Standardization of Low Protein Wheat Flour

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Baking Properties of Low-Protein Flour

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- **Dough preparation**
  - Lower water absorption
  - Sticky dough surface
  - Little silkiness
  - Bucky dough
  - Reduced extensibility
  - Lower kneading and fermentation tolerance
- **Baking**
  - Reduced oven rise
- **Bread**
  - Lower volume yield
  - Increased tendency of sidewall collapse
  - Weak crumb structure
  - Prolonged crustiness (+)

Wheat Protein Affecting Bread-Making Properties

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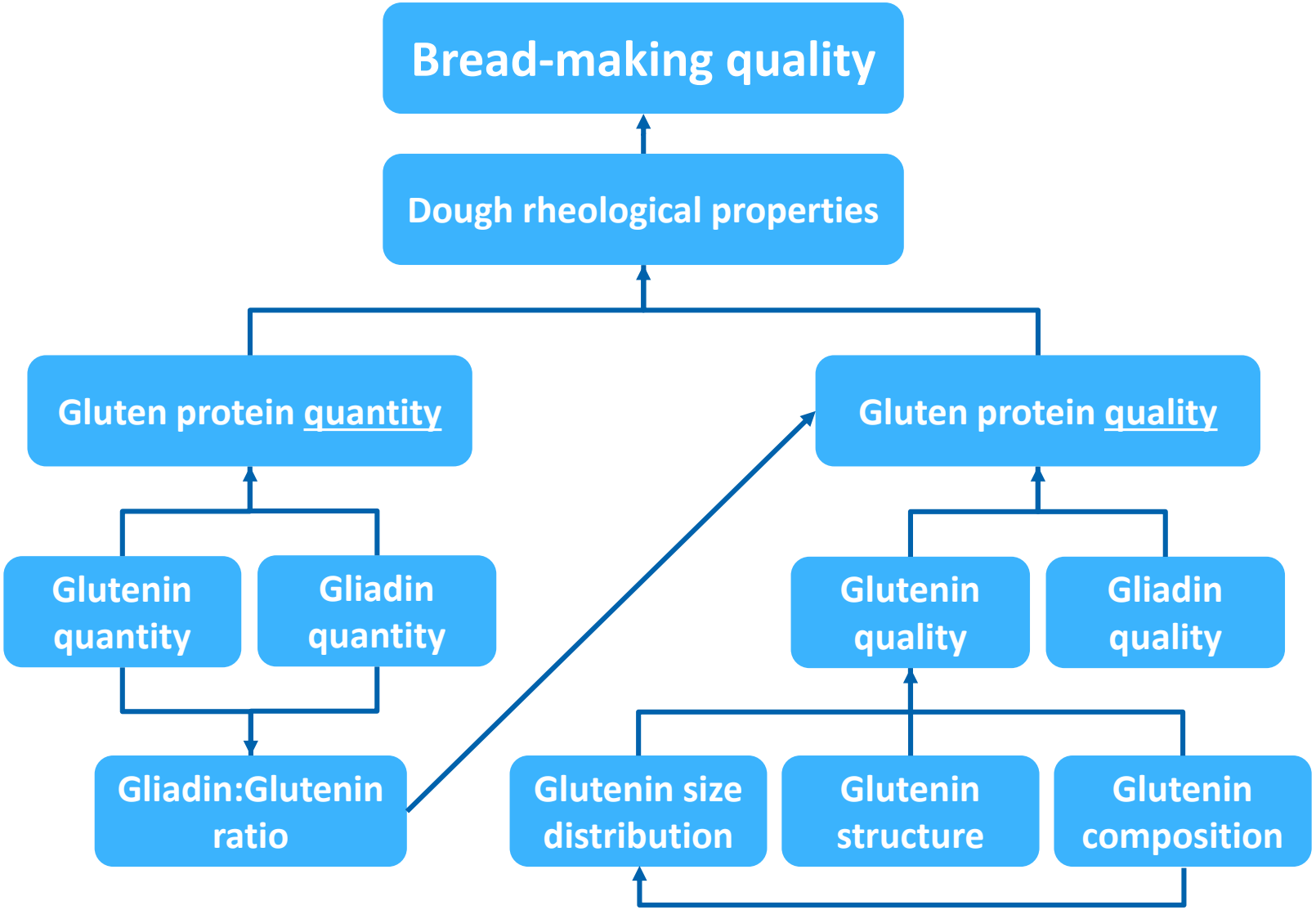

Modif. from Veraverbeke and Delcour, 2002

Gliadin and Glutenin Mechanical Properties

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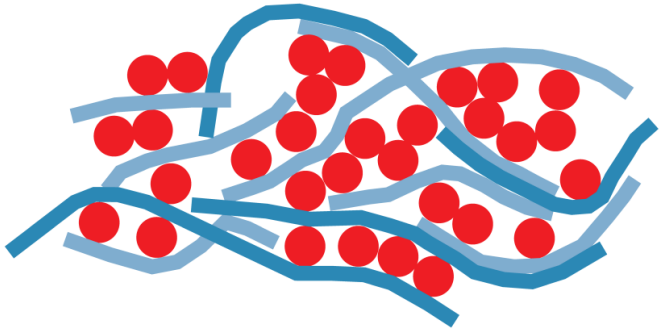
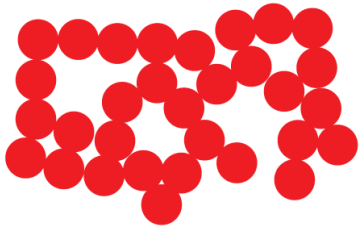
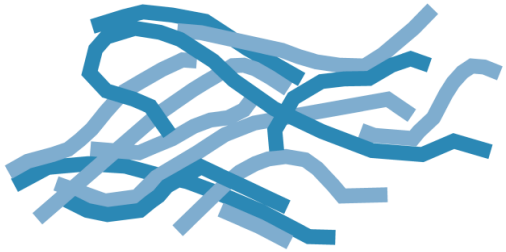




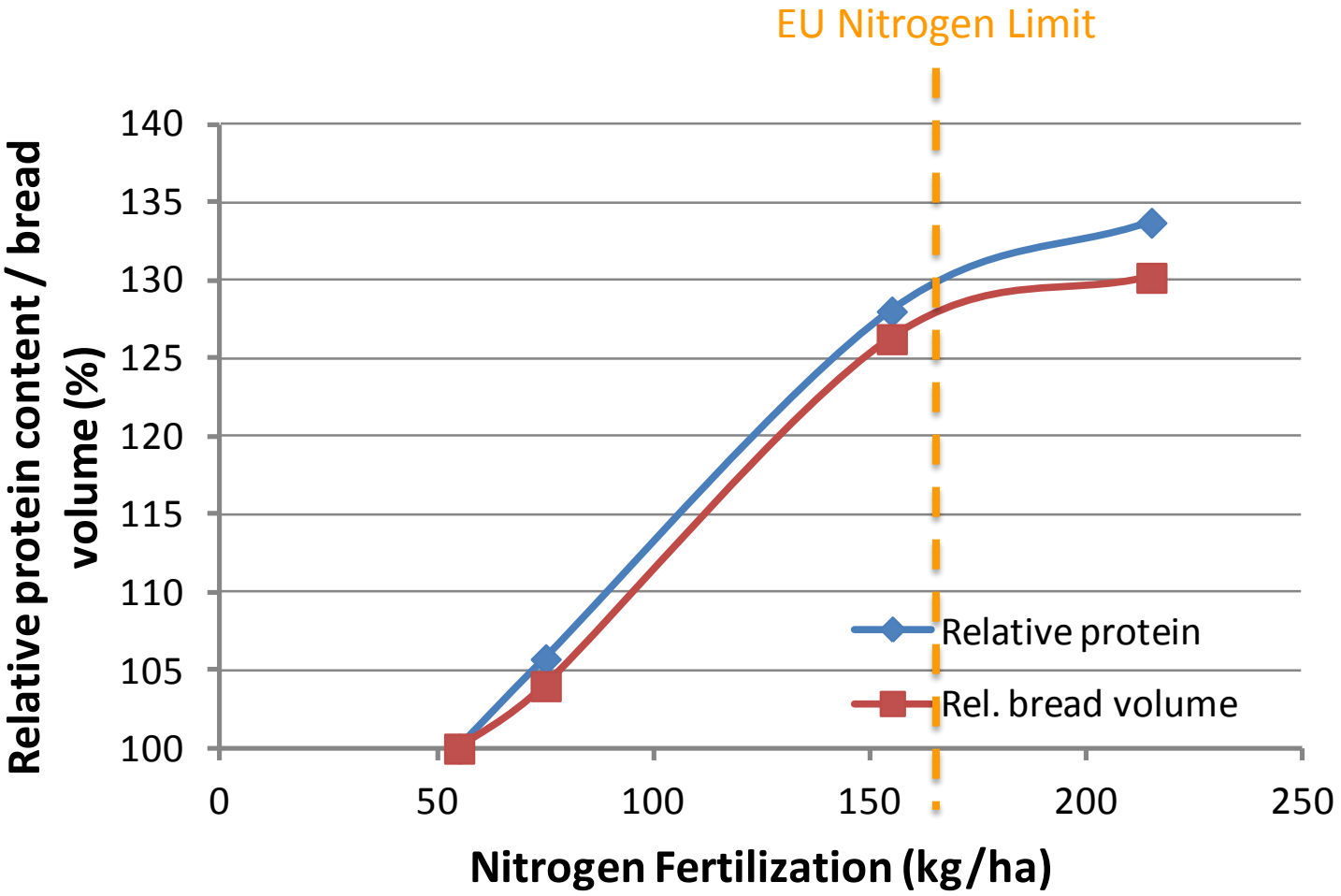


Gluten
(Gliadin & Glutenin)

Gliadin

Glutenin

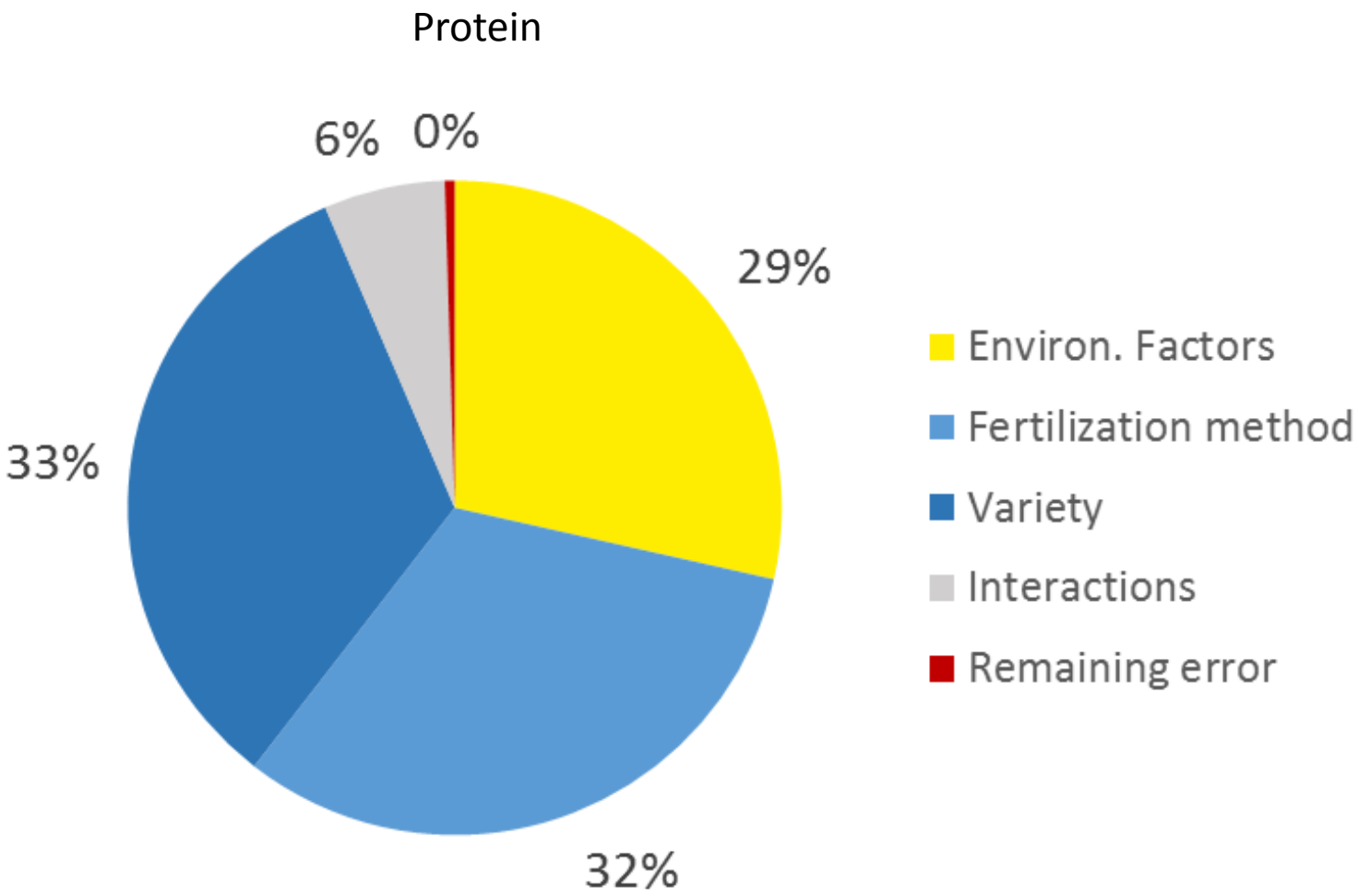
Effects of Nitrogen Application on Protein and Bread Volume of 10 Spring Wheat Cultivars



Data from Johansson et al., 2001. Cereal Chem. 78(1), 19-25

Data for N = 55 kg/hg are reference values (100 %)

Effect of Environmental Factors, Nitrogen Fertilization and Wheat Variety on the Protein Content of Winter Wheat



Lilia Levy Häner und Cécile Brabant, 2016. Agrarforschung Schweiz 7 (2): 80–87

The Baking Volume as Function of Gas Production and Gas Retention

Baked Volume as a Function of Viscosity and Viscoelastic Dough Properties

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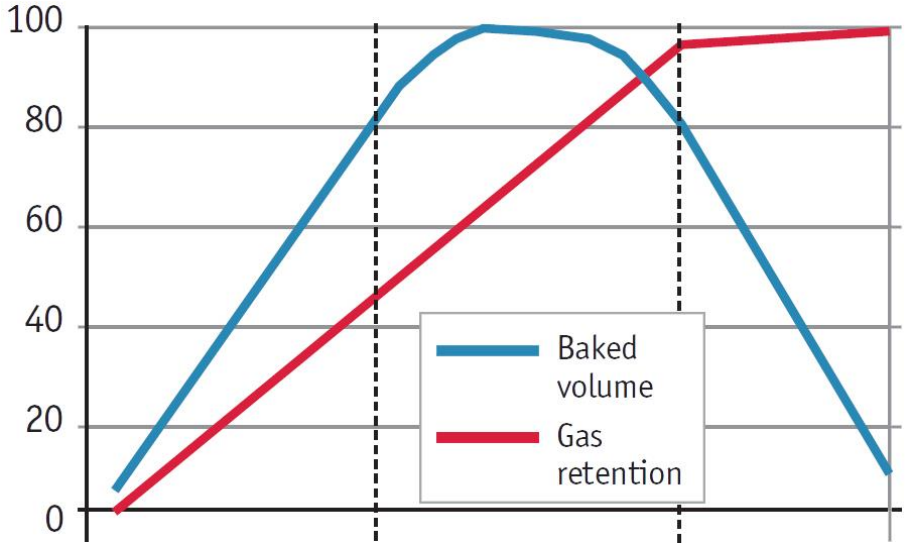

Soft, weak	**Normal for baking**	**Firm, short**
Mainly inelastic, plastic	**Rheologically balanced, extensibly elastic**	**Mainly elastic**
Viscoelastic	**Viscoelastic**	**Elastoviscous**

Dough characteristics

Baked volume	=	f (gas production + gas retention)
Gas production	=	constant (controllable)
Gas retention	=	f (dough consistency)
Baked volume	=	f (viscosity + elasticity)
Viscosity	=	constant (controllable)
Baked volume	=	f (elasticity)

Weipert, D. In: *The Future of Flour*. Popper *et al*., eds., 2006

Basic Principles to Increase the Baking Volume

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- **Increase gas production / fermentation power**
- **Improve gas retention**
  - A) by increasing the dough viscosity
  - B) by optimization of the dough elasticity
    - 1) through better stability
    - 2) through better extensibilty (by softening)

Measures to Increase the Gas Production (Fermentation Power)

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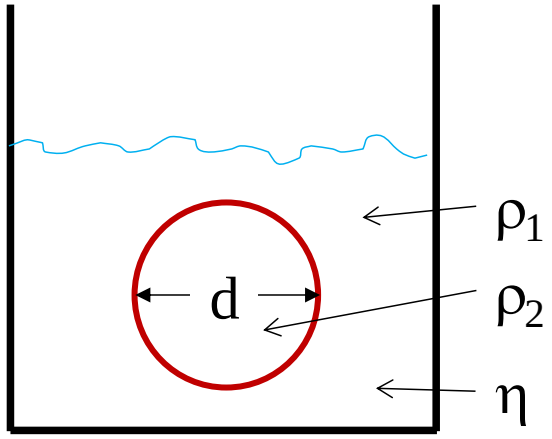
- **Yeast**
  - Increase dosage
  - Choose suitable type of yeast (for retarded fermentation or frozen dough)
  - Yeast food (minerals, e.g. ammonium salts)
- **Sugar**
  - Sucrose
  - Dextrose (Glucose)
  - Trehalose
- **Enzymes**
  - Enzyme-active malt flour
  - α- and ß-amylase
  - Glucoamylase
  - Xylanases

Brewer's yeast – does not use pentoses!

Measures to Increase the Gas Retention
A - Viscosity

- **Measures in the mill**
  - Selection of wheat (lots, varieties)
  - Increase starch damage (→ finer flour)
    - Higher water absorption but
    - Risk of fast break-down by amylase → loss of stability
- **Increase water absorption by addition of**
  - Vital wheat gluten
  - Hydrocolloids
  - Milled plant fibres
- **Enzyme addition**
  - Oxidases: oxidative gelation, gluten strengthening
  - Xylanases: dissolve water-***in***soluble xylans



$$w_a = \frac{1}{18} \cdot \frac{d^2 \cdot (\rho_2 - \rho_1)}{\eta} \cdot g$$

Stoke's Law

Measures to Increase the Gas Retention
B - Elasticity, 1 – Dough Stability

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- **Improve water binding**
  - Lower water addition
  - Add vital wheat gluten
  - Add hydrocolloids
- **Enzyme addition**
  - Oxidases: oxidative gelation, gluten strengthening
  - Xylanases: dissolve water-***in***soluble xylans
  - Transglutaminase: gluten strengthening
  - Lipase & co.: gluten strengthening
- **Flour maturation**
  - Storage, aeration
  - Ascorbic acid
  - Oxidizing agents
- **Gluten stabilization**
  - Salt, phosphates
  - Emulsifiers

Measures to Increase the Gas Retention
B - Elasticity, 2 - Dough Softening

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- **Measures countering B1)**
  - Higher water addition
  - Avoid vital wheat gluten
  - Avoid hydrocolloids
- **Enzyme addition**
  - Malt flour
  - Amylases
  - Xylanases: dissolve water-soluble xylans
  - Proteases
- **Dough softening agents**
  - L-Cysteine
  - Inactivated, glutathion-rich yeast

Contribution of Various Enzymes to Gas Production and Gas Retention

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Function	GA	ßA	αA	WEX	WUEX	LIP	GOX	TG	PHY
Gas production									
fermentable sugars	++	++	+	o	o	o	-	o	o
other nutrients	o	o	o	o	o	+	-	o	+
water	-	-	+	++	-	-	-	o	o
Gas retention									
viscosity	o	o	-	--	++	o	+	o	o
gluten extensibility	o	o	+	+	-	+	-	-	o
gluten stability	o	o	-	-	+	+	++	++	+

GA = glucoamylase, ßA = ß-amylase, αA = α-amylases, WEX = xylanases acting on water-extractable xylans, WUEX = xylanases acting on water-unextractable xylans, LIP = triacyl-, phospho- and glyco-lipasen, GOX = glucose oxidase, TG = transglutaminase, PHY = phytase

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Enzymes for Compensation of Low Protein

Xylanase, oxidase, carboxyl esterase, transglutaminase

Enzymatic Hydrolysis Sites in Wheat Xylan

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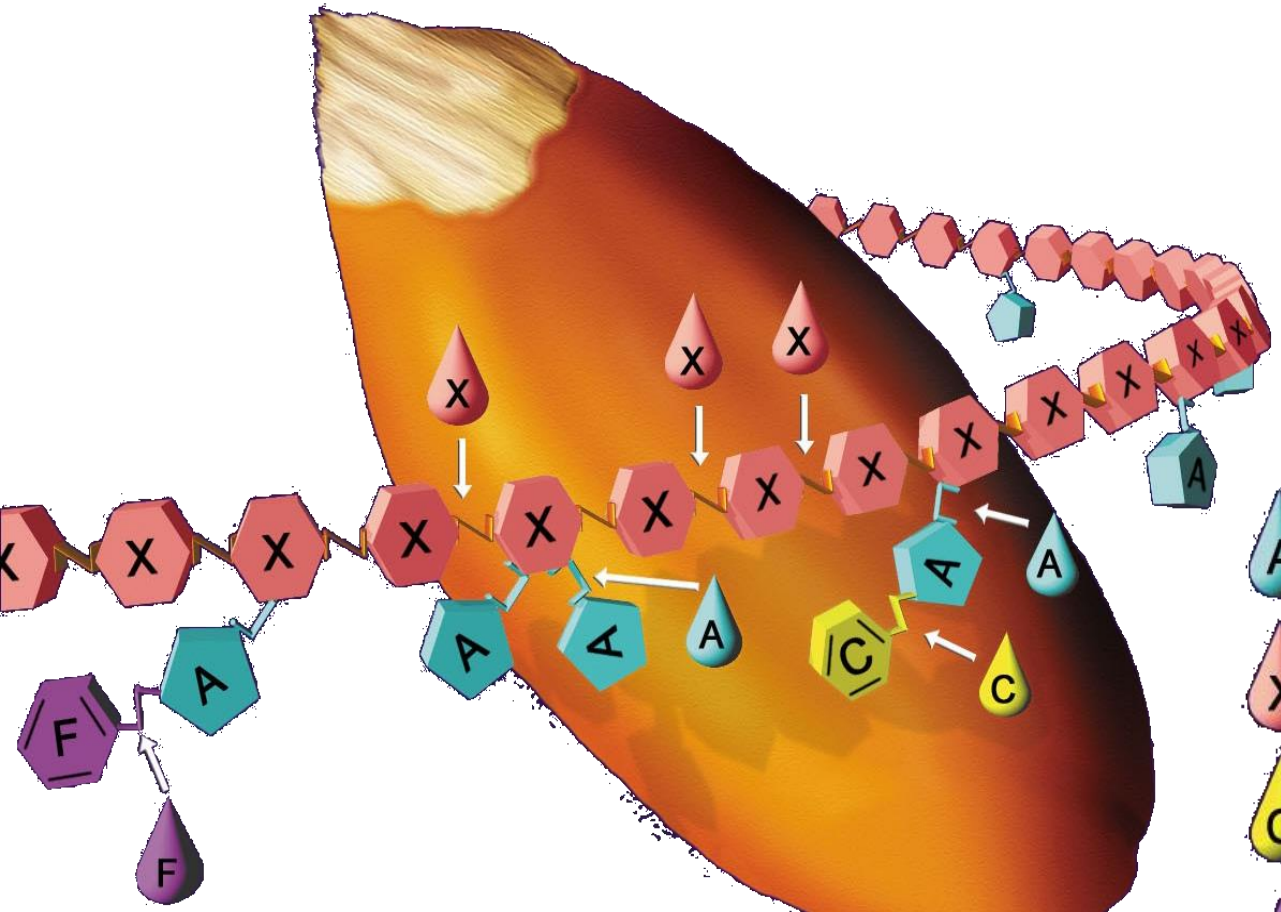

- A — Arabinose
- X — Xylose
- C — Coumaric acid
- F — Ferulic acid

- A — α-L-Arabinofuranosidase
- X — Endo-1,4-ß-xylanase
- C — Coumaric acid esterase
- F — Ferulic acid esterase

Effect of Various Xylanases on Pentosan* Viscosity

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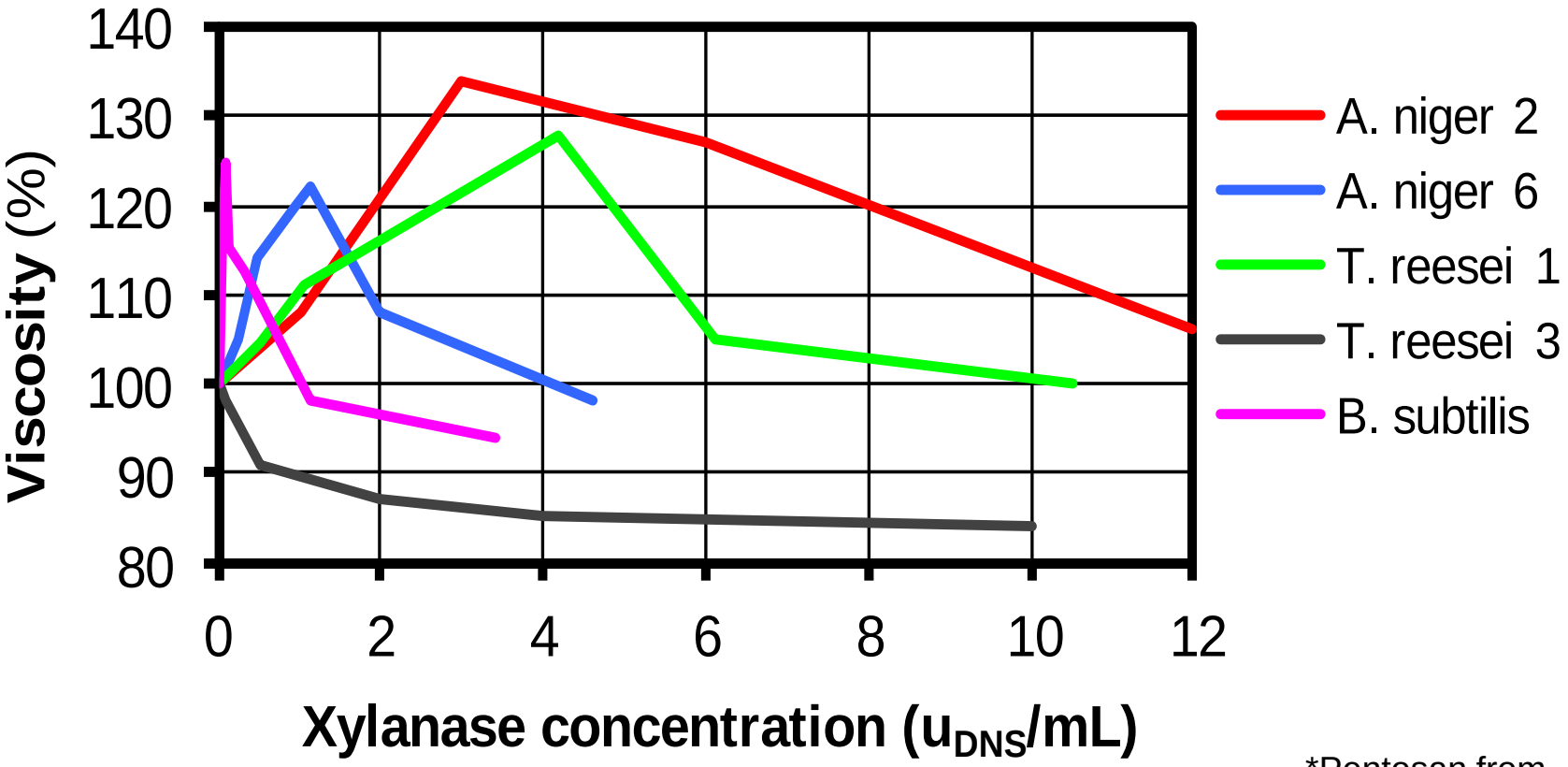
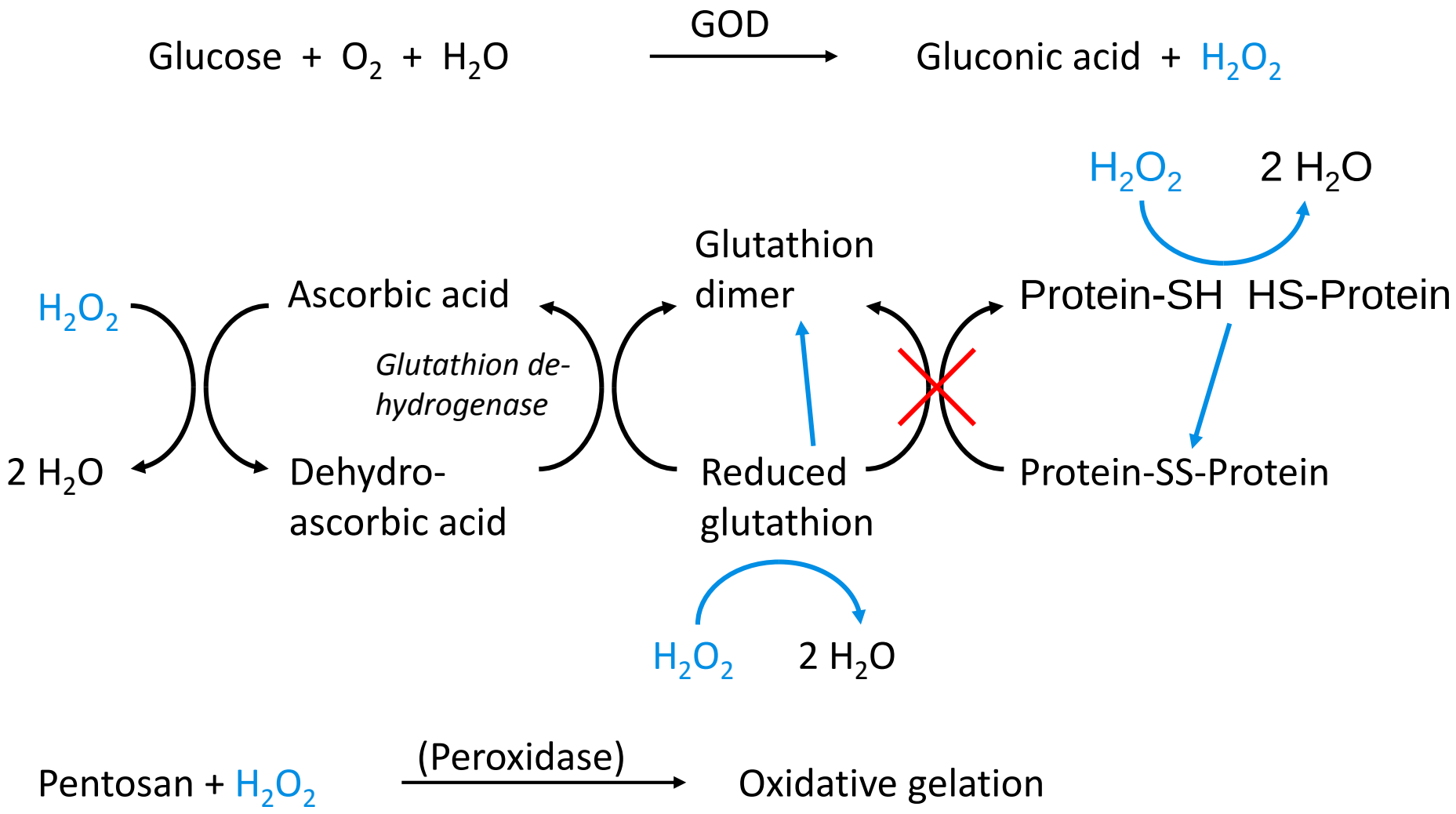
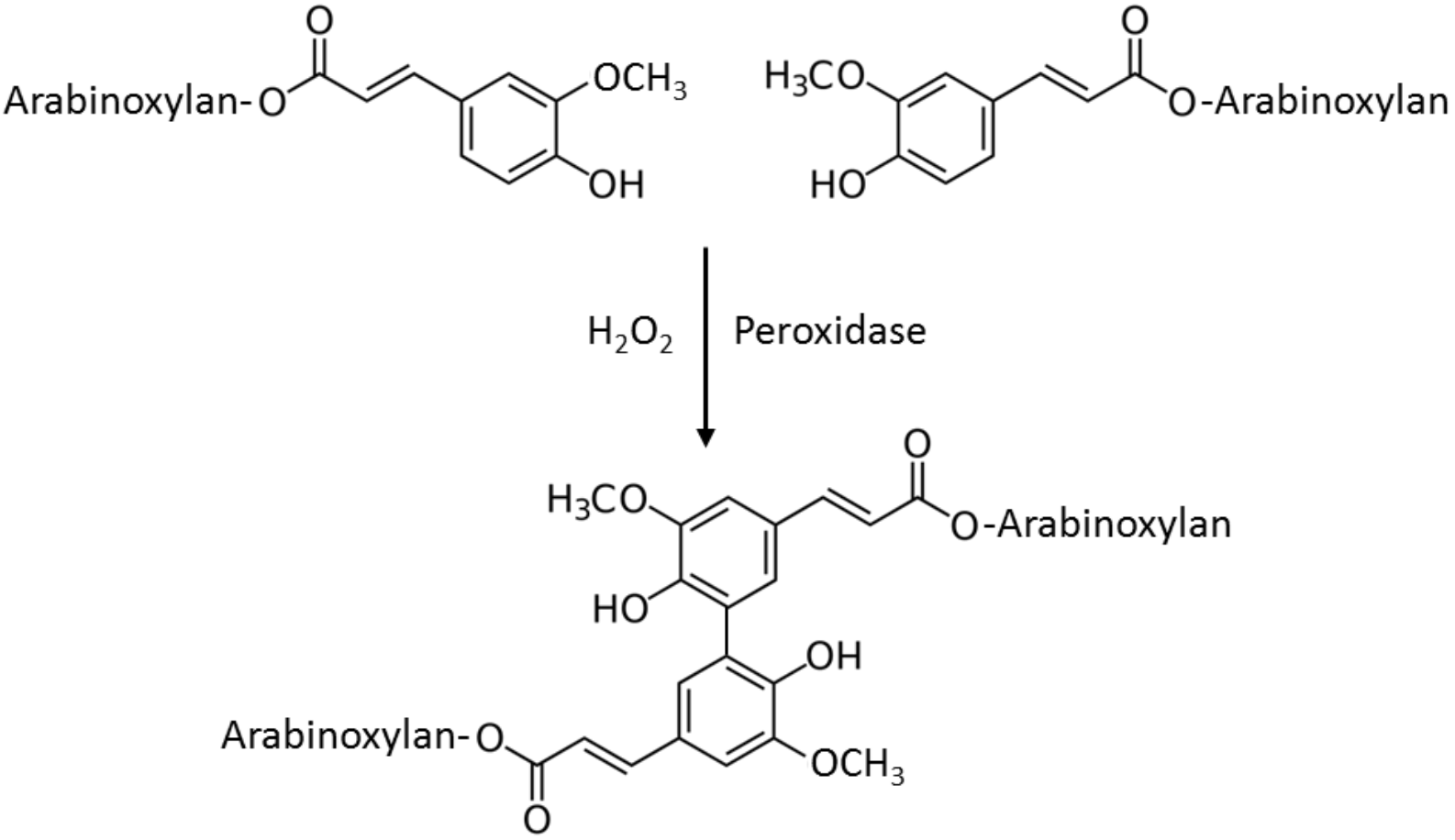


*Pentosan from wheat starch tailings

Effects of Glucose Oxidase in Dough



Oxidative Gelation of Arabinoxylan



→ **Firm binding of water**

Glucose Oxidase in German Breakfast Rolls

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Stress test by over-proof of dough pieces

German soft wheat flour

Simplified Classification and Distribution of the Main Lipids in Wheat Flour (averages; % d.s.)

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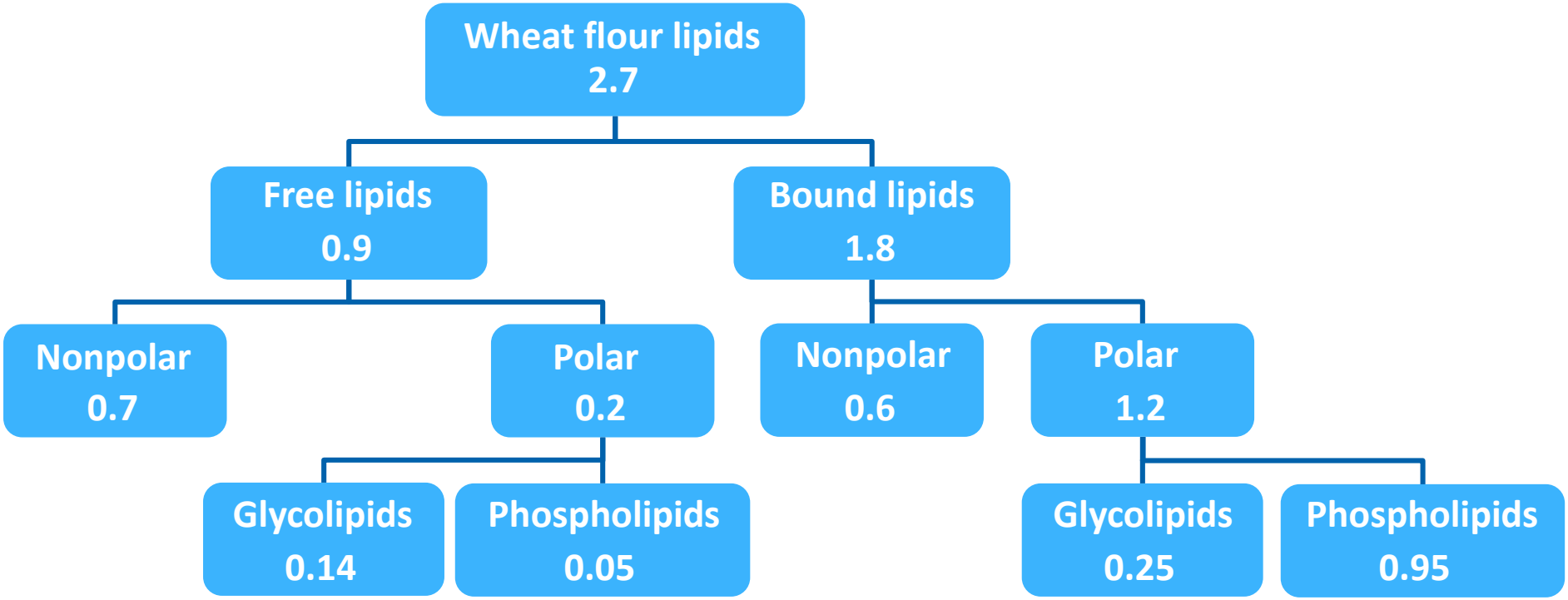
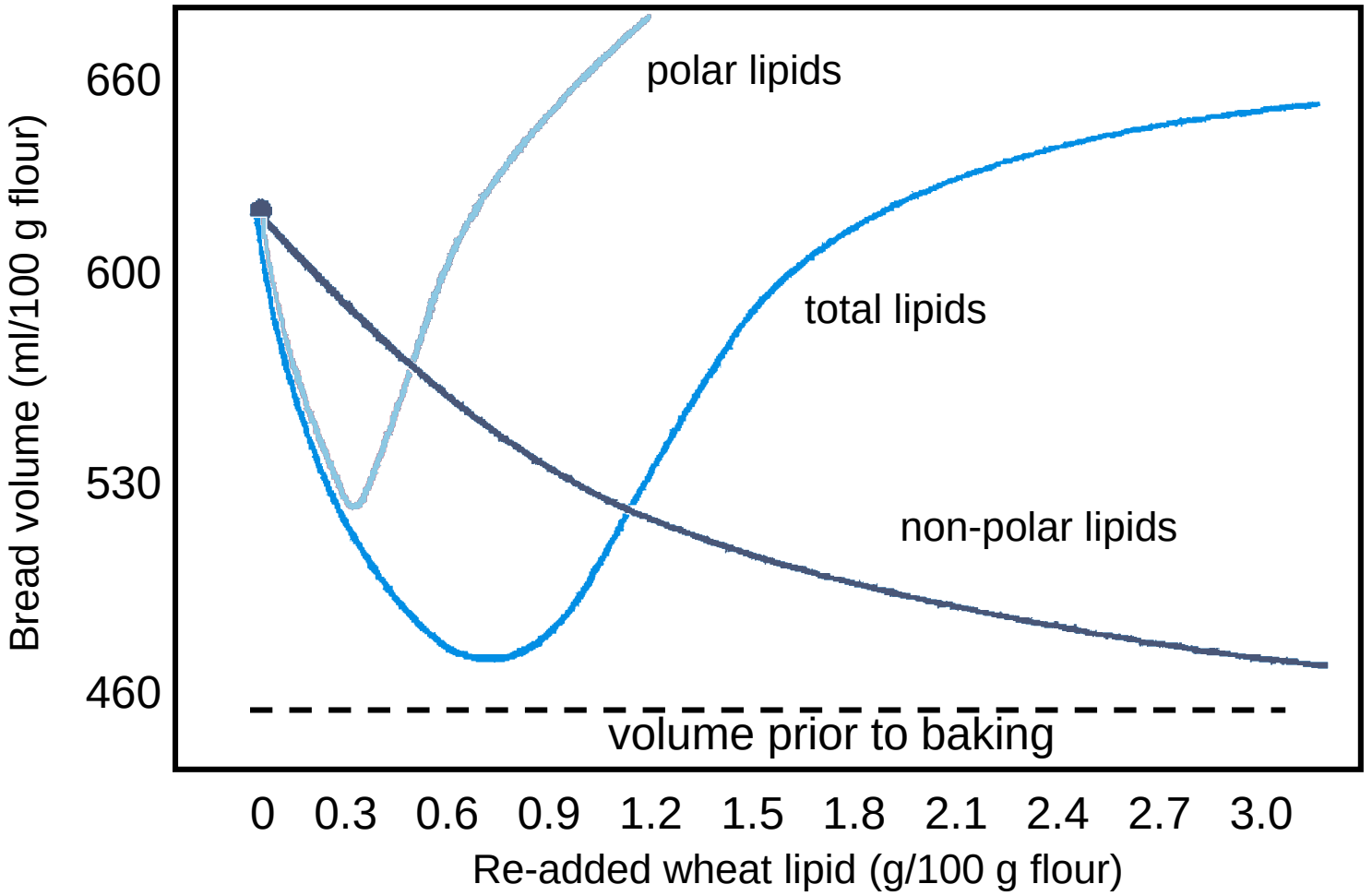


Modif. from Pomeranz & Chung, 1978, using data from Chung & Ohm, 2009

Effect of Wheat Lipids on Volume Yield of Defatted Wheat Flour



Modif. from MacRitchie & Gras, 1973

Action of Lipolytic Enzymes

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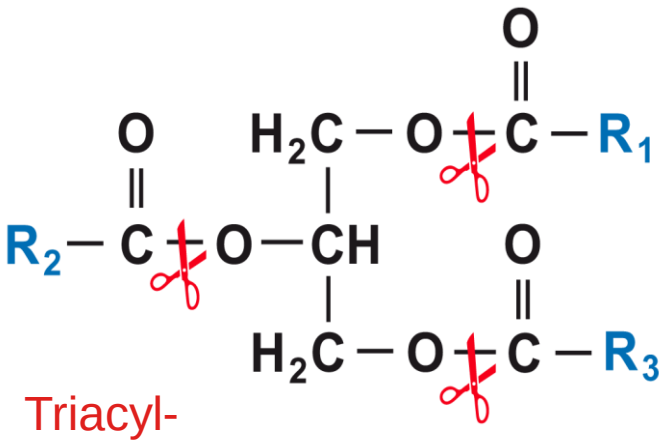
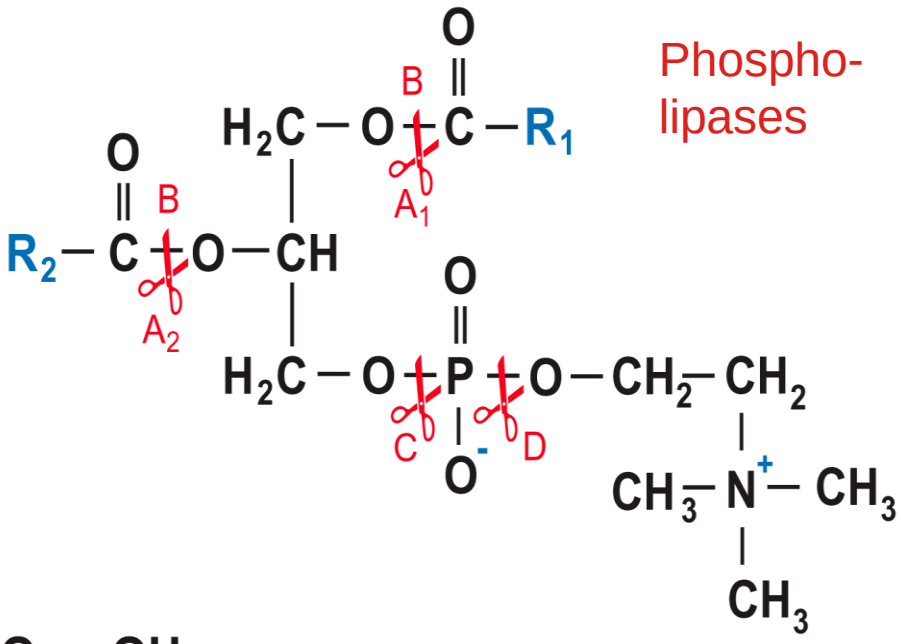
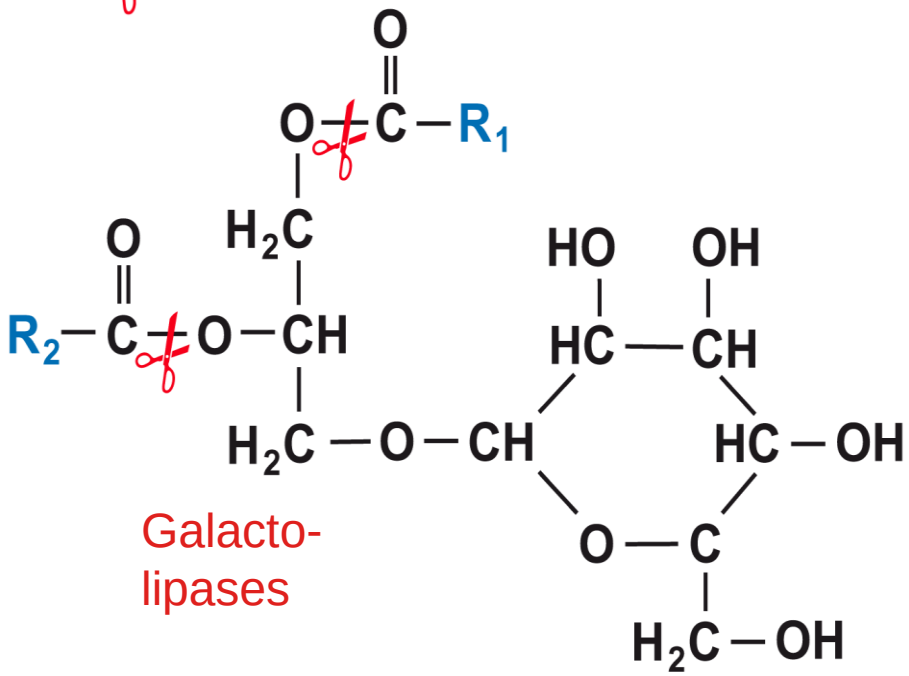


Triacyl-
lipases



Phospho-
lipases



Galacto-
lipases

R_1, R_2, R_3= fatty acid residues

Gas Cell Stabilization by Proteins, Lipids and Arabinoxylans

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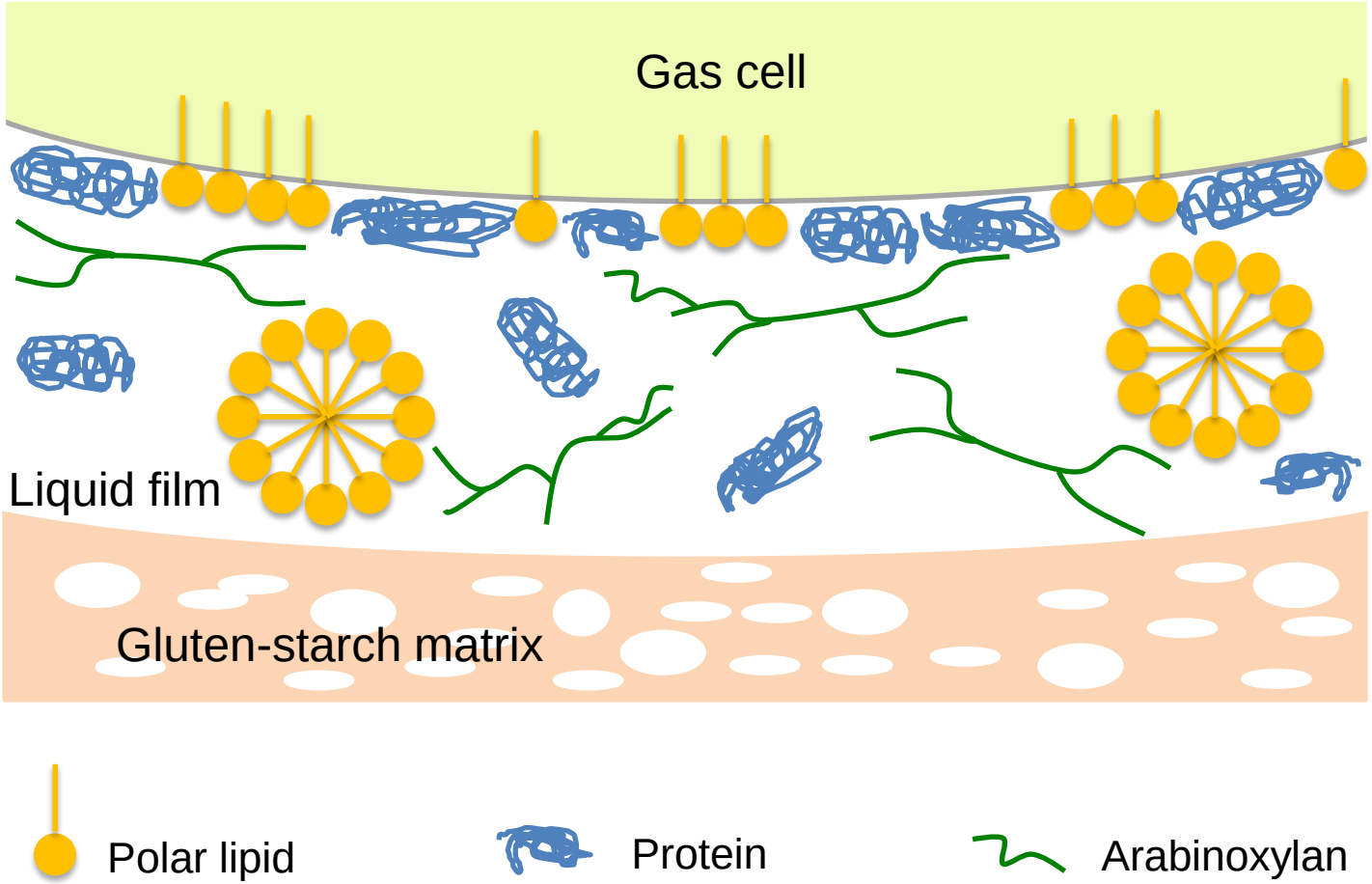

Modif. from Sroan and MacRitchie, 2009

Effect of Dosage and Proof Time on Baguette Rolls with Alphamalt EFX Super

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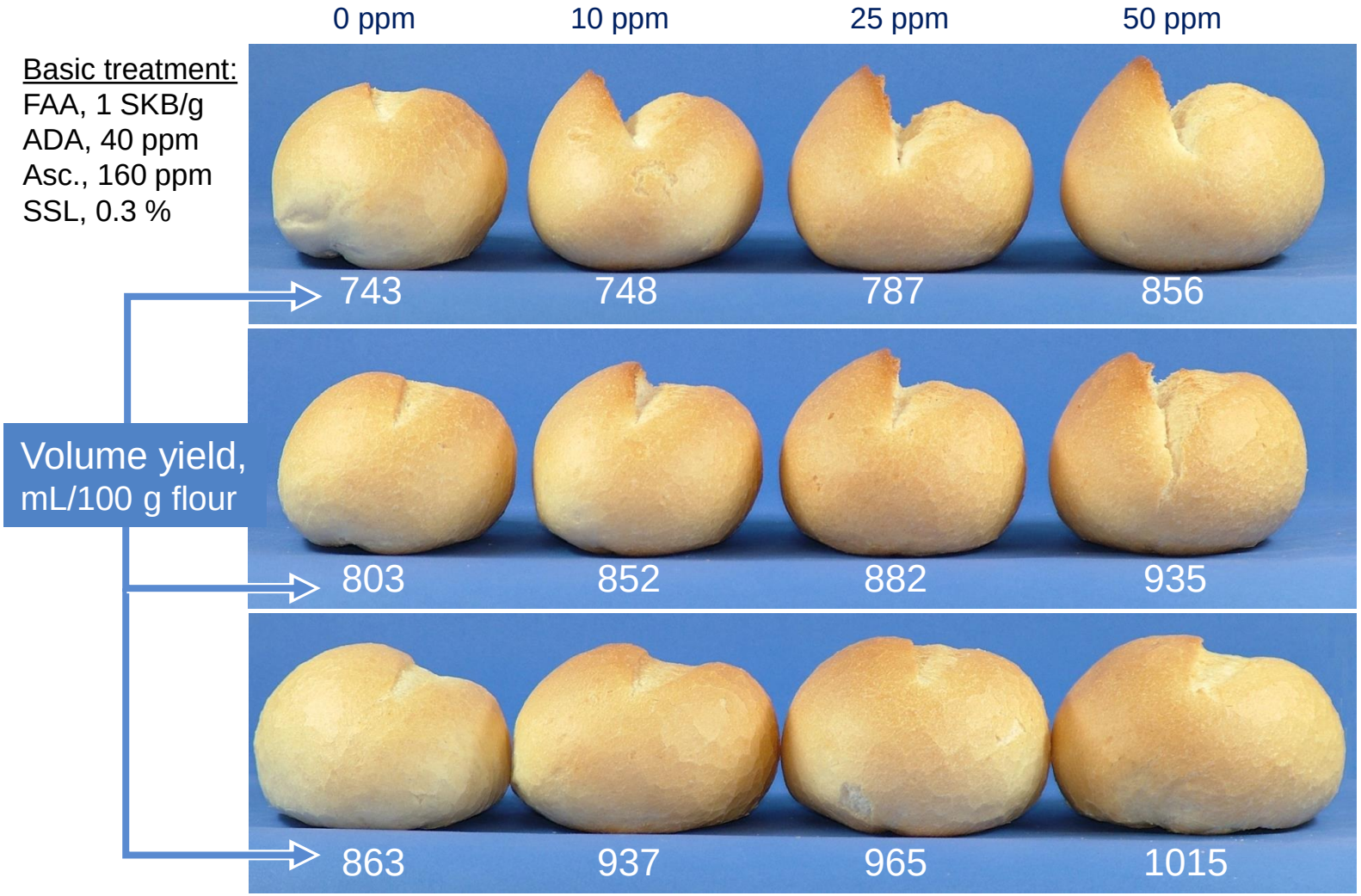
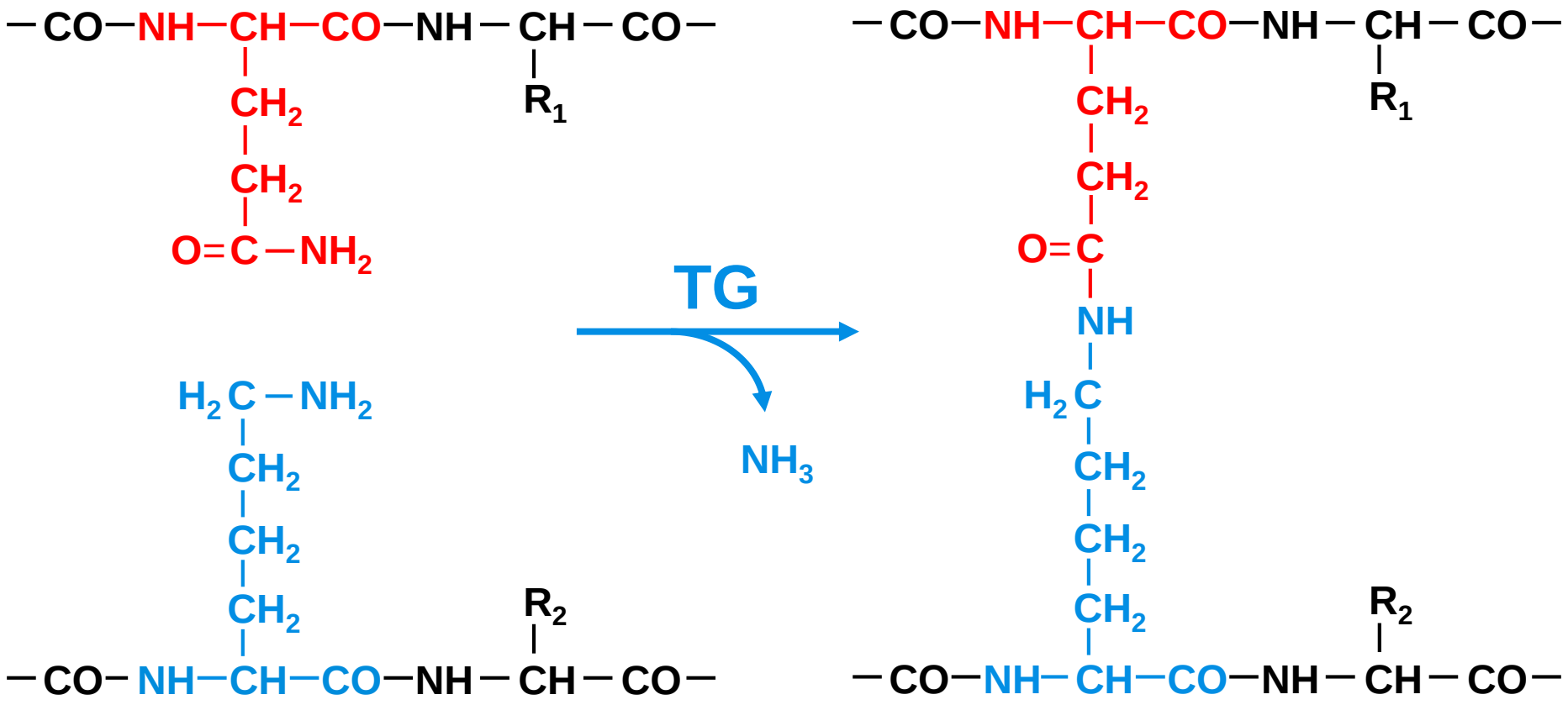


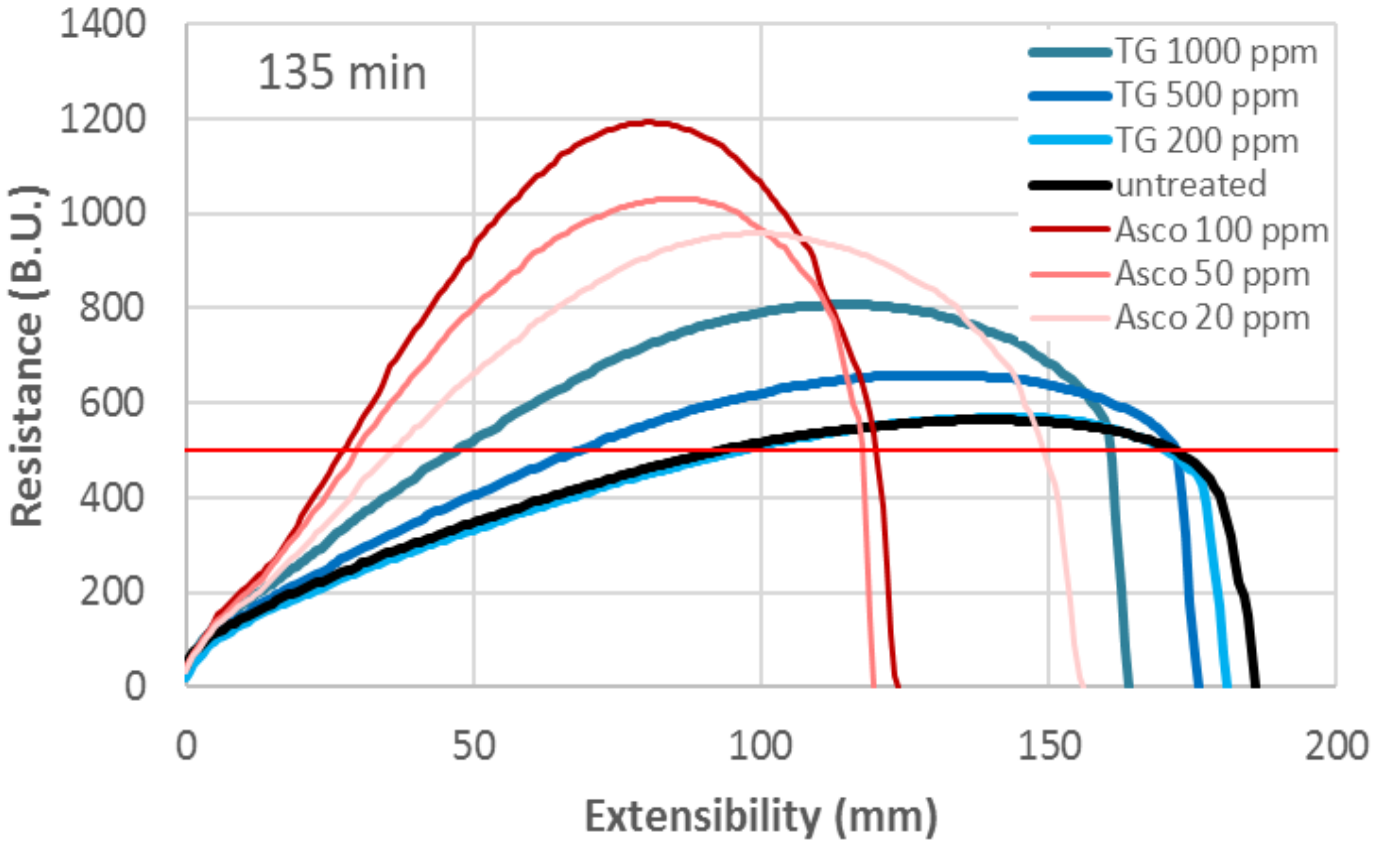
Effect of Transglutaminase on Protein



Effect of Transglutaminase on the Extensogram

TG = Transglutaminase, 100 u/g

Wheat flour	
Ash	0.60 %
Protein, d.b.	14.6 %
Wet gluten	33.9 %
Gluten Index	84
Falling No.	431 s
Water abs.	59.9 %



Transglutaminase in Brazilian Baguette

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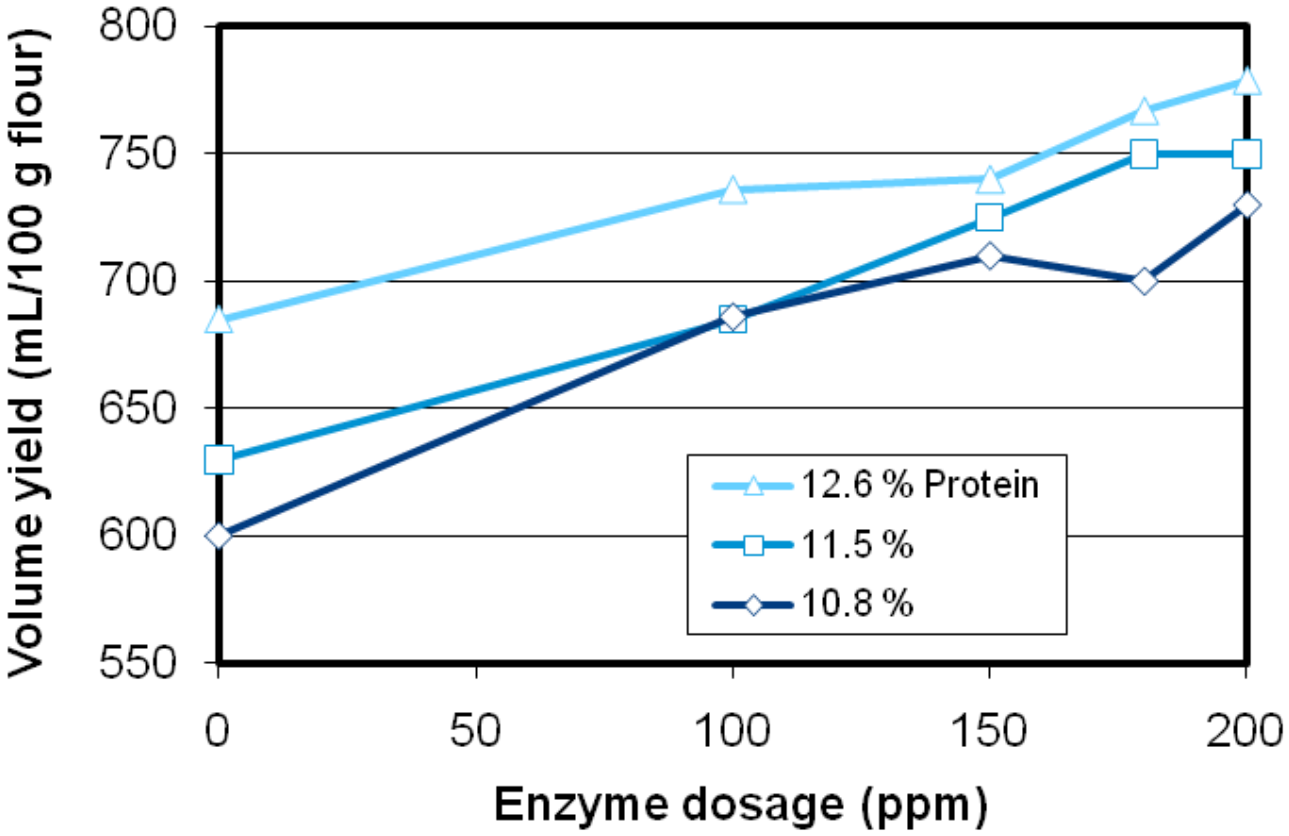
Fermentation time: 3 h

without TG Alphamalt PT 100 C, 50 ppm

Effect of Protein Content and Enzyme Treatment on Volume Yield



German A-wheat, breakfast rolls, 40 ppm ascorbic acid, Alphamalt A 6003

- **Enzymes have always been able to compensate for the lack of protein content in baking!**
- **Most enzymes have a pronounced effect on dough rheology.**

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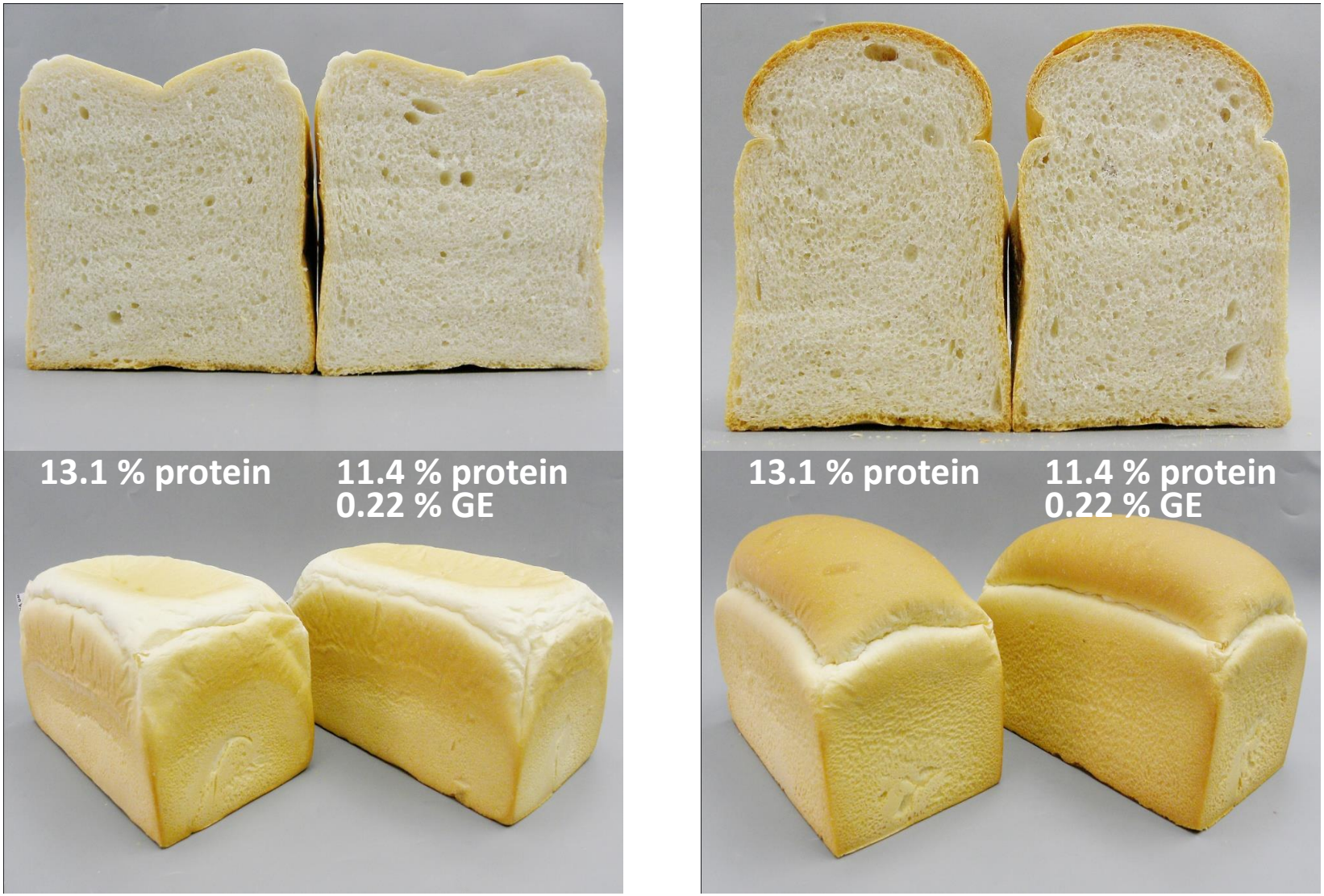
Compensation of Protein Lack

Examples

Gluten Enhancer (GE) for Compensation of a Protein Gap



U.S. wheat; protein on wet basis; basic treatment with ascorbic acid, amylase & xylanase

Gluten Enhancer (GE) vs. Vital Wheat Gluten (VWG) in Whole Meal Sandwich Bread

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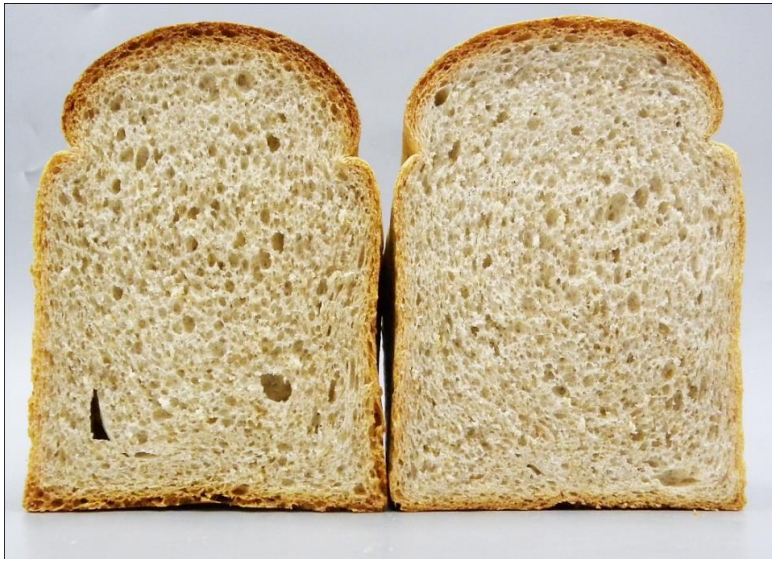
US whole meal wheat flour (11.2 % protein w.b.)
basic treatment with amylase, xylanase, and ascorbic acid



5% VWG
15.2 % protein (w.b.)

2% VWG + 0.3% GE
12.8 % protein (w.b.)

5% VWG
15.2 % protein (w.b.)

2% VWG + 0.3% GE
12.8 % protein (w.b.)

Hard- and Soft Wheat Mixtures

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Basic treatment: 300 ppm Powerzym S + 50 ppm Alphamalt Gloxy 12082

80/20, basic treatment

70/30, basic treatment
+ 0.1% EMCEgluten Enhancer 22

Reduction of Gluten Content by Addition of 10% Cassava Flour

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- **Cassava flour contains only 1 % (non-gluten) protein**
- **The use of cassava impairs the formation of the protein network**
  - Reduction of the total protein content
  - Decrease, sometimes collapse in volume
  - Stability of baked goods severely affected
- **The missing protein is compensated by added vital gluten**

Improvement of Reduced-Protein Flour (1)

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90 % German wheat flour (11.8 % protein) + 10 % cassava flour; basic treatment with amylase, xylanase, lipase and ascorbic acid

Control, 4 % added gluten (13.6 % protein)

1 % added gluten + 0.3 % EMCEgluten Enhancer 22 (11.4 % protein)

Improvement of Reduced-Protein Flour (2)

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90 % German wheat flour (11.8 % protein) + 10 % cassava flour; basic treatment with amylase, xylanase, lipase and ascorbic acid

Control, 4 % added gluten (13.6 % protein)

1% added gluten (11.4 % protein)

+ 0.3 % EMCEgluten Enhancer 22

Résumé

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- Fluctuations in protein quantity and quality can be due to origin, variety, growth conditions, fertilization.
- Flour improvement should aim at standardization, not optimization of the baking performance.
- Enzymes are versatile tools to adjust the rheological and the baking properties of wheat flour.
- Flour improvers based on enzymes can compensate a lack of protein within a wide range of protein content, resulting in comparable dough and baking properties.
- Flour improvers cannot increase the protein content.
- Using lower protein flower or reducing the addition of vital wheat gluten also has the potential to save on raw material costs.

¡Muchas gracias por su atention!

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