Mitigation Options: The FRI Acrylamide Program

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University of Wisconsin–Madison

Food Research Institute 2004 Annual Meeting

May 17–19, Madison, Wisconsin

Topics to be presented include:

- Obesity and its impact on health
- Food pathogen implications to the at-risk population
- Microbial adaptation
- Food safety research at FRI and the UW–Madison, including updates on prions, acrylamide, and microbial interventions

Full Details and Registration Form:

www.wisc.edu/fri

[deadline: May 1, 2004]

U.S. Food Law and Regulations Symposium

Food Research Institute, June 8–9, Madison, Wisconsin

Topics to be presented include:

- History and Structure
  - Overview of Food Law and Regulation; Standards of Safety/Burden of Proof; How the Process Works; Impact of Technology and Demography
- Product Development — The Label
  - Development of FDA Nutritional Labels; The Where and How of Label Information; Consumer Perception of Regulations; Breakout Session to Design a Label
- Manufacturing
  - Third Party Audit View, Regulations at the Factory Level; National Recalls and State/Local Participation; Complying with the Regulations

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Presentation Outline

1. Background
2. Rationale
3. UW-Madison program

The joys of cooking

a)1960s: Polynuclear arenes

b)1970s–80s: Heterocyclic amines

c)2002: Acrylamide

d)Next up: Advanced glycation end products

The European Regulators

GERMANY TO SLOW COOK CHIPS DUE TO CANCER FEARS

January 25, 2003 Reuters

BERLIN — The consumer affairs ministry was cited as saying on Saturday that German food makers have agreed to recommend that chips be cooked at lower temperatures to reduce the build up of acrylamide.

The story says that in the future, packaging in Germany will recommend that potato chips are deep fried at 347 degrees Fahrenheit or baked in fan ovens at 180–190C, the ministry said.

The European Regulators (cont'd.)

Germans spark cancer fears over Ryvita
by Roger Boyes in Berlin and Nigel Hawkes, Health editor

…Baerbel Hoehn, the region's powerful consumer minister and Green Party member, recently ordered raids on 1,200 snack bars and fast food restaurants as part of an acrylamide crackdown. The aim was to see whether chips were being fried at higher temperatures than 175C (347F), which is regarded as the danger threshold by Germany…

Lessons Learned

1. You can’t refute poor data with no data
2. Well-conducted research takes time
3. In the end, science will provide a rational perspective

Lessons Learned (cont'd.)

The Foster Maxim (***Sanitized***)

"When you're up to your butt in alligators, it's hard to remember that your objective was to drain the swamp."

—*Mike Foster*

FRI Acrylamide Program
Focus: Intervention and mitigation

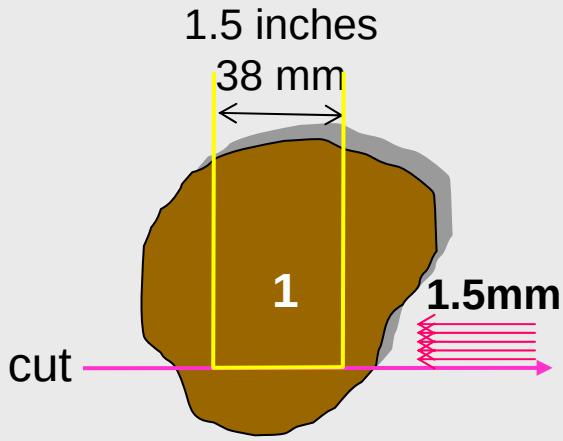
- **Initiated in April 2002**
- **Currently has 11 industrial sponsors**
- **Program structure**
  - **PI, Mike Pariza; Special Advisors, Hyuk Yu and Ron Weiss**
  - **Basic mechanisms and intervention (Dr. Bob Lindsay)**
  - **Applied research and intervention (Dr. Yeonhwa Park)**
  - **Cultivar biology and management (Dr. Phil Simon)**
  - **Process control with enzymes (Dr. Glenn Chambliss)**

Method: French Fries

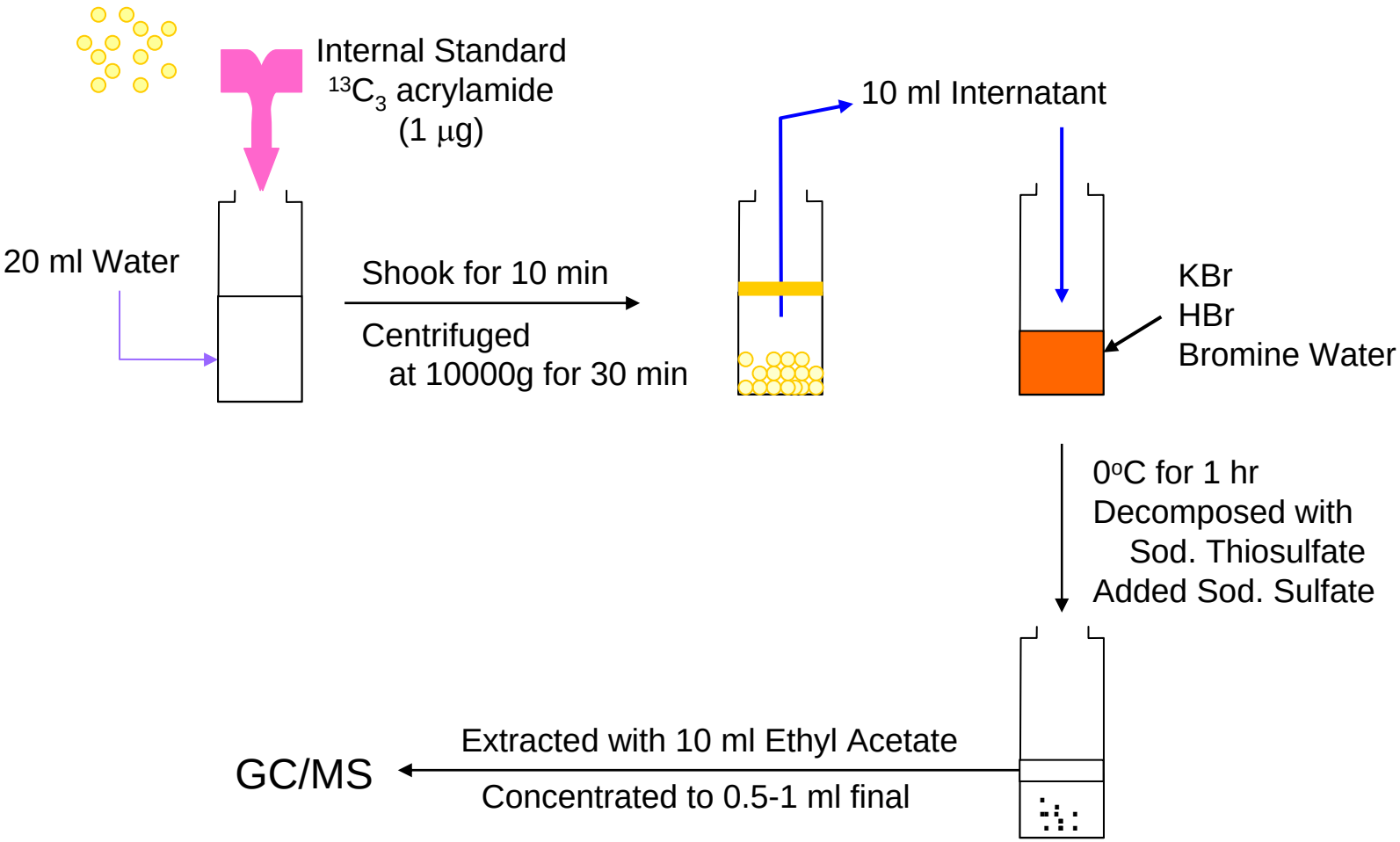
- Based on industrial practice
- Cut potato with French fry cutter
  - 3/8 inch thickness, cut to 3 inches long
  - discard outer pieces with skin
- Soak in water prior to blanch
- Blanch: 80ºC for 10 min
- Pool, mix well, and use 30 pieces per sample
- Soak for 10 min in treatment solution with 1.5% salt/0.5% SAPP
- Dry: 6 min under fan, 3 min each side
- Par-fry: 191ºC for 1 min in corn oil
- Freeze: -20ºC overnight
- Final fry: 171ºC for 2 min 45 sec in corn oil
- Grind with a food processor, then prepare for analysis

Method: **Potato Chips**

- Chipping potatoes
- Cut cubes of 1.5 sq. inch then slice to 1.5 mm thickness
- 39 slices/ 3 potatoes/ sample
- Fry at different times/temps using commercial fryer with two fry pots



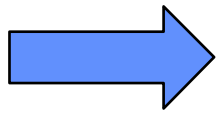
FRI Modified Method



Beginnings: The tuber… .

Heat

Free amino acids
(esp. asparagine)
Reducing carbohydrates



Acrylamide

Chromophores

Maillard Reactions

Breeding →
Crop Production →
Postharvest Storage →
Processing of Potatoes

Free sugars,free amino acids, starch, phytate, calcium, nitrate

→ Acrylamide
Chip Color

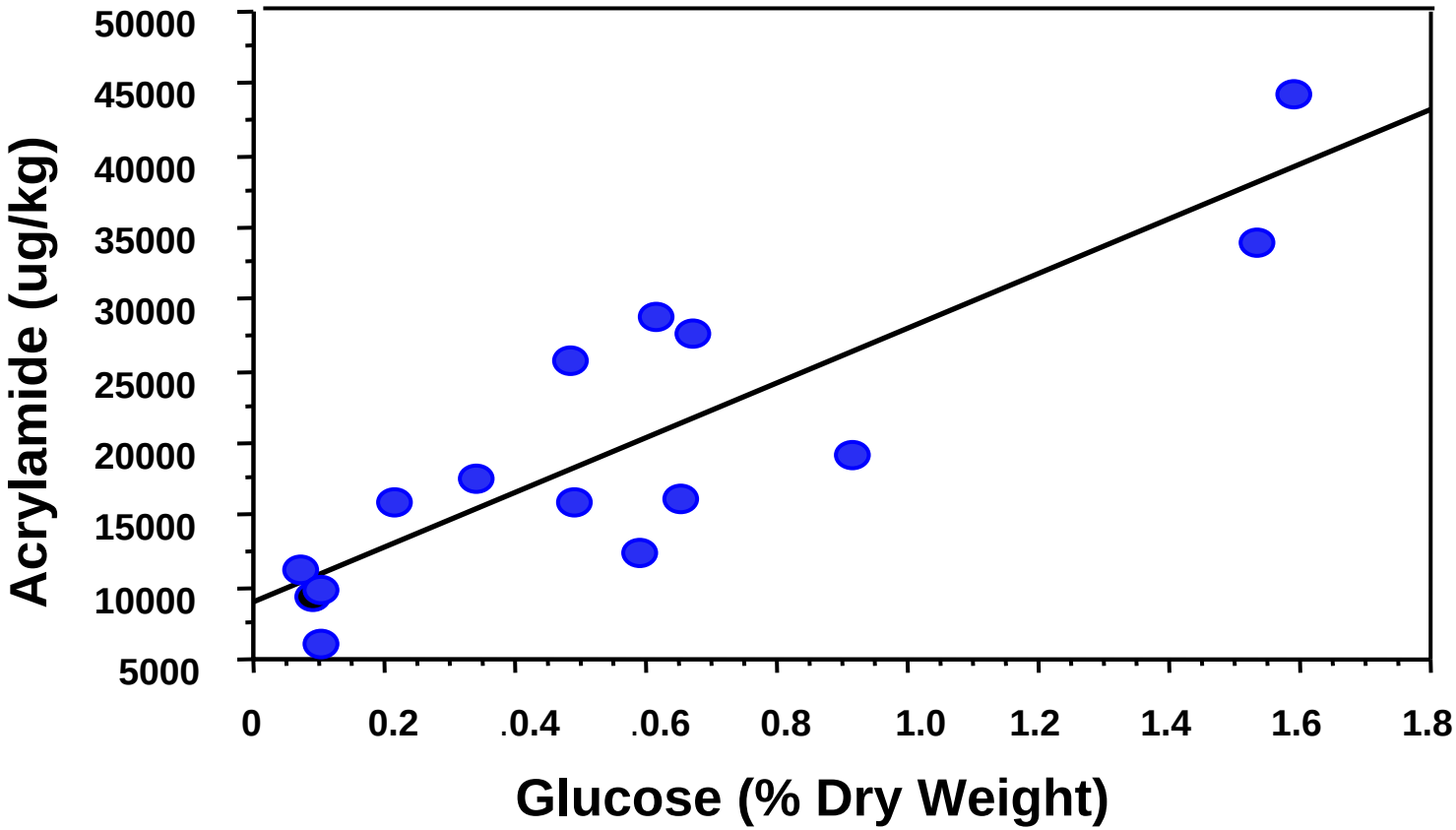
Factors Influencing Potential for Acrylamide Formation

- Genetic background
  - Cultivated potatoes
  - Wild *Solanum* relatives
- Cultivation practices
  - Soil nitrogen
  - Soil calcium
- Harvest factors
  - Quality and maturity of tuber at harvest
- Postharvest storage conditions

Ongoing Studies

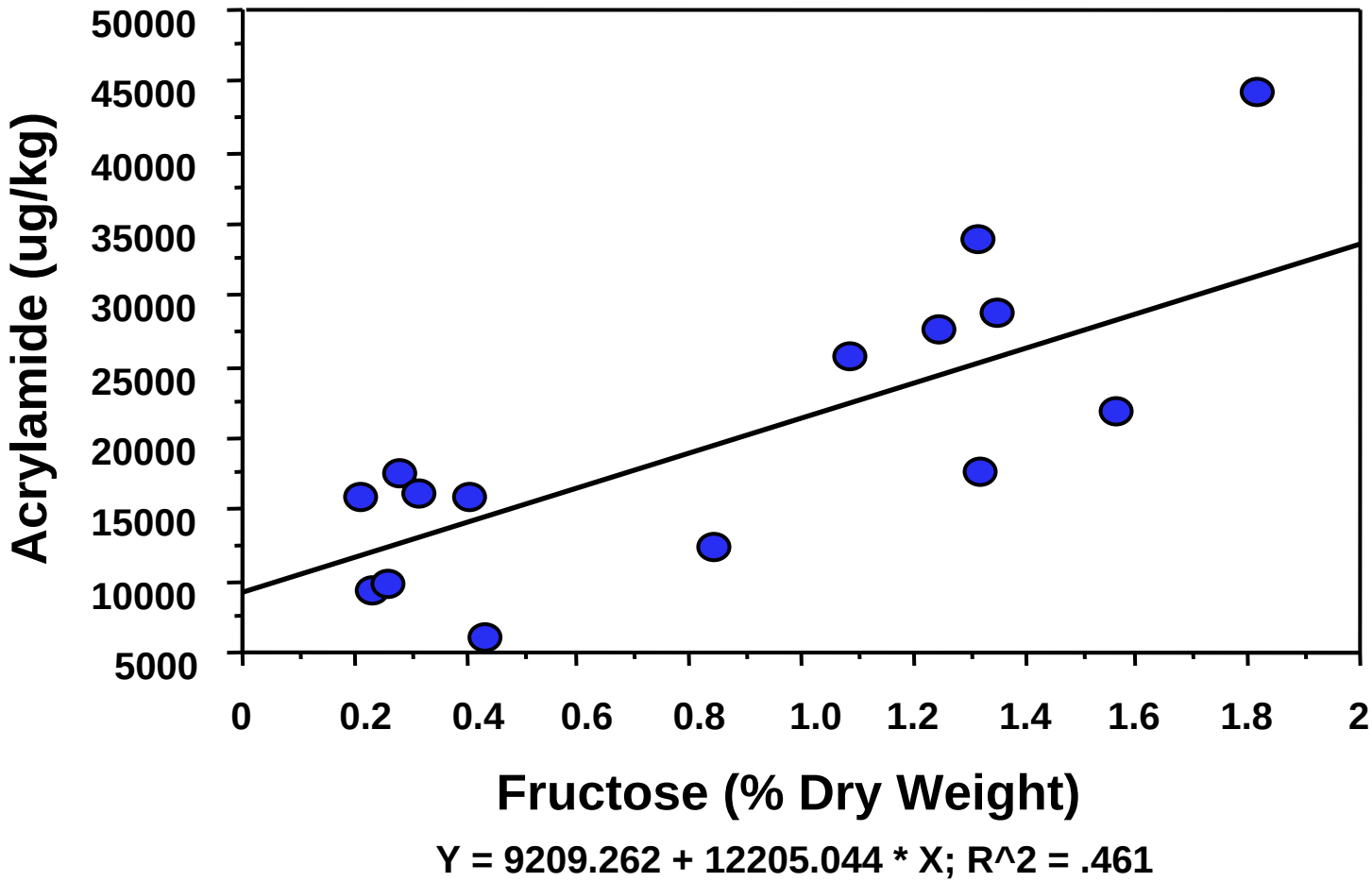
- Variation in sugars and asn in wild species materials
- Nitrogen study
  - Effect of N rates on acrylamide, asn, and sugars in tubers
- Calcium study
  - Effect of Ca rates on acrylamide, asn, and sugars in tubers
- Maturity study
  - Asn, sugars, and acrylamide at different vine kill and harvest dates
- Storage study
  - Preconditioning – slowly bringing down to a cold temperature – influence on sugars and asn

Correlation between Acrylamide Formation and Glucose Concentration

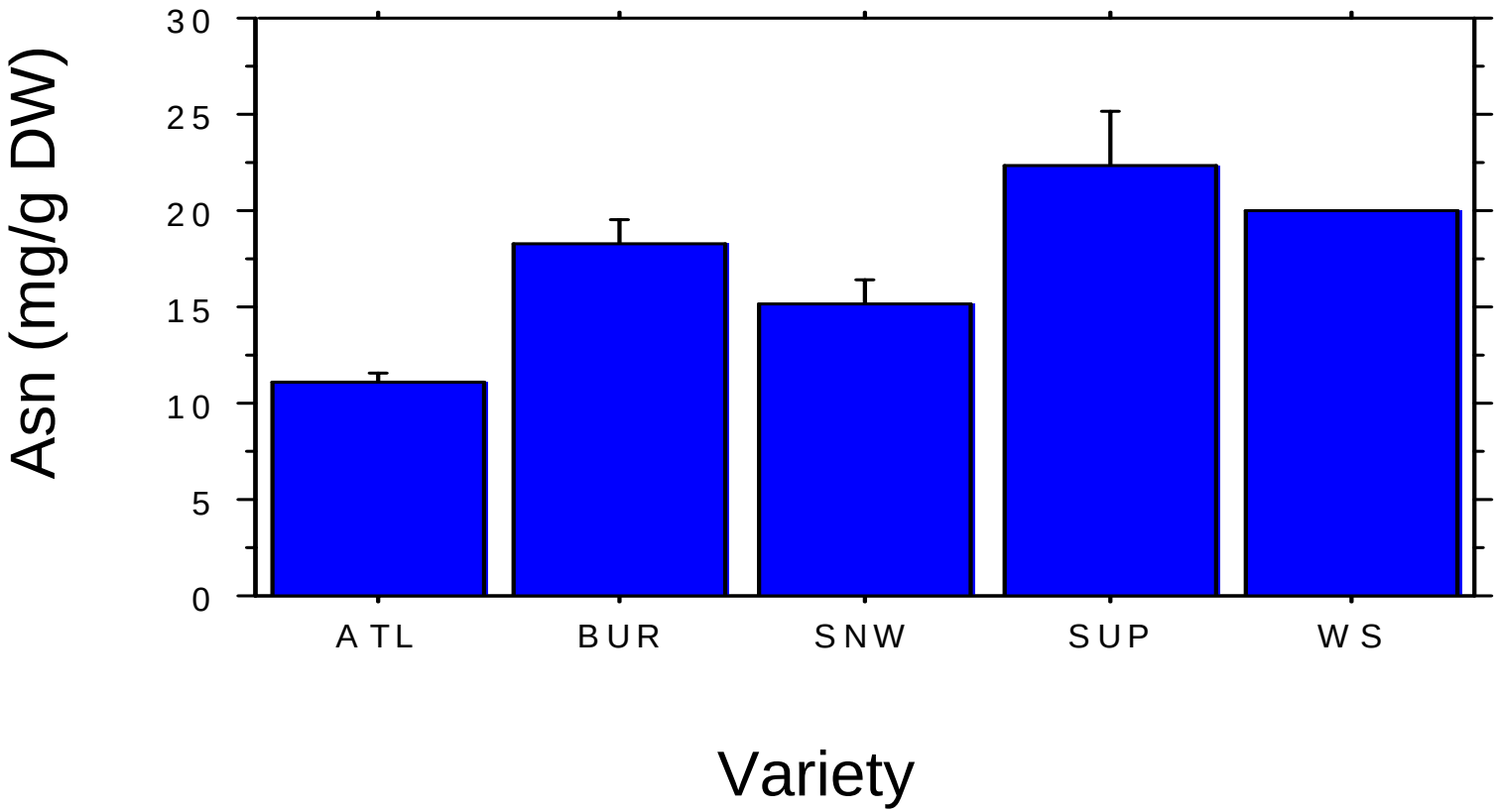


Y = 9018.051 + 19016.991 * X; R^2 = .752

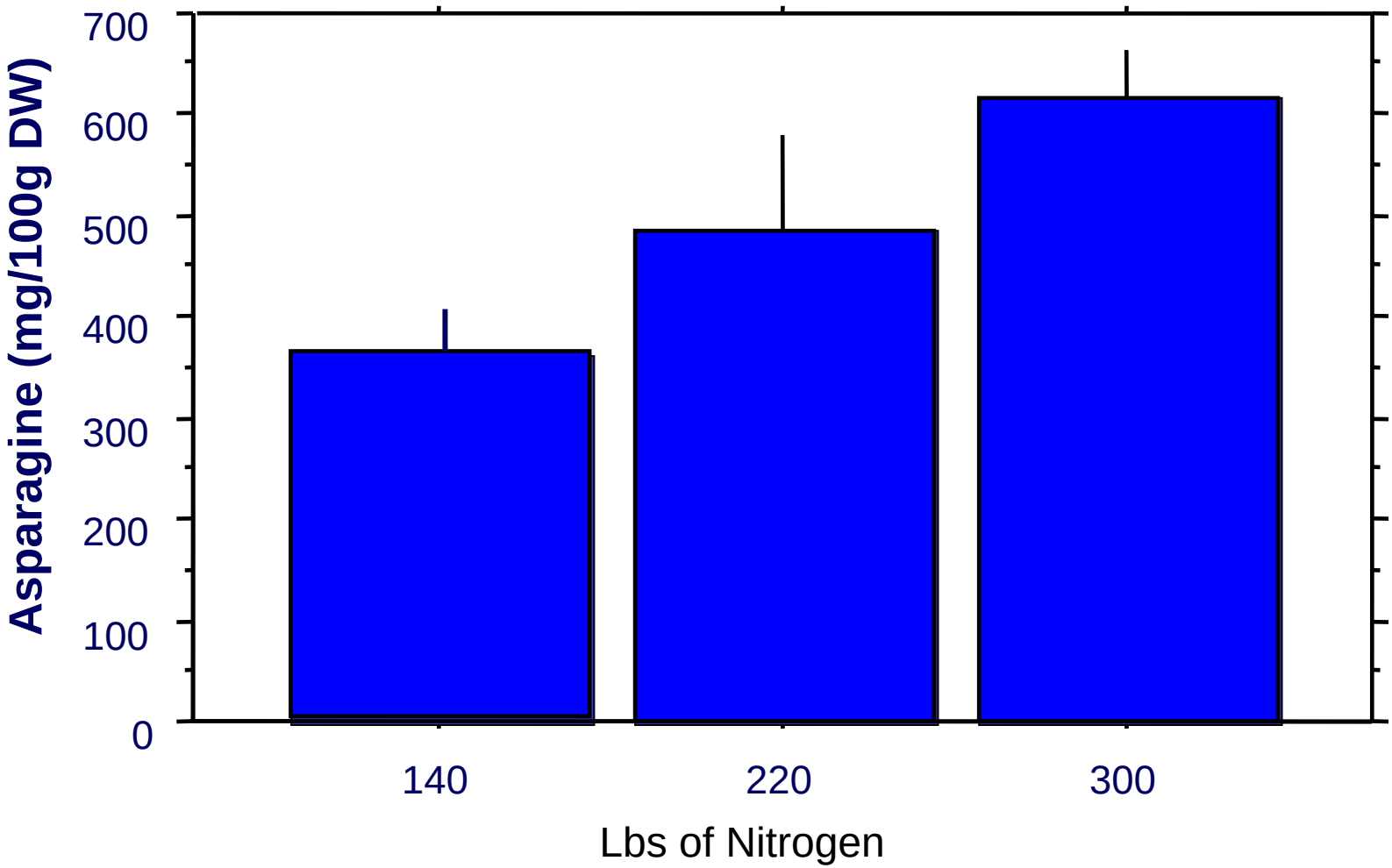
Correlation between Acrylamide Formation and Fructose Concentration



Range of Amino Acid Values in Different Potato Varieties at Harvest



Treatment Effects for WI1348



Reducing Sugars Appear to have the Greatest Effect on Acrylamide Production Potential

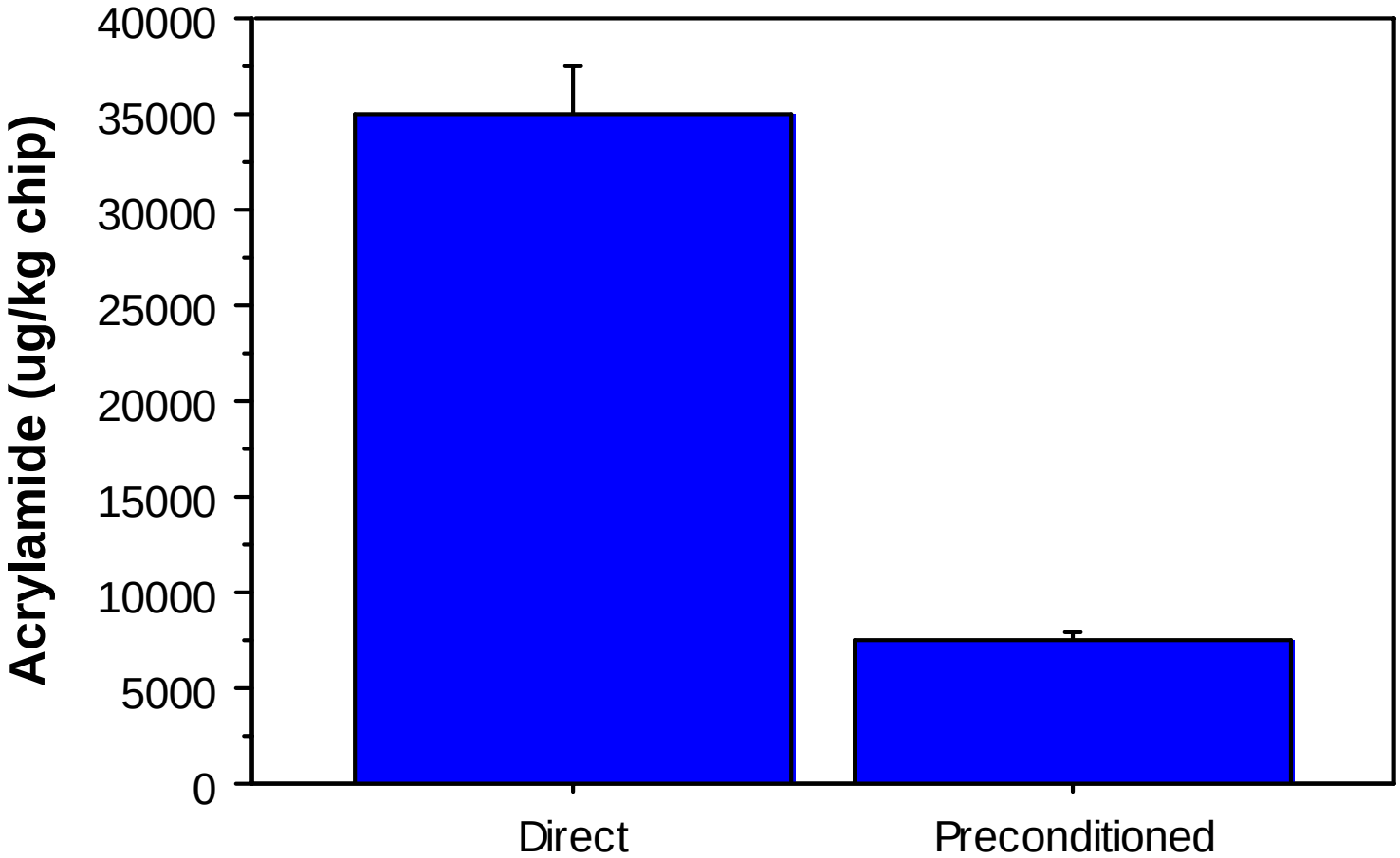
- No correlation between sucrose concentration and acrylamide
- No correlation between asparagine and acrylamide
  - Asparagine *has always been* the reactant in excess

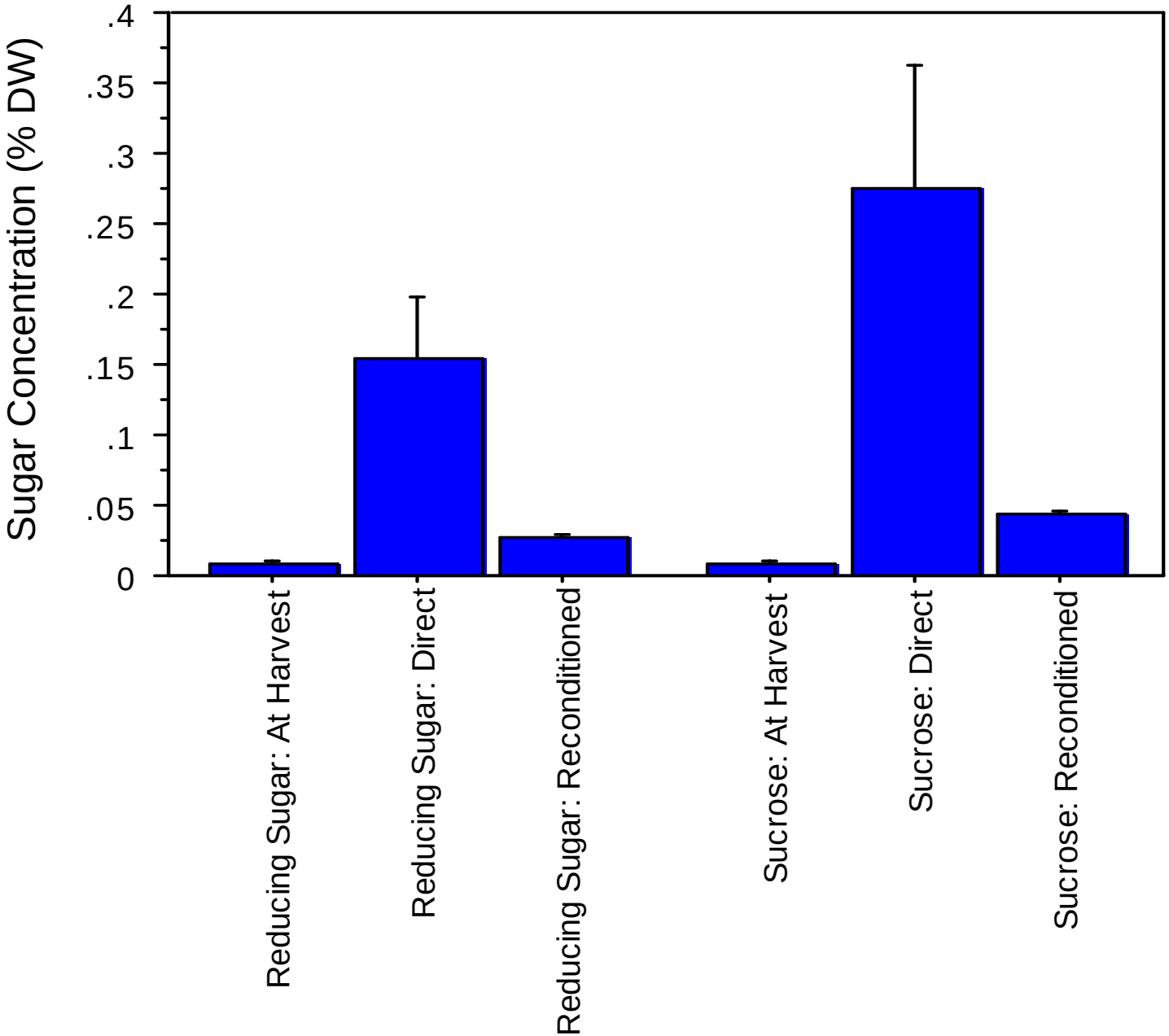
Possibilities of Selecting for Low Asn Tubers

- Range of asn values in diploid derivative tubers at harvest – 10-32 mg/g dw
- Range of asn values in diploid derivative tubers after storage – 5-50 mg/g dw

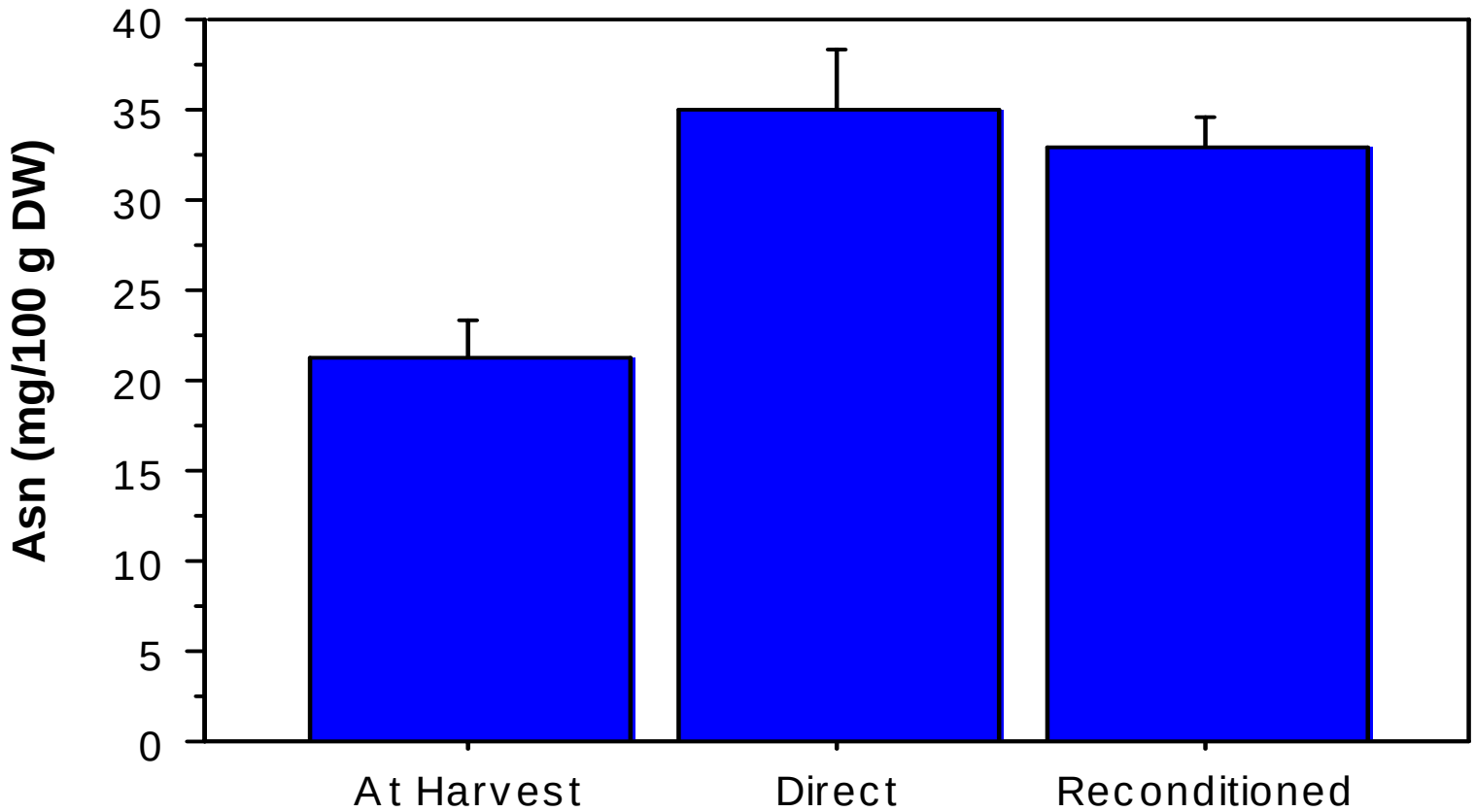
Slow cooling of potatoes after harvest (0.2 °C/day down to 2 °C “preconditioning”) reduces sugar levels

Acrylamide in Potato Chips from Tubers Direct from 2 °C and Preconditioned to 2 °C




Sugar Concentration (% DW)
0
.05
.1
.15
.2
.25
.3
.35
.4
Reducing Sugar: At Harvest
Reducing Sugar: Direct
Reducing Sugar: Reconditioned
Sucrose: At Harvest
Sucrose: Direct
Sucrose: Reconditioned

Changes in asparagine as a function of storage and reconditioning

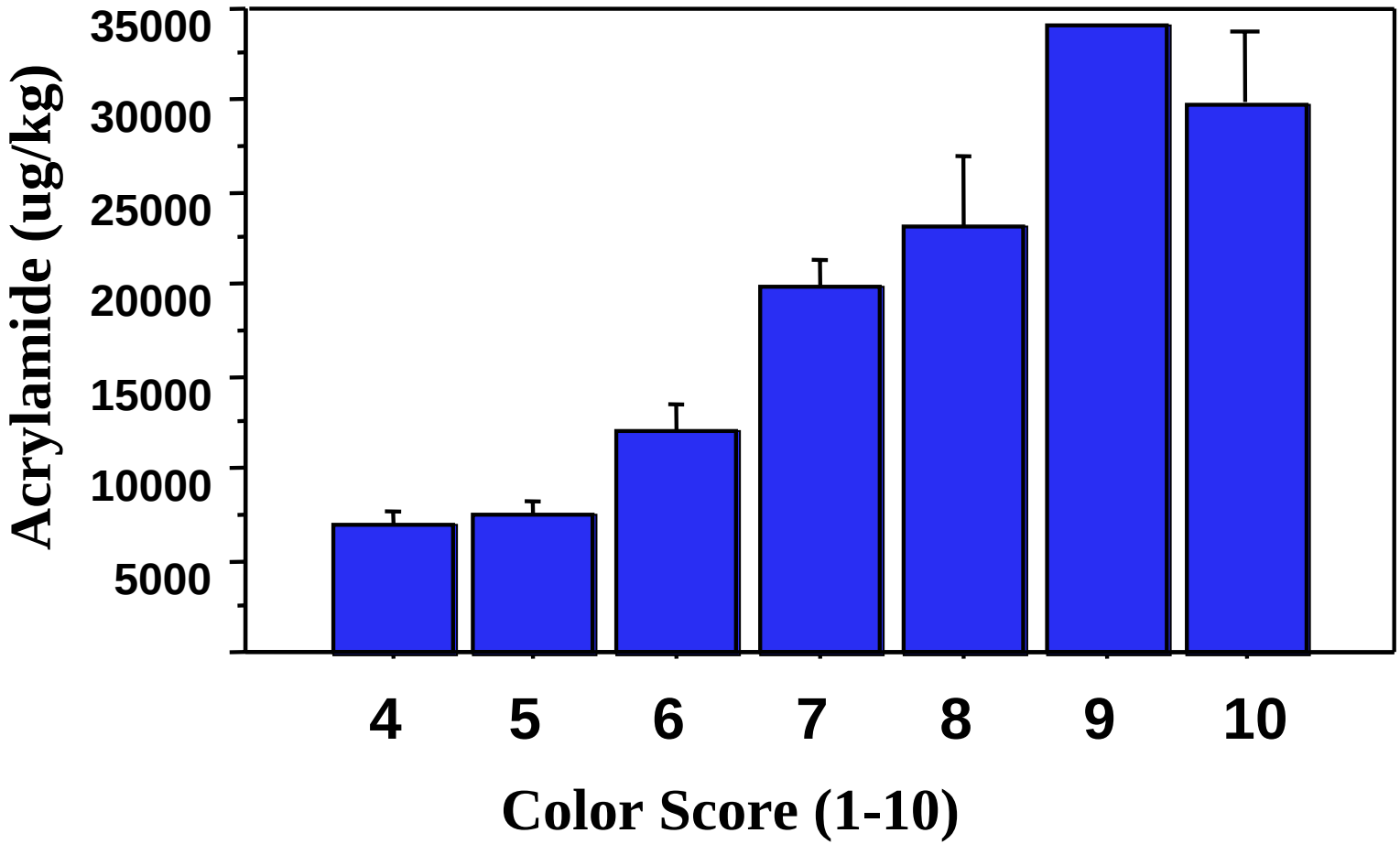


Other Tuber Components to Evaluate

- Phytate
- Calcium
- Starch

Next: At the processing plant… .

Chip Color and Acrylamide Concentration



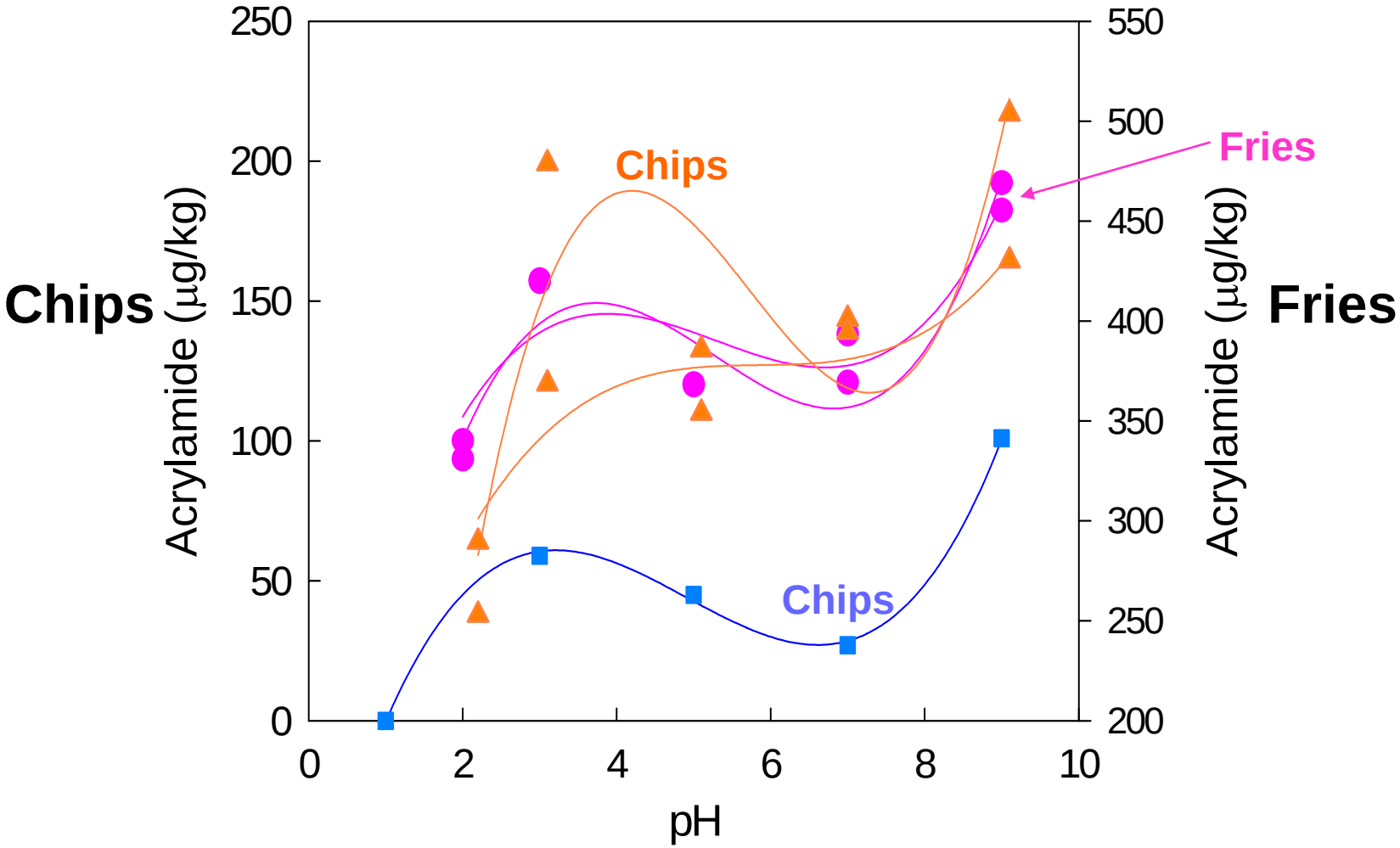
Association of Color with Acrylamide Formation

- Darker colored product associated with higher levels of acrylamide
  - Higher levels of precursors

Options

1. Control the concentrations of the precursors (reactants)
2. Control the reaction

pH Effect

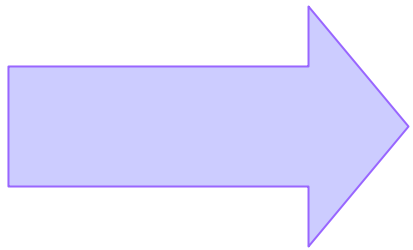

Chips
Acrylamide (µg/kg)
250
200
150
100
50
0
550
500
450
400
350
300
250
200
Fries
Acrylamide (µg/kg)
Fries
Chips
Chips
0
2
4
6
8
10
pH

Treatment Variables

Phytate

Ca^{+2}

pH

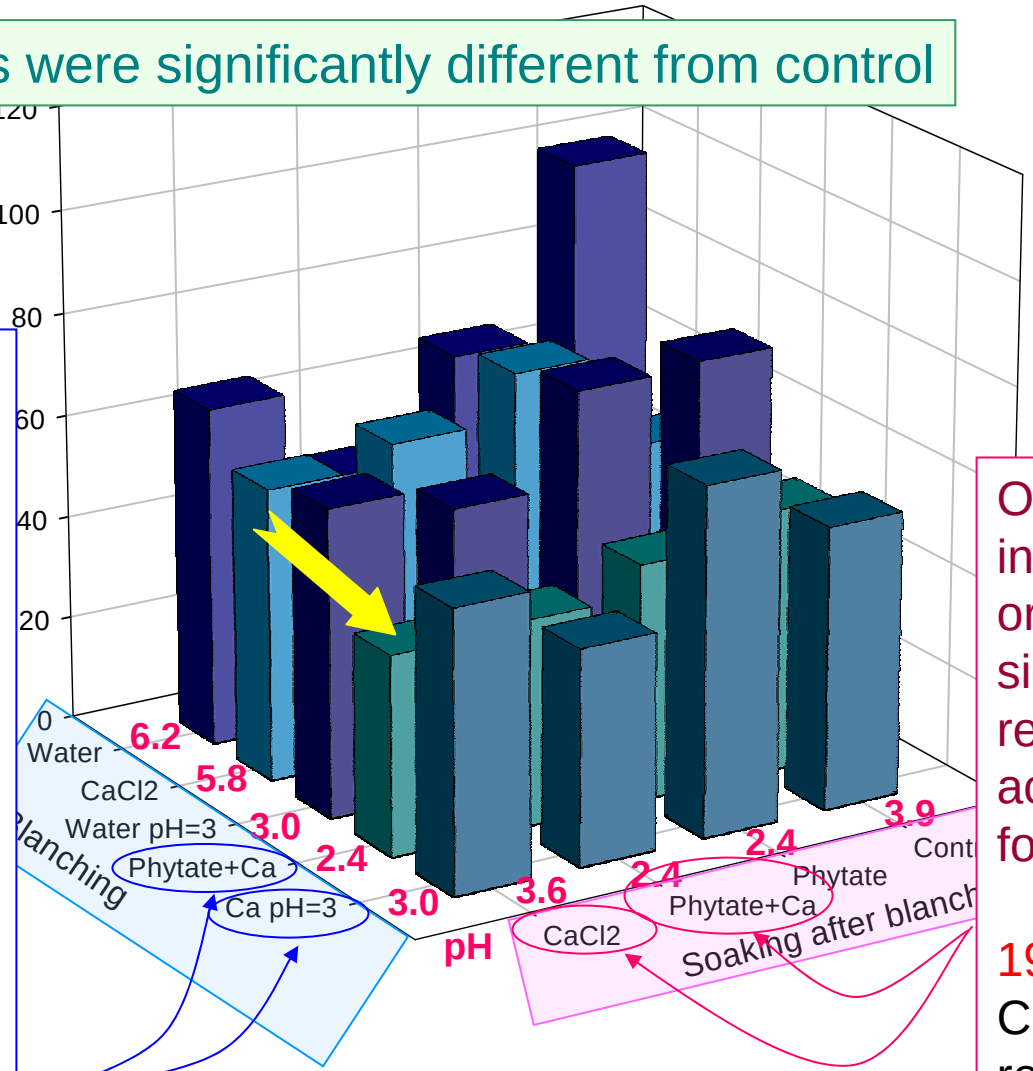


Determine effect on acrylamide formation individually and/or in combination

Phytate/Ca^{++} Experiments

All treatments were significantly different from control

Phytate: 0.025%
$CaCl_2$: 0.1%
n=3 - 5



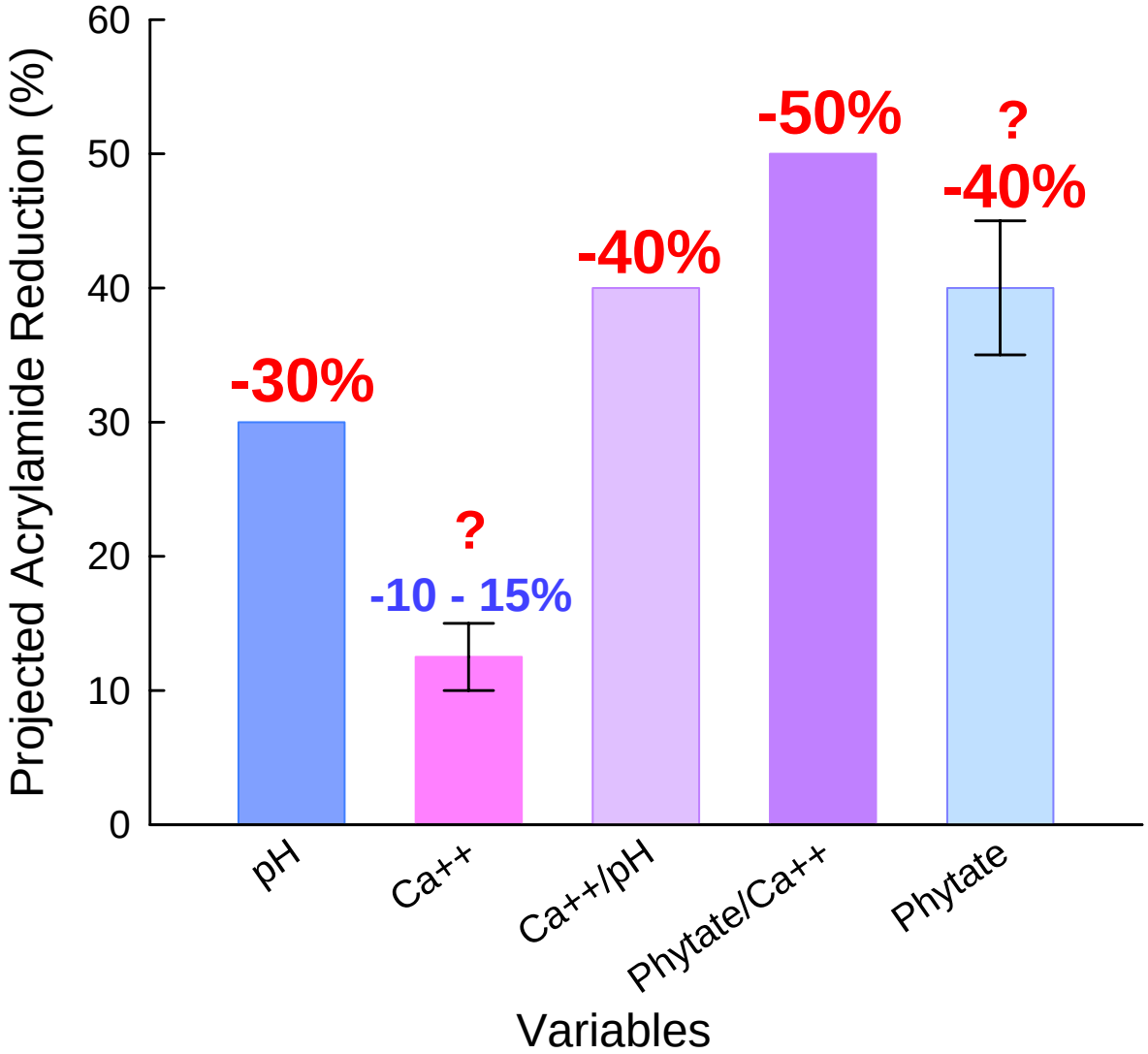
Overall, blanching in $CaCl_2$ pH=3 solution or Phytate/$CaCl_2$ significantly reduced acrylamide formation.

26% reduction for $CaCl_2$ pH=3 and 40% reduction for Phytate/$CaCl_2$.

Overall, soaking in $CaCl_2$ solution or Phytate/$CaCl_2$ significantly reduced acrylamide formation.

19% reduction for $CaCl_2$ and 25% reduction for Phytate/$CaCl_2$

Summary for Phytate/Ca^{++} Experiments



We are also investigating enzymatic strategies for controlling acrylamide, both pre- and post-processing