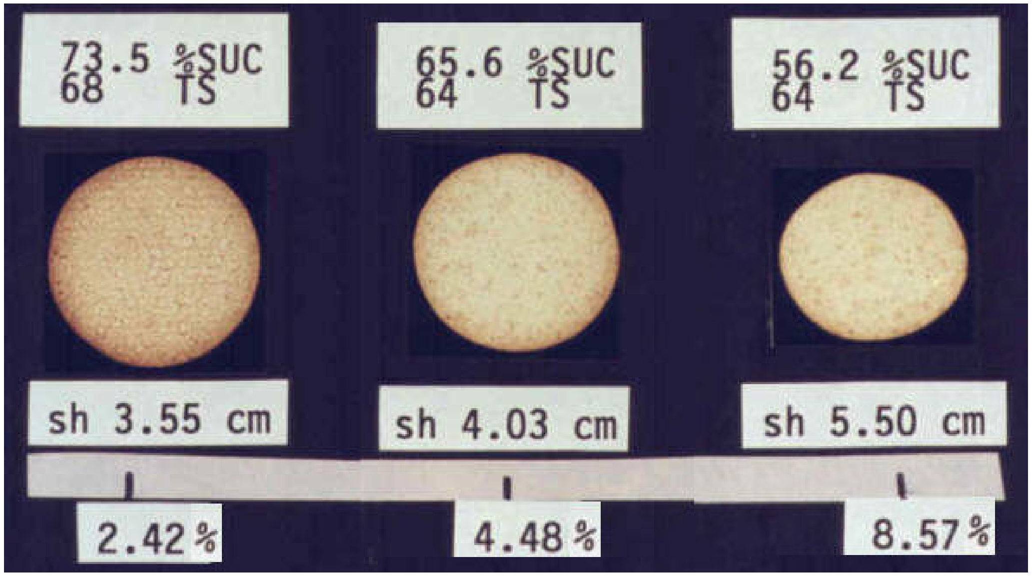
MOISTURE LOSS DURING BAKING AND BAKED PRODUCT GEOMETRY DEPEND ON % SUGAR CONCENTRATION & TOTAL SOLVENT AND DETERMINE PACKING EFFICIENCY & SHELFLIFE



FORMULA

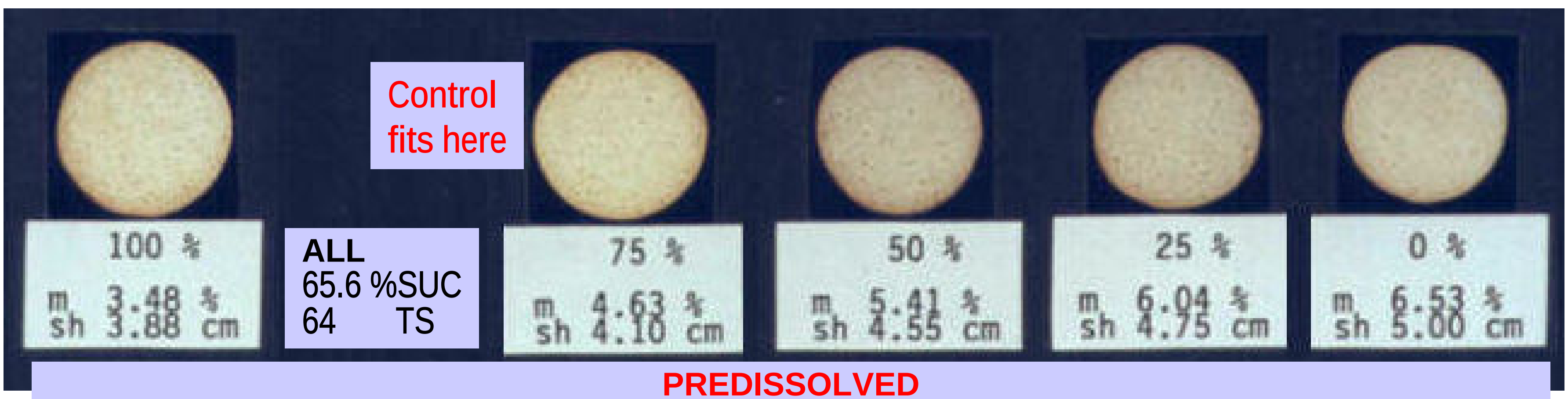
ADD *CRYSTALLINE* SUCROSE TO MIXING BOWL

PERFECT SYMMETRY → ROUND → SIGNIFICANT SNAP-BACK

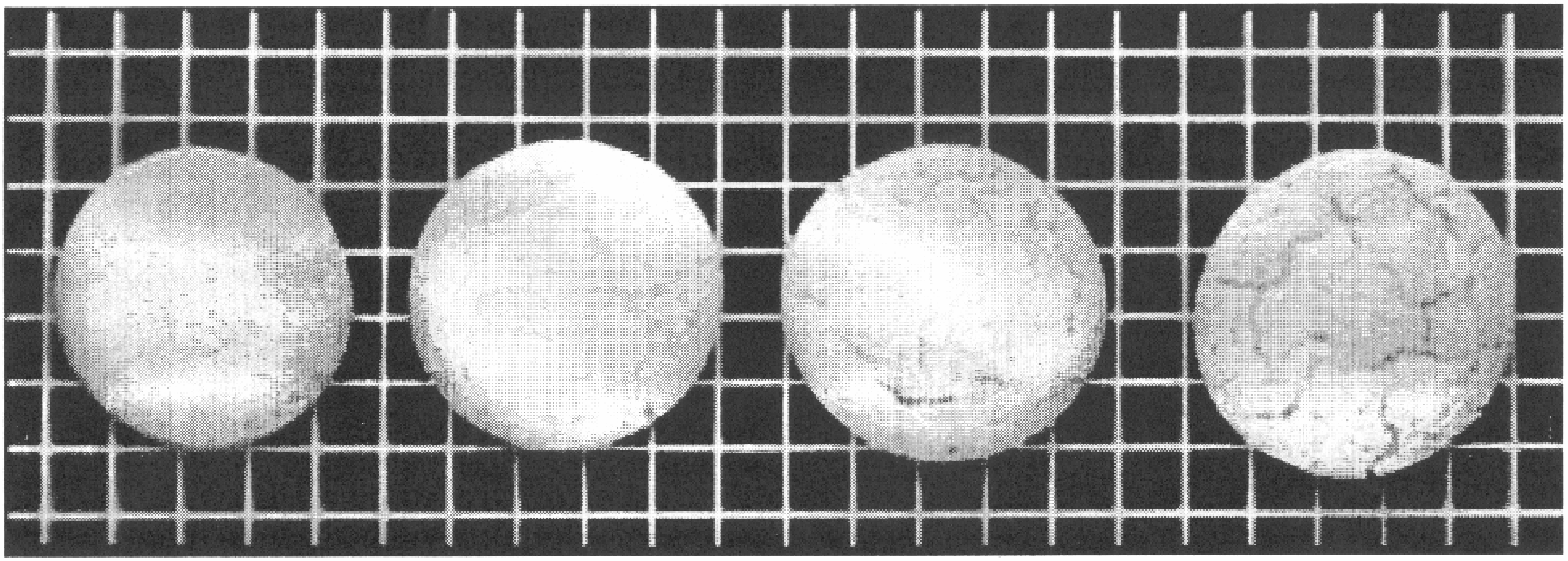
HEIGHT OF 4

FINAL BAKED MOISTURE CONTENT

USE *PREDISSOLVED* SUCROSE TO IDENTIFY EXTENT OF SUGAR DISSOLUTION DURING MIXING OF STANDARD CONTROL



COLLAPSE AND SURFACE CRACK



0.5 1.0 1.5 2.0

Comparison of cookies with different levels of sodium bicarbonate (lb per flour cwt) using a constant level of acid in the formula to generate corresponding extents of vertical expansion during baking, in order to demonstrate that the cause of cookie surface crack is COLLAPSE, not sugar recrystallization nor surface drying.

EFFECT OF SUGAR TYPE: AACC 10-50D

SUGAR SNAP COOKIE BAKING ⇒ *VERY HIGH %S **

Perfect Symmetry

⇒

No gluten development during mixing

Small width

⇒

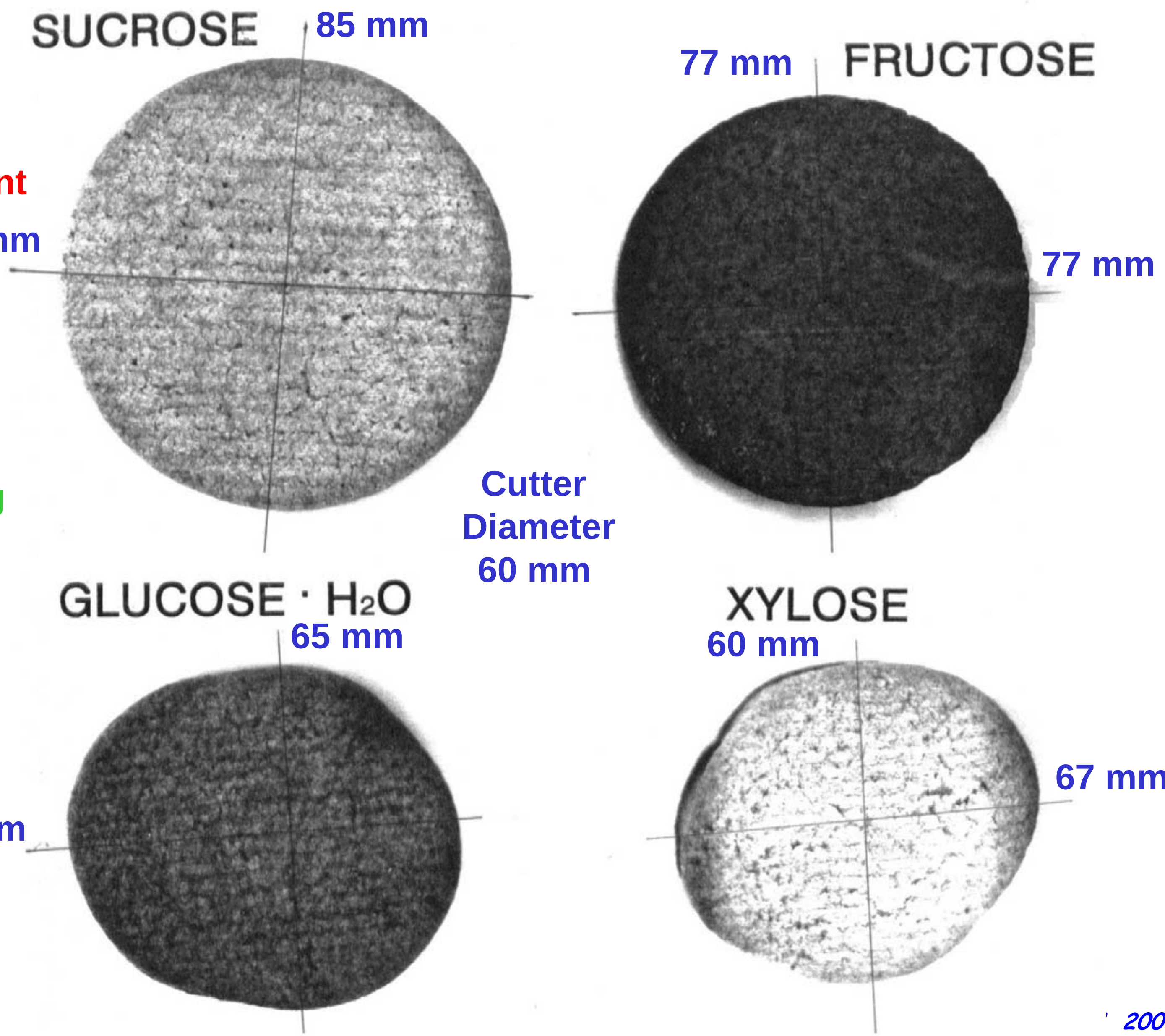
Starch gelatinzation/ pasting during baking

Asymmetry L << W

⇒

Gluten development during mixing

→ **"Snap-back"**



*** *Very high %S***
(sugar concentration) to exaggerate
***sugar* functionality**

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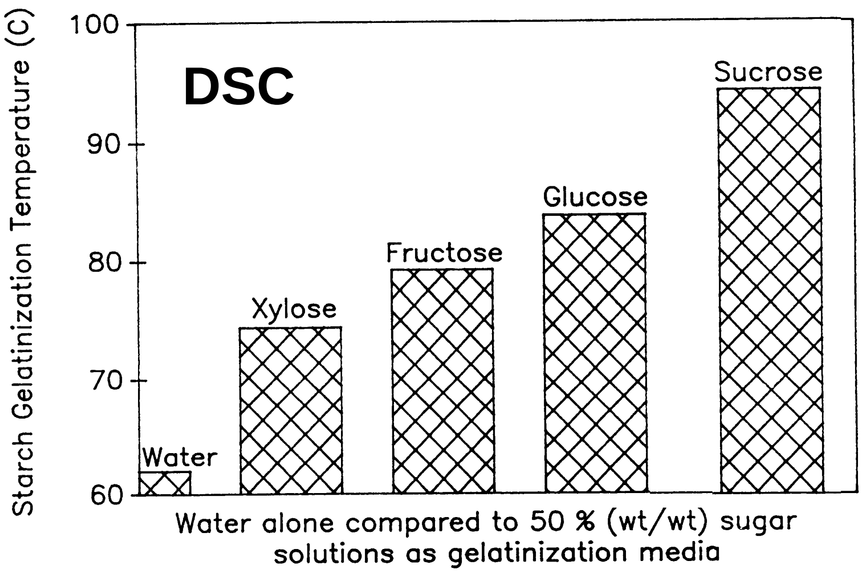
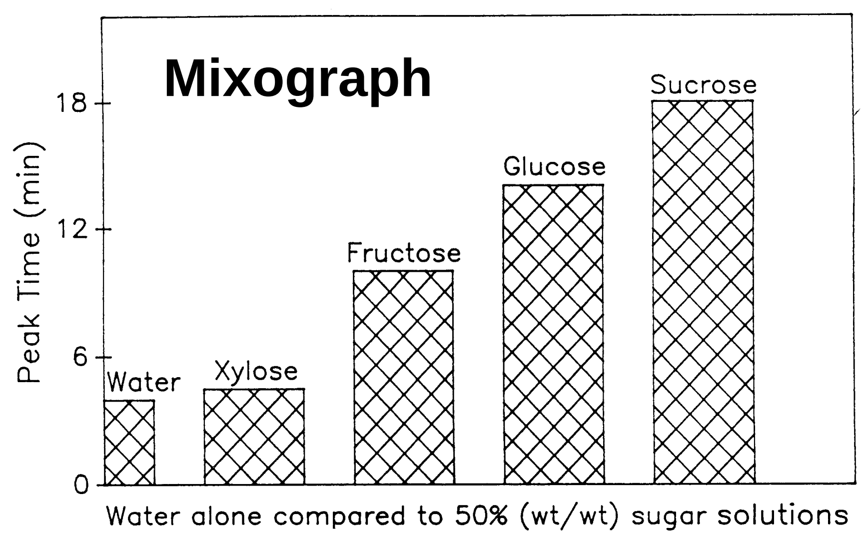
Effect of sugar type at constant concentration

on starch during baking



on gluten during mixing



EFFECT OF SUGAR PARTICLE SIZE:

AACC 10-50D SUGAR SNAP COOKIE BAKING ⟹ *VERY HIGH %S* *

Same flour, same formula, same process …..
Sucrose ONLY → same solubility in water …..
So baking performance is ONLY effect of sugar particle size …..

Larger particle size delays sugar dissolution during mixing AND EVEN during baking !!!!
→ Greater starch gelatinization/pasting → smaller cookie size

BUT sugar snap formula → %S great enough to prevent gluten development during mixing
→ Danger = learn about sugar functionality, NOT flour functionality with 10-50D

MEDIUM **EXTRA FINE** **BAKER'S SPECIAL**

* *Very high %S* (sugar concentration) to exaggerate *sugar* functionality

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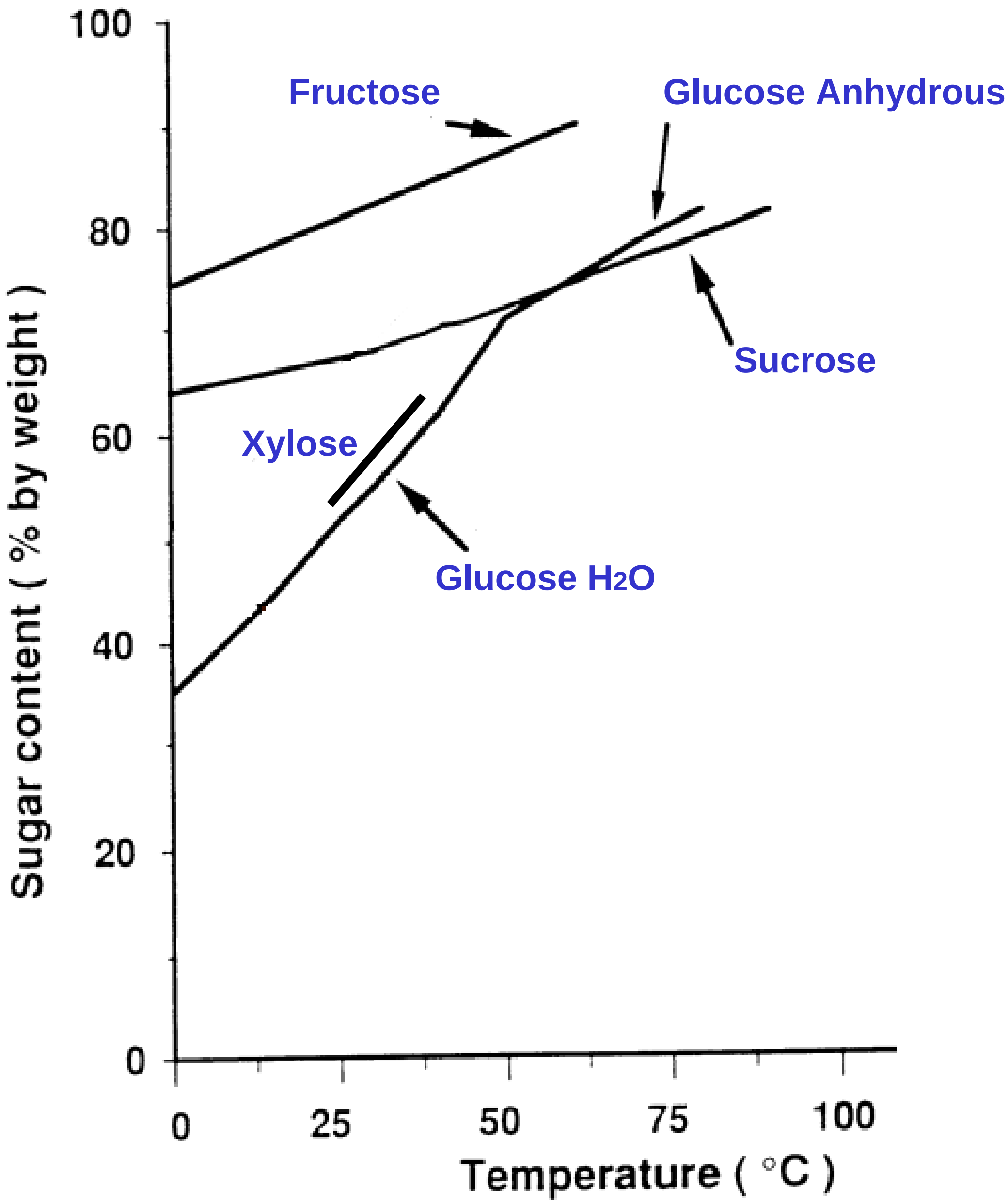
EQUILIBRIUM **EXTENT** OF SUGAR DISSOLUTION = SOLUBILITY
DEPENDS ONLY ON TEMPERATURE AND SUGAR TYPE



BUT **RATE**
OF SUGAR DISSOLUTION
DEPENDS ON SOLUBILITY
AND PARTICLE SIZE

PARTICLE SIZE
IN THIS EXPERIMENT

S > F >> G & X

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LINK FUNCTIONAL COMPONENTS TO FLOUR SPECIFICATIONS?

[WHC ~ SRC water g H_2O / g dry Component]

Moisture

[2.8] Gluten

Protein

[10] Pentosans

Ash

Acid viscosity

Starch

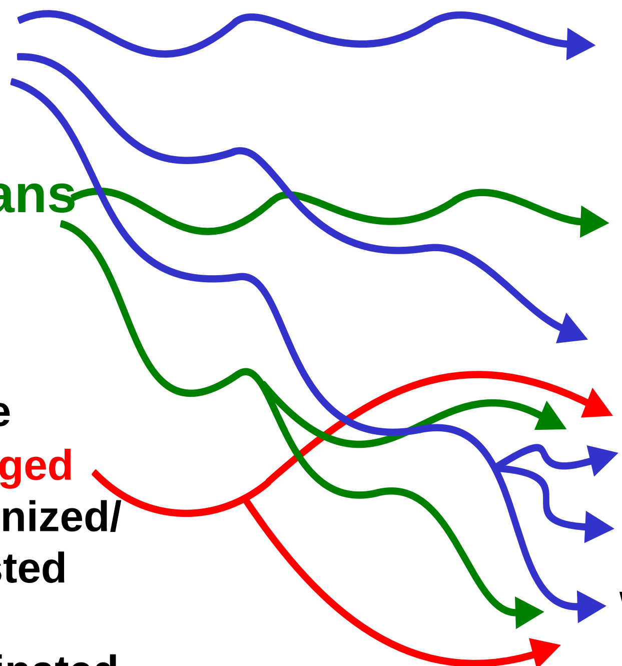
[0.3 - 0.45] Native

[1.5 - 10] Damaged

[> 10] Gelatinized/ pasted

Waxy

Chlorinated



P

L

W

Traditional Alveograph

BUT Protein

[2.8] Gluten vs Nongluten [negligible]

Gliadins vs Glutenins *rye gene translocation ?*

Film-formers, NOT networks *Network-formers*

Pentosans ≠ Ash

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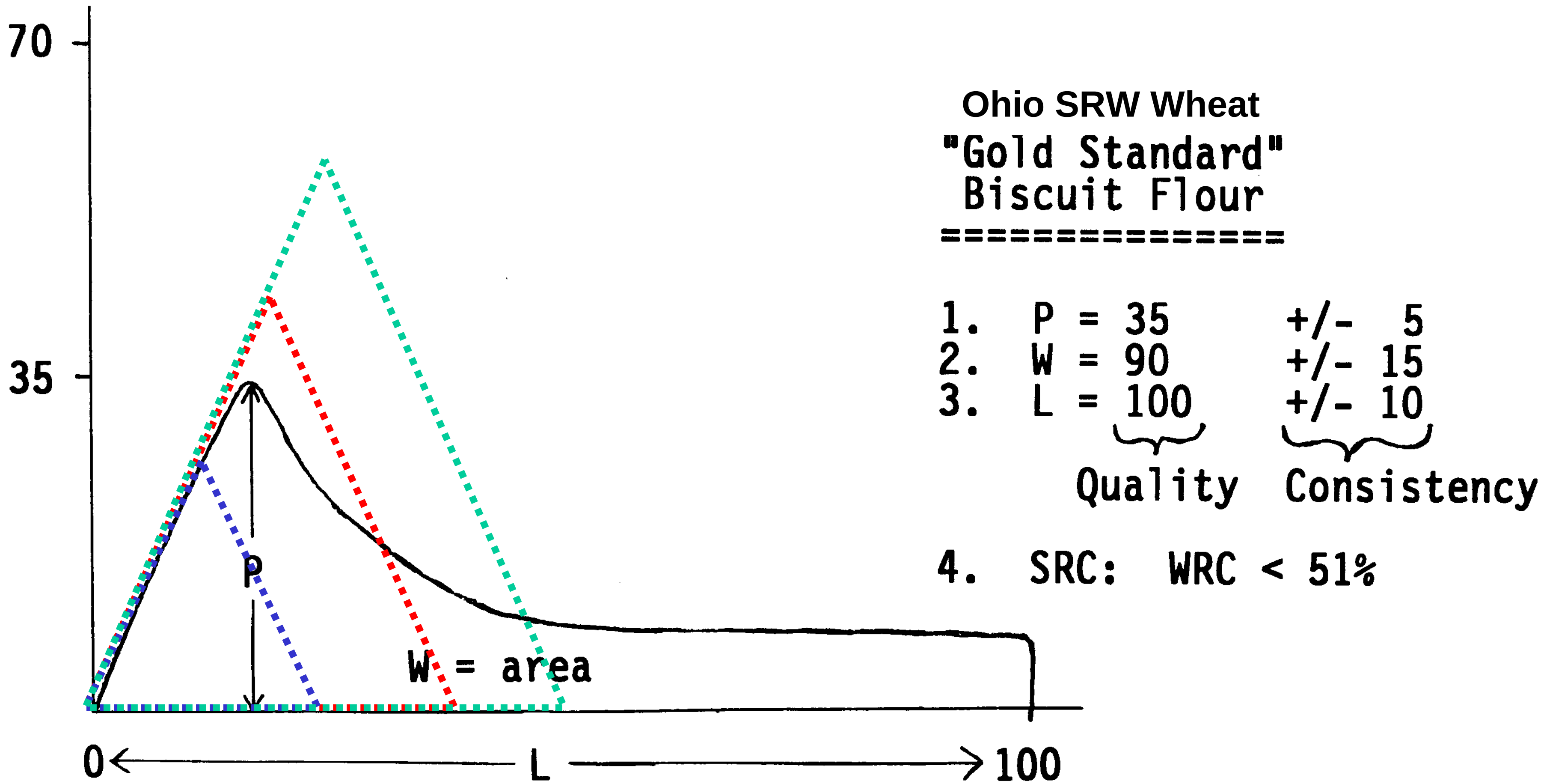
INTERPRETATION OF *TRADITIONAL* ALVEOGRAM

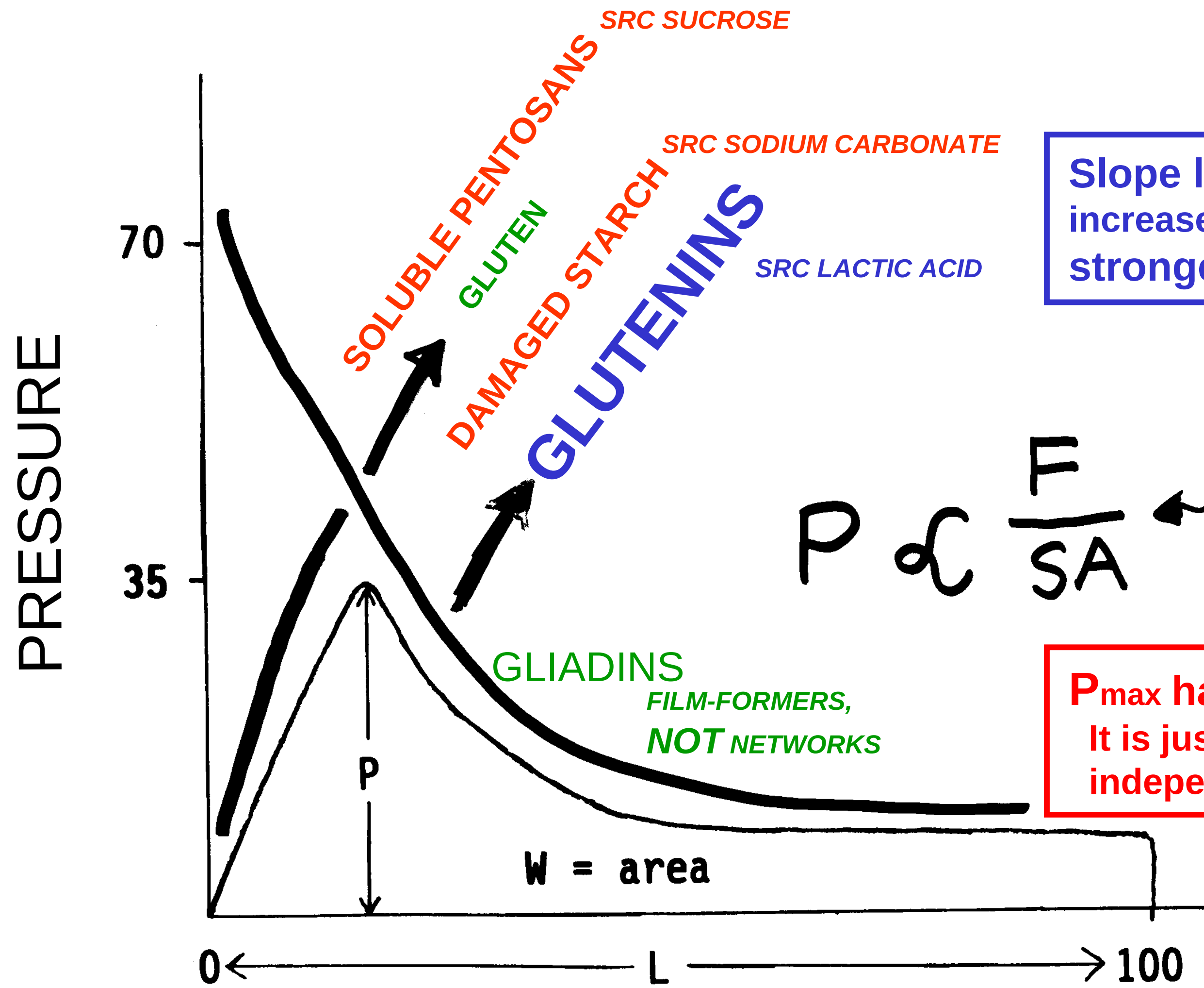
Visualize a triangle for rationale in following slides:

the greater the Pmax, the greater the L at Pmax, so we are looking for effects beyond that simple result of the geometry of the alveogram shape.



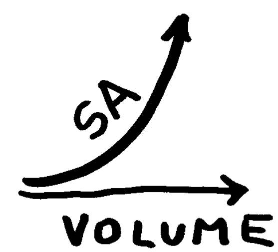
WHAT DO WE LOOK FOR IN THE ALVEOGRAM ?

LOCATE CONTRIBUTIONS DURING BUBBLE EXPANSION FROM FLOUR FUNCTIONAL COMPONENTS



Slope less negative than due to increase in bubble surface area ==> stronger, more orientable glutenins

$$P \propto \frac{F}{SA}$$



P_{max} has no functional meaning !!
It is just the coincidence of two independent simultaneous processes:

1) yield stress resistance to initial expansion
2) bubble is expanding at a constant VOLUME rate, so surface area increases as shown

TIME OF BUBBLE EXPANSION => BUBBLE VOLUME
1 sec = 5.5 mm of L and 1 mm of L = 5.0505 cc of air

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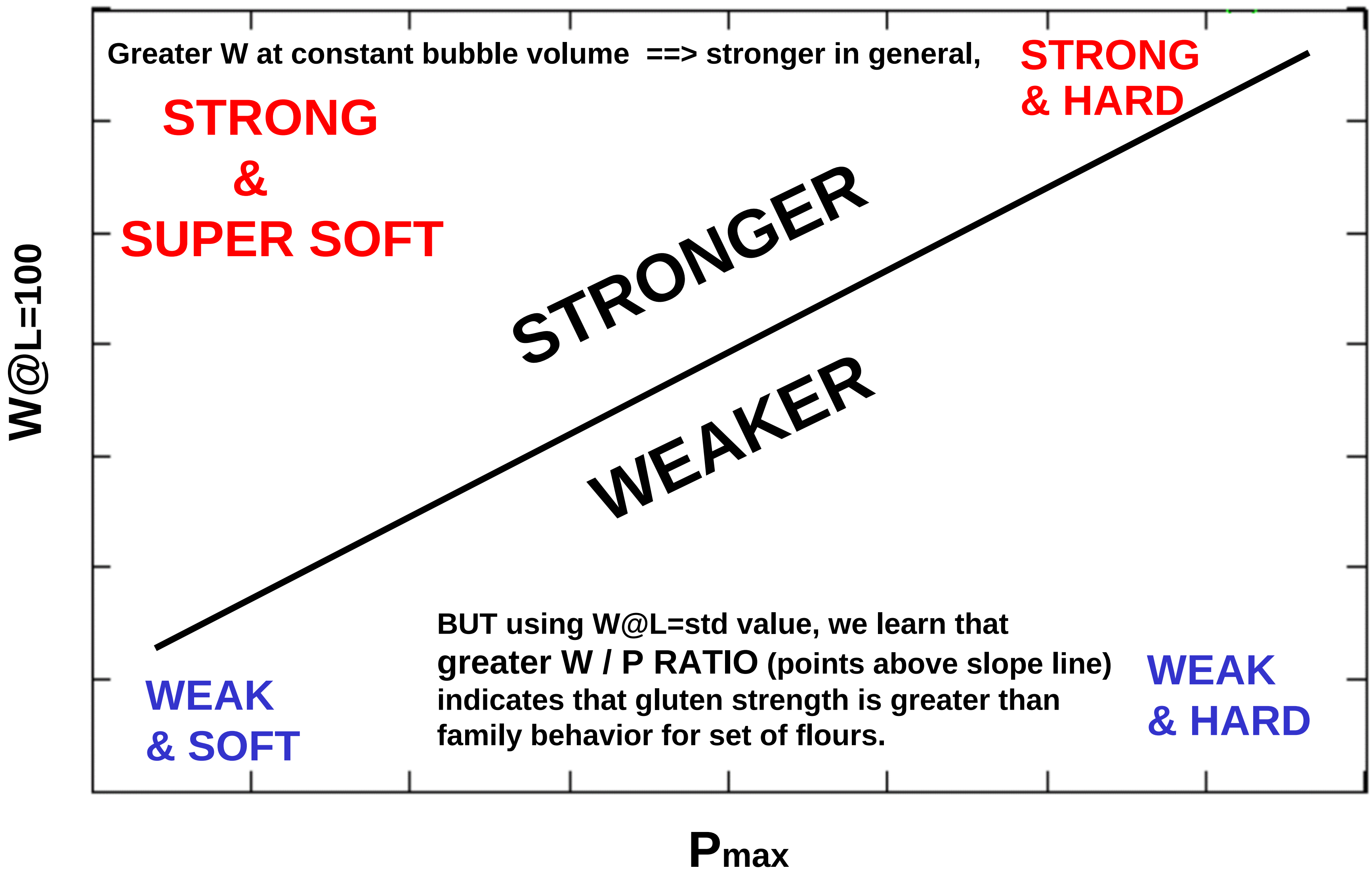
W AT STANDARD L VALUE vs P_{max}

STANDARD BUBBLE VOLUME CALCULATED AT STANDARD L VALUE

FOR L = 100 BUBBLE VOLUME ~ 505cc

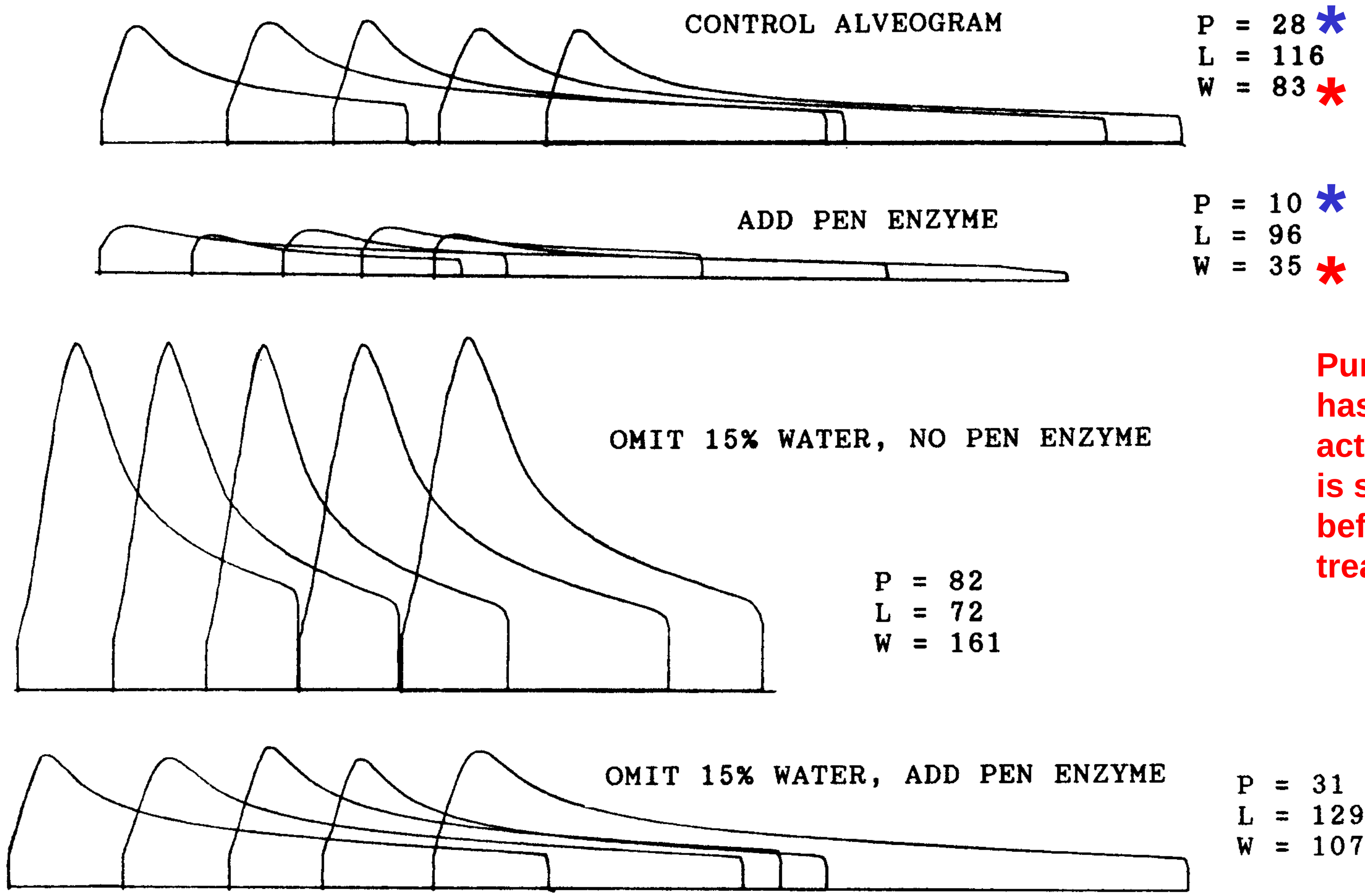


ROLE OF PEN ENZYME IN FLOUR FUNCTIONALITY

EFFECT OF PEN WATER COMPENSATION

[Slade and Levine (1993h)]

OHIO SRW-BASED FLOUR



SO *NOT* A STRONG FLOUR

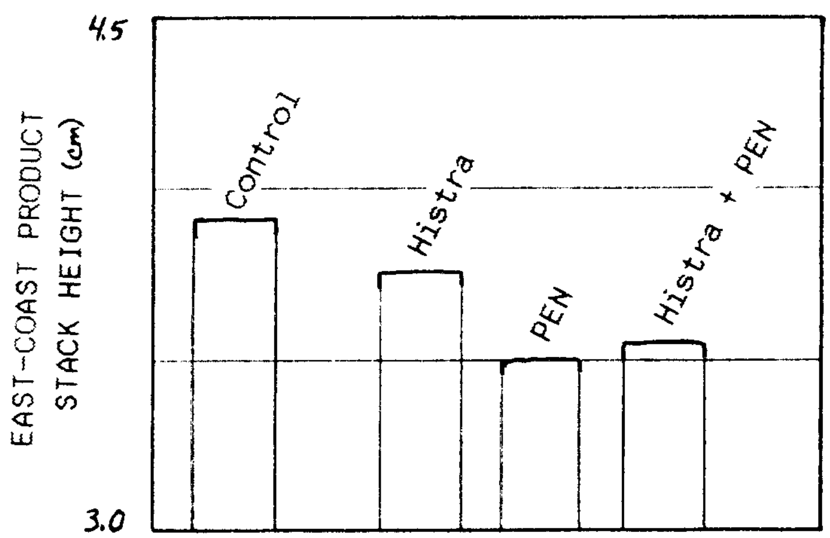
Pure pentosanase has no protease activity, so gluten is still the same as before enzyme treatment !

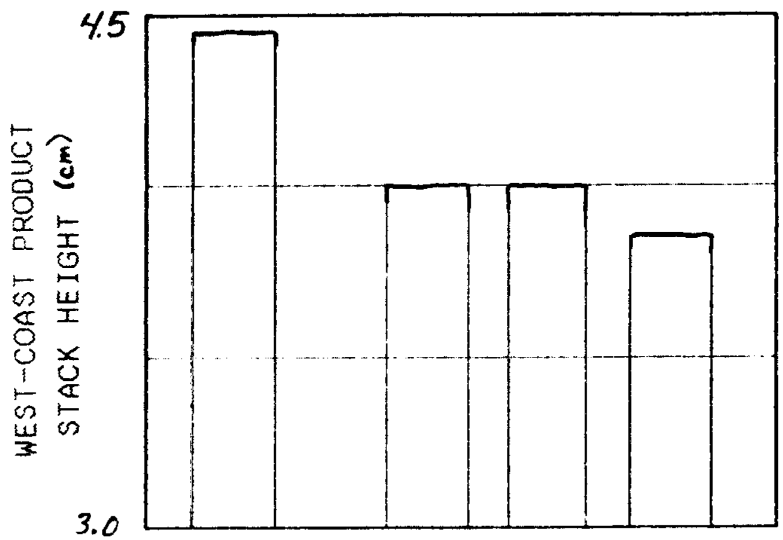
MODIFICATION OF FLOUR FUNCTIONALITY BY ADDITION OF ENZYMES TO A COOKIE DOUGH

HISTRA = α-AMYLASE **PEN = PENTOSANASE (water accessible AXase)**

EFFECT OF ENZYMES ON STACK HEIGHT OF

MODEL WIRE-CUT (AACC 10-53) COOKIES





[Slade and Levine (1993h)]

POSSIBLE ACTIONS - PNW SW CLUB-BASED FLOUR + PEN & HISTRA

REPLACE PNW SWC BY INTERMOUNTAIN SW

HOW CAN THE TRADITIONAL ALVEOGRAM CAUSE CONFUSION FOR RUNNING A MILL AND SATISFYING CUSTOMERS ?

VERY DIFFERENT BISCUIT FLOURS CAN BE MILLED FROM VARYING WHEAT BLENDS,

BUT THEY CAN HAVE THE SAME ALVEO P_{max} AND SRC H2O (or AWRC) VALUES ......

% 25R26 in SRW Blend	P_{max}	SRC H_2O	SRC LA	P GLUTEN	SRC NaC	P DAM ST	SRC Suc	P WA PENT
10	36	53	**80**	9	**70**	12	**98**	15
15	36	53	85	12	70	12	93	12
20	36	53	90	15	65	9	93	12
25	36	53	**95**	18	**65**	9	**88**	9

SO, THE SAME ALVEOGRAPH P_{max} VALUE CAN BE MEASURED FOR 4 FLOURS WITH VERY DIFFERENT PERFORMANCE FOR PROCESSIBILITY, PRODUCT QUALITY, BREAKAGE, AND SHELFLIFE !

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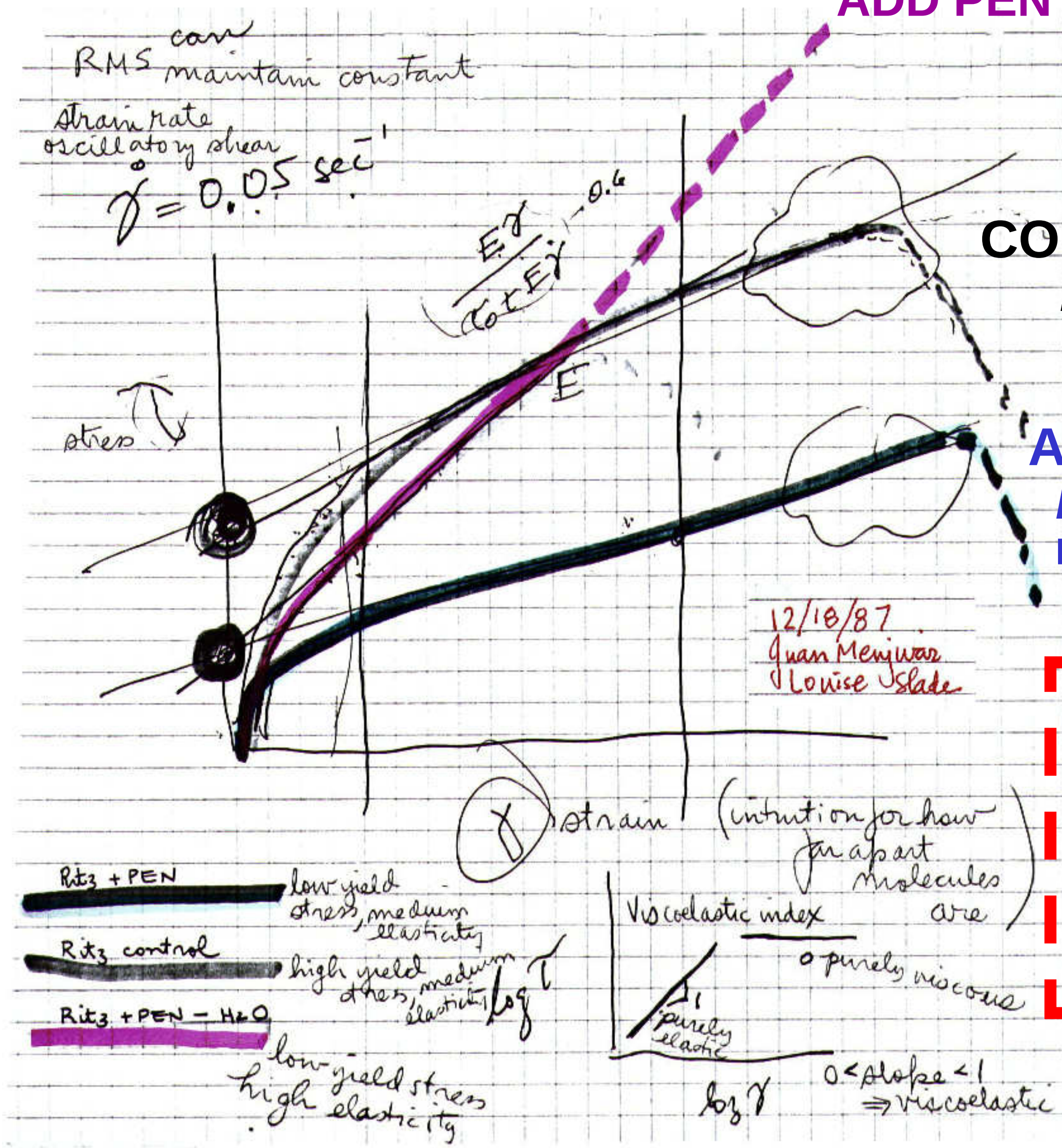
EFFECT OF PENTOSANASE (WA-AXase) ON FLOUR FUNCTIONALITY IN A SNACK CRACKER DOUGH --- "TRUE" RHEOLOGY

RHEOMETRICS MECHANICAL SPECTROMETER   STRESS-STRAIN PROFILES



ADD PEN ENZYME & DECREASE WATER LEVEL

LOW YIELD STRESS

HIGH ELASTIC RECOVERY

CONTROL DOUGH

HIGH YIELD STRESS

MEDIUM ELASTIC RECOVERY

ADD PEN ENZYME

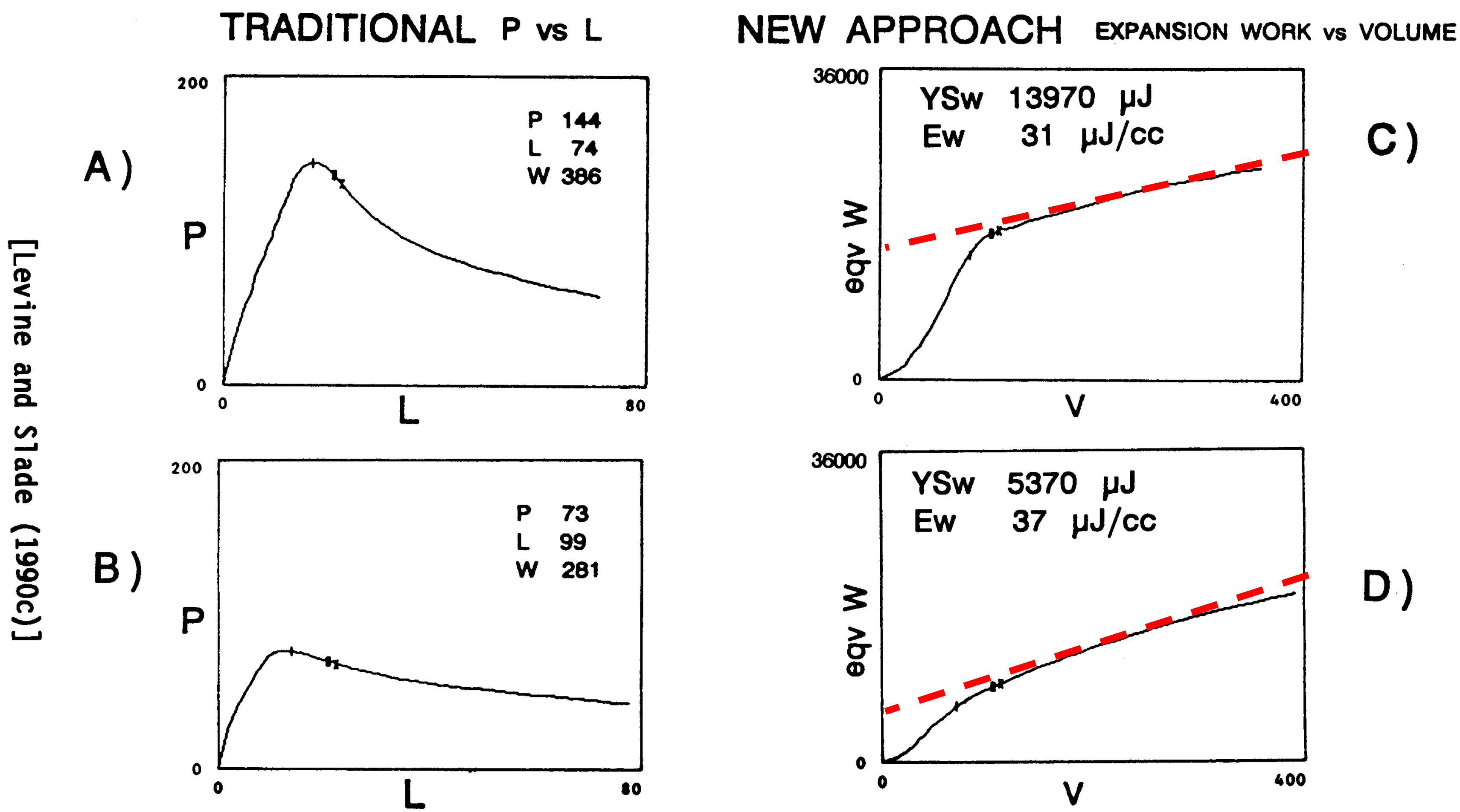
LOW YIELD STRESS

MEDIUM ELASTIC RECOVERY

CONCEPTUAL BASIS FOR TRANSFORMATION FROM TRADITIONAL ALVEOGRAM TO STRESS-STRAIN ALVEOGRAPHY PROFILES

If we had analog alveograms to digitize, or better digital alveograms than the AlveoLink provides, we could transform the P vs L profiles to Equivalent Work vs Volume

A NEW WAY TO LOOK AT ALVEOGRAMS



A and B) Traditional alveograph P vs. L curves for two samples of hard wheat flour with significantly different pentosan contents but equal gluten contents;
C and D) the conversion to corresponding plots of equivalent expansion work vs. bubble volume for the respective alveograph data in parts A and B.

Separate parameters analogous to yield stress, in units of μJ, and to elasticity, in units of μJ/cc, are obtained from the intercept and slope, respectively, of the notional stress-strain curves in parts C and D.

AACC 56-11 SRC

4 STANDARD DIAGNOSTIC SOLVENTS USED AT 5X EXCESS TO AVOID KINETIC EFFECTS ==> CAN *NOT* COMPARE TO RHEOLOGICAL METHODS

Reference
(all components to varying extents)

Deionized Water
≤ 51%

exaggerate

5% Lactic acid
≥ 87%

but DESWELL damaged starch and pentosans !!

Glutenins

67% Ohio SRW Chlorinated or RyeGT
177% Can HRS

EFFECT OF MILLING EXTRACTION RATE !
Higher extraction rate
===>
increase
SRC W
SRC Na C
SRC Suc
decrease
SRC L Ac

exaggerate

50% Sucrose
≤ 89%

Pentosans

86% Ont SWW
126% Can HRS & Can patent durum

exaggerate

5% Sodium Carbonate
≤ 64%

Damaged starch

64% Ohio SRW
123% Can patent durum

Flour **Performance** *pattern* of SRC values appropriate for end-use

Flour **Conformance** lot-to-lot *variation* in SRC values

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Interpretation of the Results

Flour Performance

- related to **pattern of SRC values** for different end-use applications

	SRC (%)			
	Water	**Lactic acid (glutenins)**	**Sodium carbonate (damaged starch)**	**Sucrose (pentosans)**
Good cookie flour	**≤ 51%**	**≥ 87%**	**≤ 64%**	**≤ 89%**
	± 0.5%	*± 1 %*	*± 0.5%*	*± 1%*
Good flour for sponge and dough system	**≤ 57%**	**≥ 100%**	**≤ 72%**	**≤ 96%**

Flour Conformance

- related to variation of SRC values from lot to lot

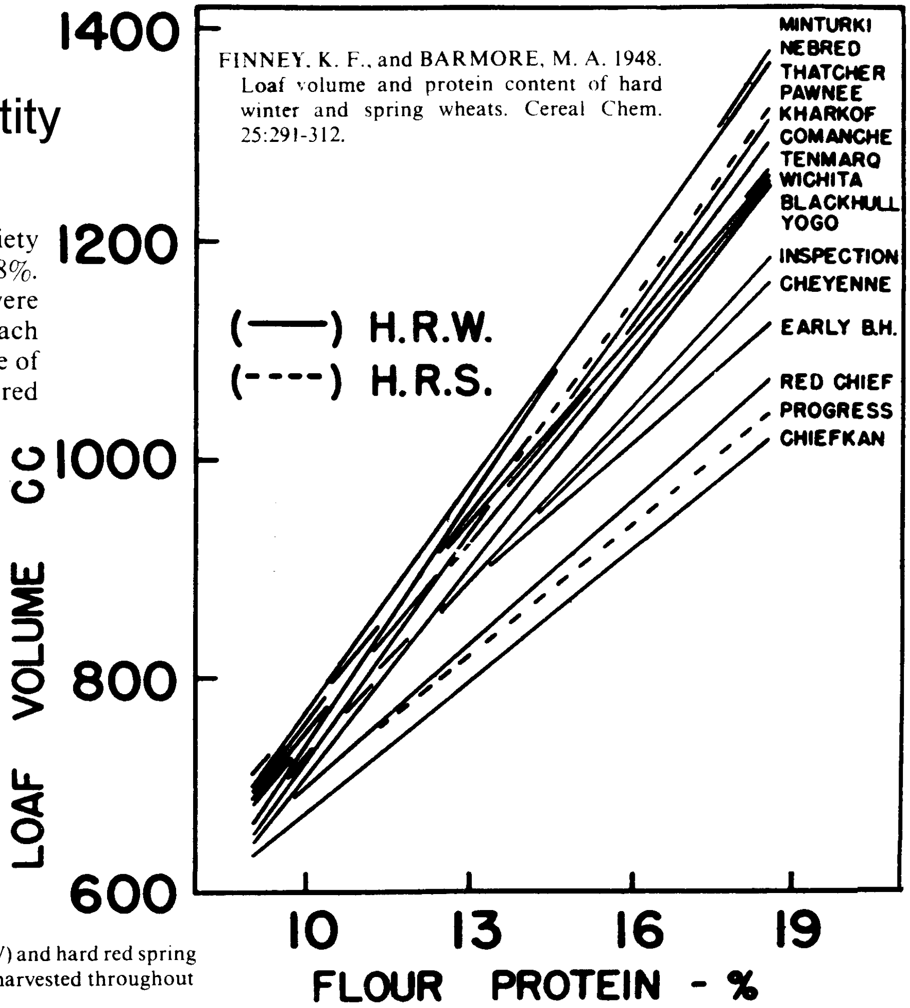
WHEN FLOUR IS MILLED FROM AN UNIDENTIFIED BLEND OF WHEAT VARIETIES, THERE IS NO RELATIONSHIP BETWEEN PROTEIN CONTENT AND FLOUR PERFORMANCE.

EVEN FOR A SINGLE WHEAT, MILLED TO DIFFERENT EXTENTS OF EXTRACTION, THERE IS NO RELATIONSHIP BETWEEN PROTEIN CONTENT AND FLOUR PERFORMANCE.

Flour Protein Quality - Not Quantity

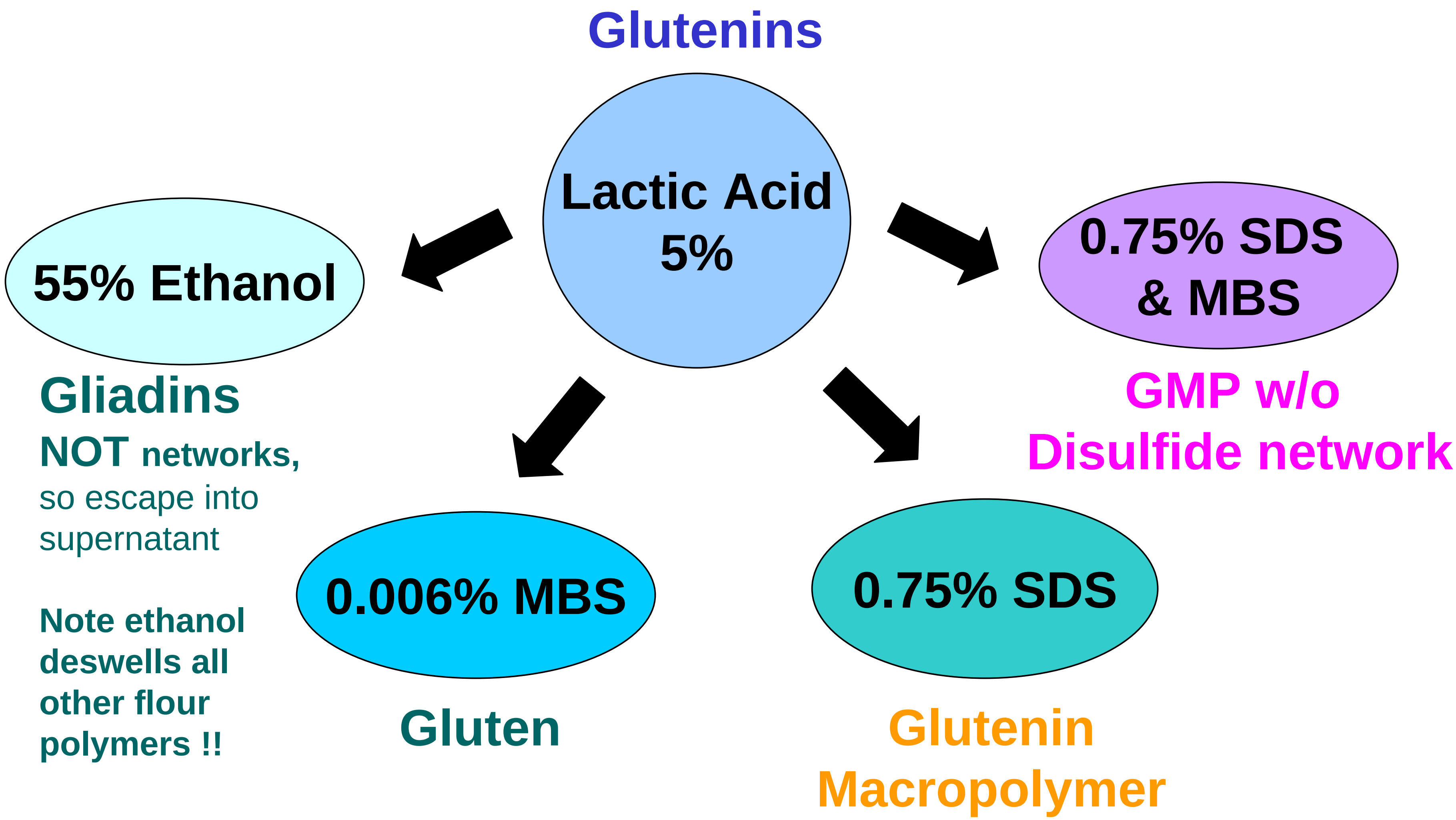
The relation between loaf volume and flour protein for each variety was linear within the limits of protein encountered, approximately 8.5–18%. Regression lines for loaf volume versus protein content for any variety were similar for four crop years, indicating that the bread-baking quality of each variety was essentially the same in different years. Again, the level and slope of the regression lines for loaf volume on protein content for the varieties differed significantly, indicating differences between varieties in protein quality.

AT A GIVEN PROTEIN CONTENT, FLOUR PERFORMANCE CANNOT BE PREDICTED FROM WHEAT TYPE, WHEN COMPARING HRW TO HRS WHEAT FLOURS.



Loaf volume-protein content regression lines for hard red winter (HRW) and hard red spring (HRS) wheat varieties. Each variety regression line represents many samples harvested throughout the Great Plains during several crop years.

4 SUPPLEMENTAL DIAGNOSTIC SOLVENTS



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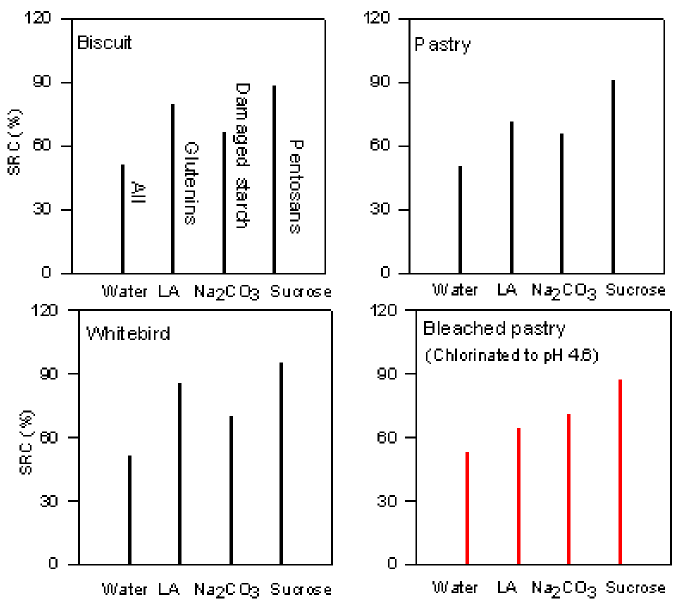
FLOUR FUNCTIONALITY = PATTERN OF SRC VALUES



BAKING PERFORMANCE = PATTERN OF FORMULA, PROCESS, AND PRODUCT

(geometry, topography, color, pH, texture, shelflife)

***Except** when starch pasting is PREDOMINANT feature of baking performance ! Chlorinated and waxy starches*

SRC PATTERNS — *Predict* — BAKING PATTERNS

SRC				Sample	Baking	AACC 10-53 Wirecut		
Water	Lactic Acid	Sodium carbonate	Sucrose		Wt.loss (%)	Length (cm)	Width (cm)	Height (cm)
51.3	79.7	66.1	88.3	Biscuit	14.9	33.9	33.9	3.5
50.4	71.3	65.9	90.7	Pastry	14.3	33.4	33.5	3.7
51.0	85.2	70.1	94.8	Whitebird	13.7	32.0	31.8	4.0
52.8	**63.9**	70.4	87.0	Bleached pH 4.6 Pastry	11.6	28.3	28.3	5.3

COOKIE vs CRACKER BAKING --

THAT'S THE DIFFERENCE *!*

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