Technological Challenges in the Production of Whole Grain Products

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Whole Grain *Challenges*

• Context
  – Can they be produced?
Whole Grain Challenges

- Context
  - Can they be produced?

OF COURSE THEY CAN BE!

- Originally all baked products were W.G.
- Companies have been & are producing high quality W.G. baked products
Whole Grain Challenges

• Reality
  – Creation/Production requires
    • ADAPTATIONS
    • MODIFICATIONS
    • TRANSFORMATIONS
  – Formulations & Processes
Whole Grain Challenges

• Process & Formulation Adaptations
  – Refined Flour Formulations
    • Optimized to a different base ingredient
    • Different intermediate product (dough)

  – Refined Flour
    • Endosperm
      – Starch & protein
Whole Grain Challenges

• Process & Formulation Adaptations
  – Whole Grain Formulations (@best)
    • Different optimization basis
    • Includes the bits removed in refined flour milling
      – Bran
      – Germ
  – @ most challenging
    • Adds non-wheat grains
    • Large pieces of the caryopsis
Whole Grain Challenges

• Effects?
  – Dilution and Addition
  – Dilutes GLUTEN Protein
    • Responsible for dough & crumb structure
  – Bran & to a lesser extent, germ
    • Interferes with its creation
    • Disrupts it
Whole Grain *Challenges*

• Effects?
  – Dilution and Addition
  – ADDS
    • Large carbohydrate polymers (Pentosans)
      – Arabinoxylans
      – Beta Glucans
      – Quite hydrophyllic
      – Compete for formula water
      – When hydrated – large effects on DOUGH properties
Whole Grain Challenges

• Effects?
  – Dilution and Addition
  • Net result:
    – A different system
      » Physical properties
      » Processing requirements
      » Final product properties
Whole Grain Challenges

• Effects & Adaptations
  – Model: Bread
  – Process: Straight Dough
  – By Process Step
Whole Grain Challenges

- Straight Dough Process
  - Scale
  - Mix
  - Ferment/punch
  - Divide/Round
  - Make-up (incl sheeting)
  - Pan
  - Proof
  - Bake
Whole Grain Challenges

• SCALING
  – Additional major ingredient(s)
  – Additional minor ingredient(s)
  – Additional or different micro ingredient blends
Whole Grain Challenges

• MIXING
  – Obligate first step
  – Creates the gluten matrix
  – Mixing *optima do exist*
    • Water content
    • Work input (time)
    • Little Red Riding Hood’s situation
Whole Grain Challenges

• MIXING: WG Challenges
  – Bran & etc are hydrophilic
    • Hydrate @ diverse rates
    • Competes with protein for water
  – Formula water must go up
  – If no adjustment
    • “ok” @ mixer
    • Underabsorbed (bucky) @ divider/rounder
      – Processing problems
Whole Grain Challenges

• ADJUSTMENTS & Consequences
  – Increased absorption (up to 20%)
    • Must be removed @ baking: time & temp. changes
  – Slack out of the mixer
    • But better later in the process
  – Reduced mixing requirements
    • f(water content, gluten)
  – Mixing optimum: narrow & cryptic
    • Easy to under or overmix
Whole Grain Challenges

• W.G. dough (w. no other adjustments)
  – WEAK
    • More viscous
    • Less elastic
    • Sticky
  – WHY?
    • Less gluten to create the matrix (structure)
    • More “stuff”
      – Interferes with gluten creation & continuity
Whole Grain Challenges

- W.G. dough (w. no other adjustments)
  - Does the bran ‘cut’ the gluten strands?
  - Probably NOT the major mechanism
  - Does cause it to fail
    - More stuff to stretch over
Whole Grain Challenges

• WEAK DOUGHS
  – Machine Poorly
    • Dividing/rounding
    • Sheeting
  – Retain Leavening Gas Poorly
  – Lack Processing Tolerance
Whole Grain Challenges

• WEAK DOUGHS
  • Morel likely
    – Lower volume
    – Poor loaf shape
    – Cripples

What to be done?
Whole Grain Challenges

• ADAPTATIONS
  – Supplement the protein
    • *Vital* wheat gluten
    • 8% to 15% or > possible
  – Issues
    • Cost
    • Mixing requirements
Whole Grain Challenges

• ADAPTATIONS, ctd
  – STRENGTHEN the Protein Matrix
    • Oxidizing Improvers
    • Used in non-W.G. applications
    • Different Chemistries
  – Increase cross-links between gluten polymers
    • Cys-Cys linkages (disulfides)
    • More elastic behavior
      – Vulcanized rubber
Whole Grain Challenges

• Oxidizing Improvers
  – Ascorbic Acid
    • Dosage limit: none
    • Usage: 0-~200 ppm
    • Rate: medium to fast
    • Rxn timing: proof thru early oven spring
Whole Grain Challenges

- Oxidizing Improvers
  - Azodicarbonamide (ADA)
    - Dosage limit: 45 ppm
    - Rate: Fast & extended
    - Rxn timing: mix thru proof

  - Potassium Bromate
    - Dosage limit: 75 ppm
    - Rate: Slow (heat triggered)
    - Rxn timing: oven (early bake)
    - Note food safety concerns!
Whole Grain Challenges

• Formula Adaptations, ctd.
  – Increase Abuse Tolerance
  – Dough Strengtheners (emulsifiers)
    • Sodium Stearoyl Lactylate (SSL)
      – Legal limit: 0.5% (FWB)
      – Gas cell stabilization
      – Proof Collapse & the ‘drop’ test
      – Additional Benefits
Whole Grain Challenges

• Low Volume Adaptations
  – FORMULA
    • Emulsifiers (SSL)
    • Add’l Yeast (1-3%)
    • Alpha Amylase*
  – PROCESS
    • Extend Proof time
      – Risk of over proofing & collapse
    • Higher dough:pan ratio
    • Both require line & equipment modifications
Whole Grain Challenges

• Dough Handling Adaptations
  – Problems
    • Weak
      – Gluten dilution
    • Sticky
      – Non-starch Polysaccharides
      – Some cereals more so than others
  – Poor Tolerance
    • Dividing/rounding
    • Sheeting
    • Make-up
Whole Grain Challenges

• Dough Handling Adaptations
  – Slow down
    • Divider, etc
  – Requires upstream & downstream compensation
Whole Grain Challenges

• Baking: WG products at the oven
  – Higher Dough Moisture
  – Hydrophilic ‘stuff’
  – Denser Doughs

• Adaptations
  – Longer bake times
  – Oven profiles to prevent burning but achieve final moisture requirements
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