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Relating the protein composition and air-water interfacial properties of aqueous wheat flour extracts

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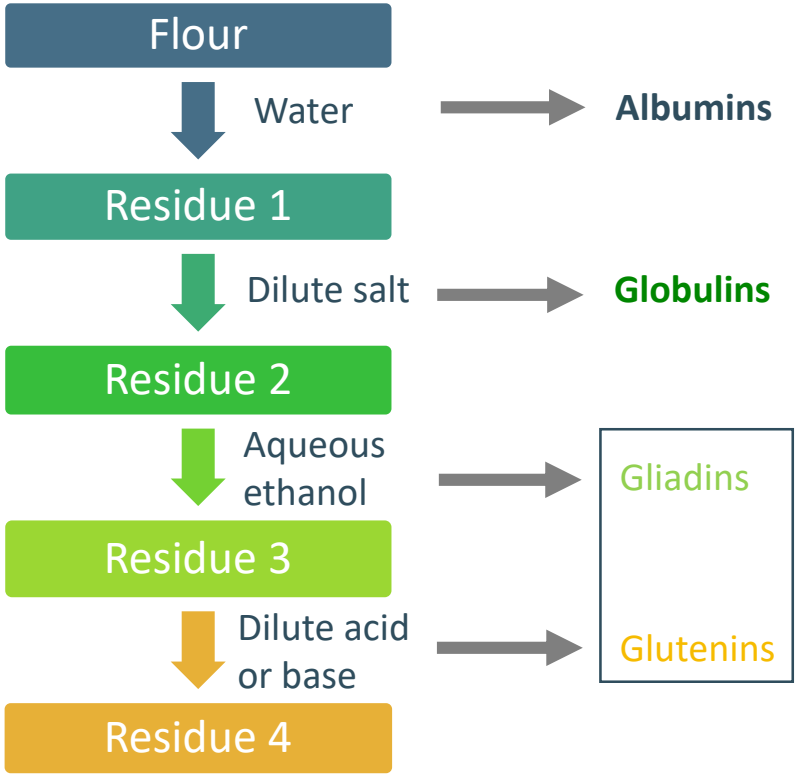
7 April 2022

- Introduction
- Objectives
- Results
- Conclusions

Introduction
Wheat proteins

Osborne Fractionation



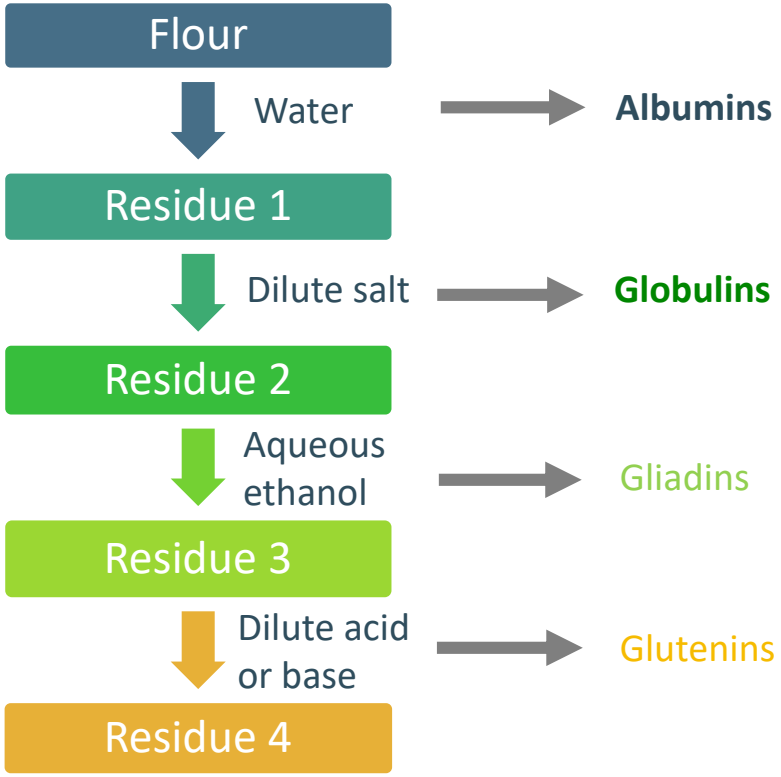
- **Major part of wheat proteins**
- **Most often focused on in cereal science, given their major functional contribution in food systems**

Osborne (1907)

Introduction

Nitrogen fertilization as a tool to alter wheat protein content/composition

Osborne Fractionation



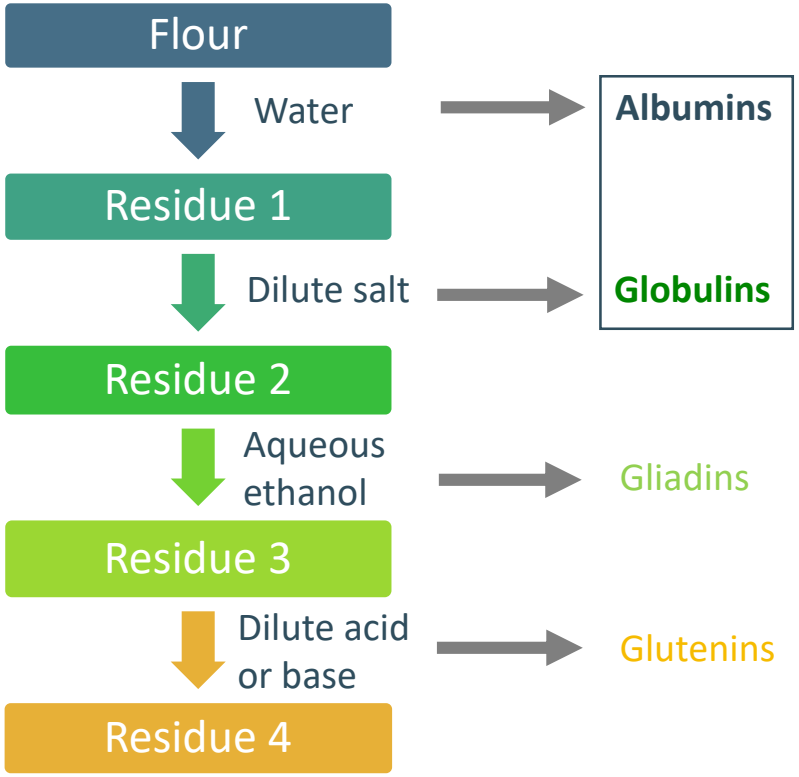
- **Protein (gluten) content and composition as main quality trait for wheat**
- **Nitrogen fertilization**
  - **Gluten content increases**
  - **Relative gliadin and glutenin levels increase and decrease, respectively**
  - **No consensus on the effect on albumin and globulin contents**

→ N fertilization as a tool to obtain wheat samples varying in protein content/composition

Jia et al. (1996); Chope et al. (2014); Wieser & Seilmeier (1998); Scheromm et al. (1992)

Introduction
Wheat proteins

Osborne Fractionation



- ☑ **Soluble in aqueous systems**
- ☑ **Potential to stabilize air/water (A/W) interfaces → foam stabilization**

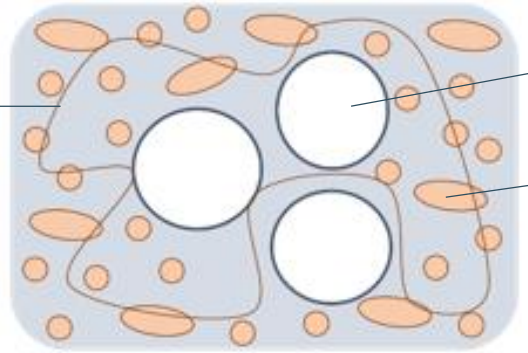
→ **Relevance in cereal based foods?**

Osborne (1907)

Introduction

Gas cell stabilization in wheat based products

- Bread dough (or cake batter) can be considered foam-type structures



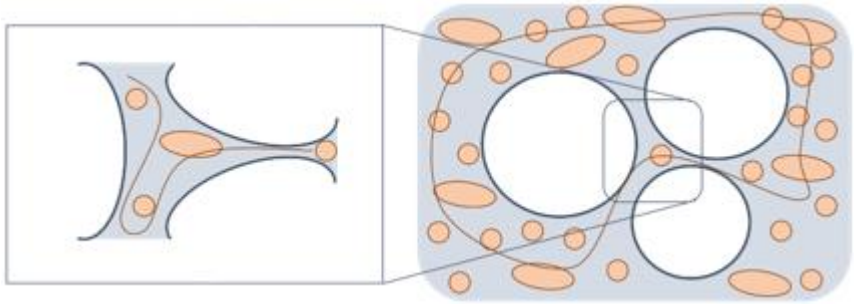
Gluten protein network

Gas cells

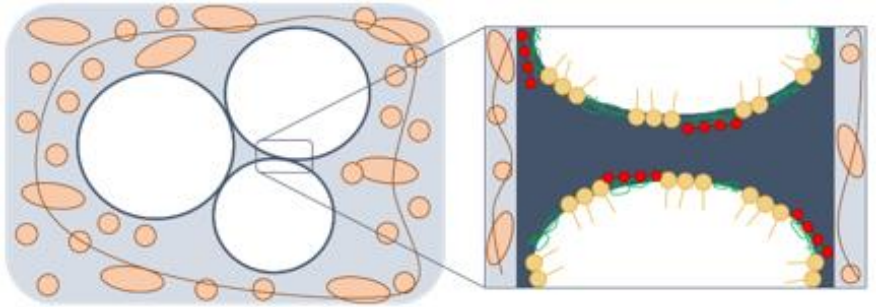
Starch granules

Mechanism 1: strain hardening by gluten proteins

Mechanism 2: Gas cell interface stabilization by surface-active constituents



Rupturing of gluten network because of pronounced extension during fermentation/baking



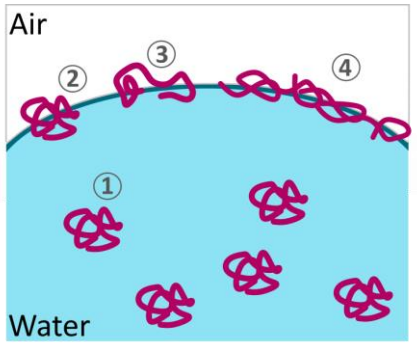
Janssen et al. (2021)

Introduction

Foam stabilization by food constituents

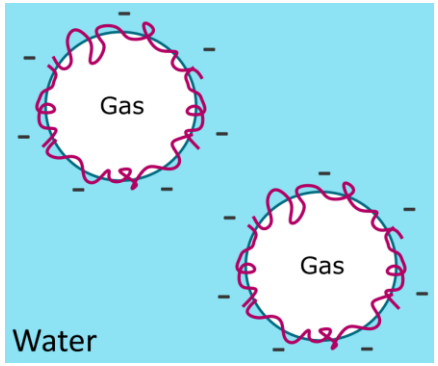
Protein Lipids NSP

Proteins

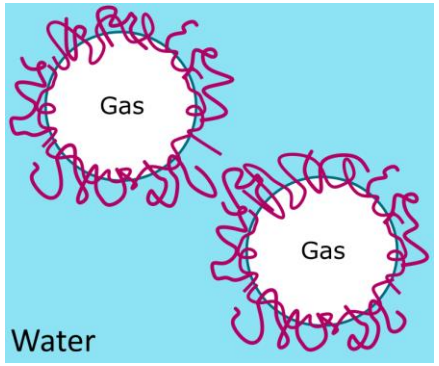


1 - Diffusion
2 - Adsorption
3 - Unfolding
4 - Protein-protein interaction
= Viscoelasticity

Electrostatic repulsion

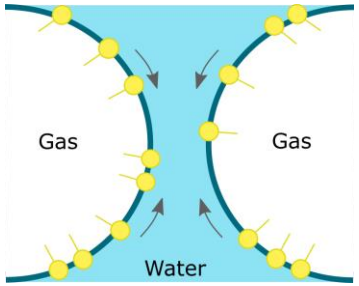


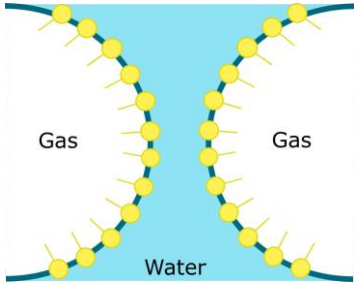
Steric hindrance



Lipids

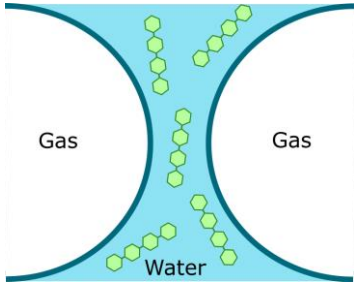
Marangoni effect



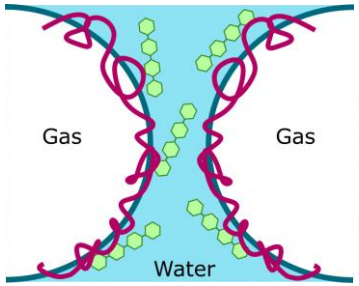


Non-starch polysaccharides (NSP)

↑ bulk viscosity



Protein-NSP complex



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Objective & approach

To investigate the potential of water-extractable wheat flour proteins to stabilize air-water interfaces and foams

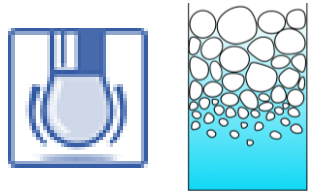
Wheat (cv. Apache) cultivation at
0 kg N/ha
150 kg N/ha
300 kg N/ha

Milling

Wheat flour

Aqueous extraction

Wheat flour aqueous extract



Foaming and air-water interfacial properties

Basic chemical composition

In-depth chemical composition

- Protein, lipid, AX, ash, polymer glucose, fructan levels
- Protein apparent molecular weight distribution (SE-HPLC)
- Protein hydrophobicity distribution (RP-HPLC)

- Introduction
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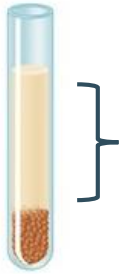
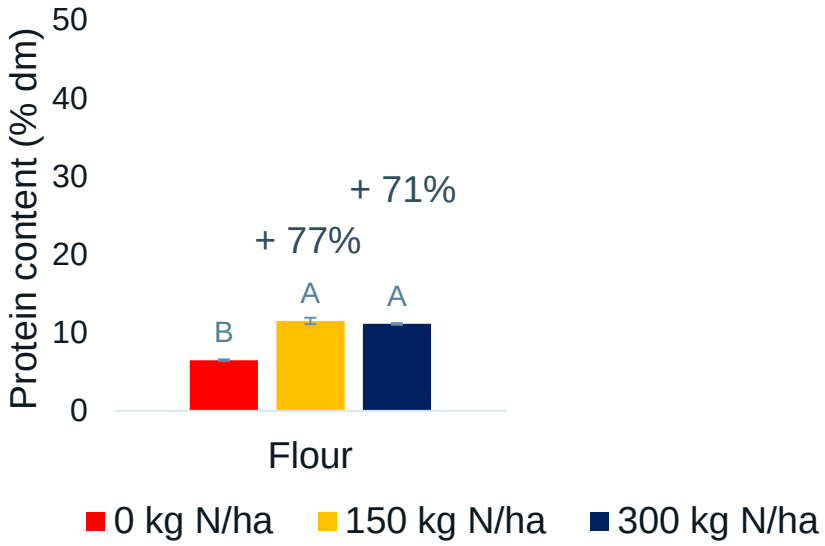
Results

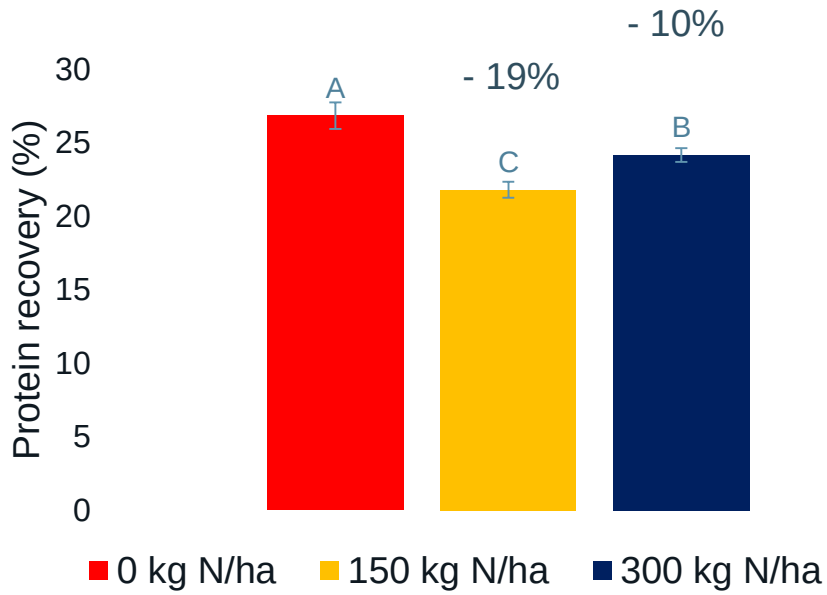
Chemical composition



Wheat flour aqueous extract

- Protein content of flours and extracts (+ protein recovery therein) obtained from wheat cultivated at various N fertilization levels

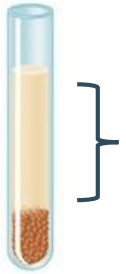




Connecting letter indicate significant (P < 0.05) differences between N fertilization levels for a given sample (flour or extract)

Results

Chemical composition



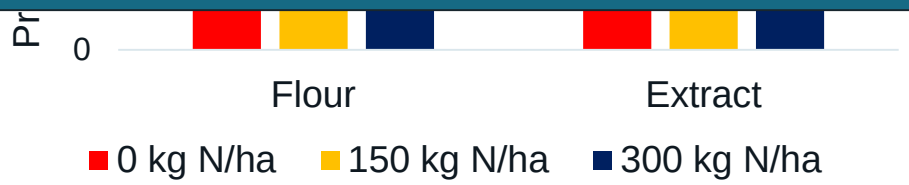
Wheat flour aqueous extract

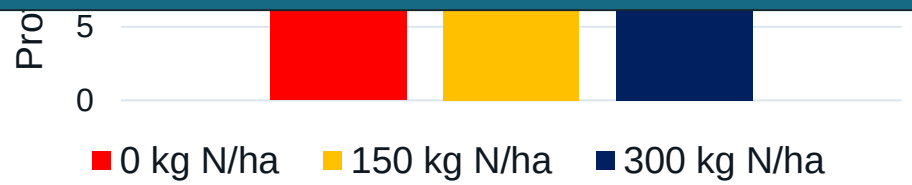
- Protein content of flours and extracts (+ protein recovery therein) obtained from wheat cultivated at various N fertilization levels

As expected, N fertilization increases the protein level in wheat flour

N fertilization also increased the amount of water-extractable protein

Relatively speaking, the increase in non-water extractable proteins was greater than that of water-extractable proteins





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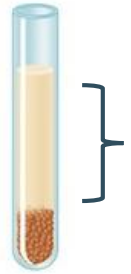
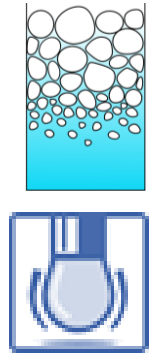
Results

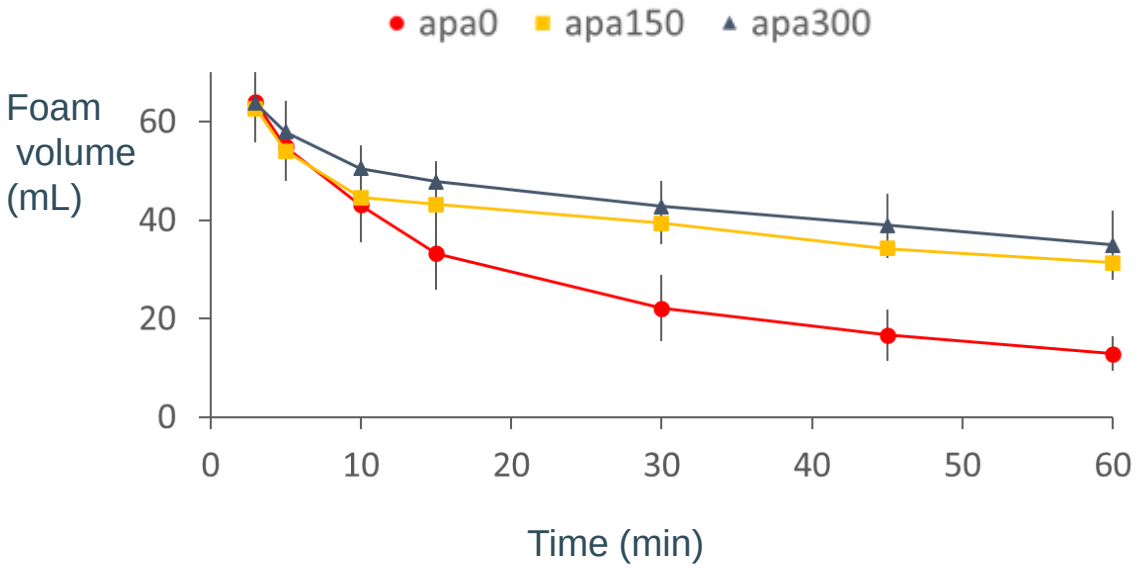
Foaming and air-water interfacial properties

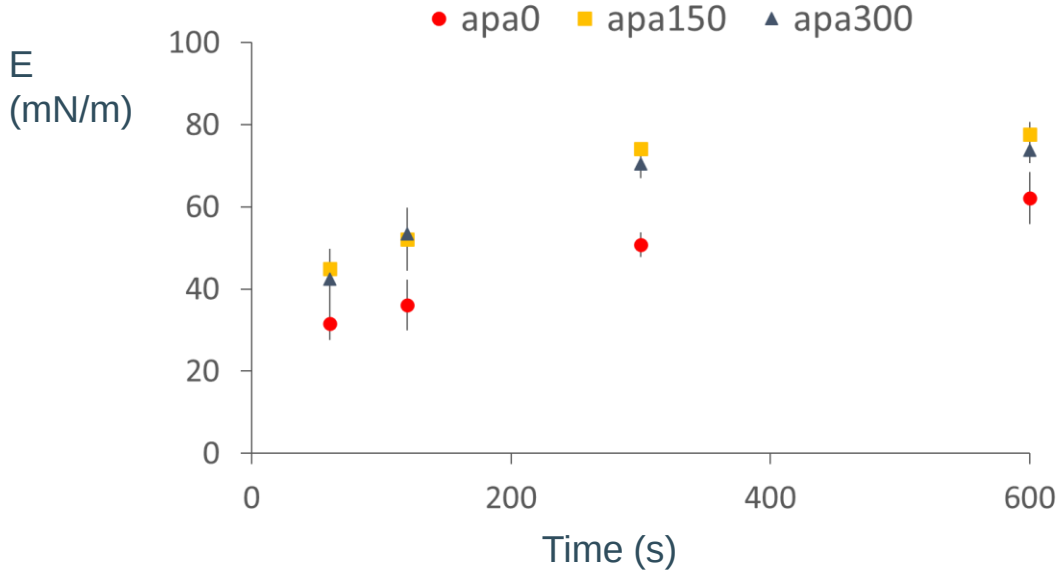


Wheat flour aqueous extract



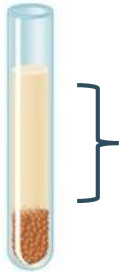
- Foaming via standardized stirring test
- Air-water interfacial properties via oscillating pendant drop tensiometry
  - Performed at 0.05% $w_{protein}/v$
  - No differences in surface tension were observed



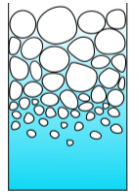


Results

Foaming and air-water interfacial properties



Wheat flour aqueous extract

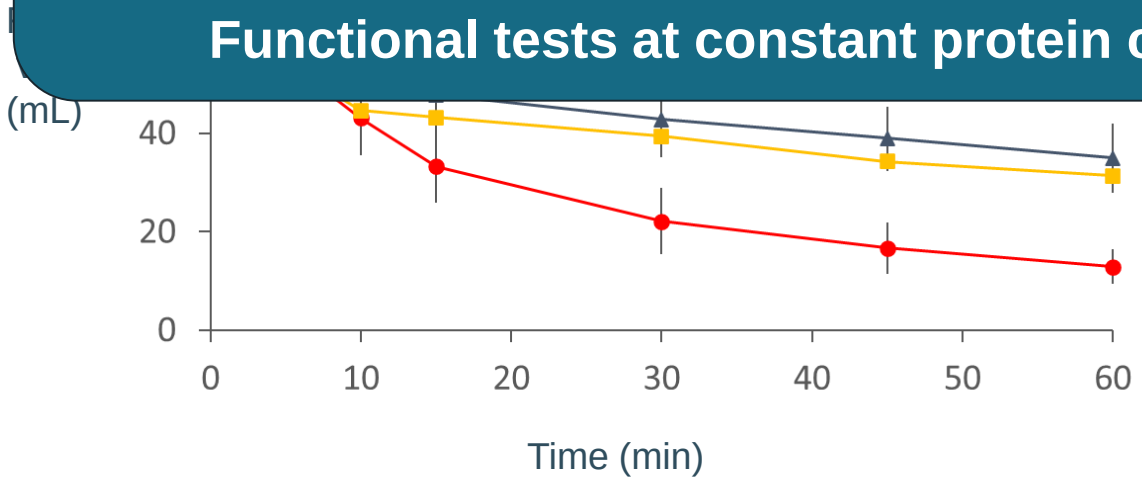


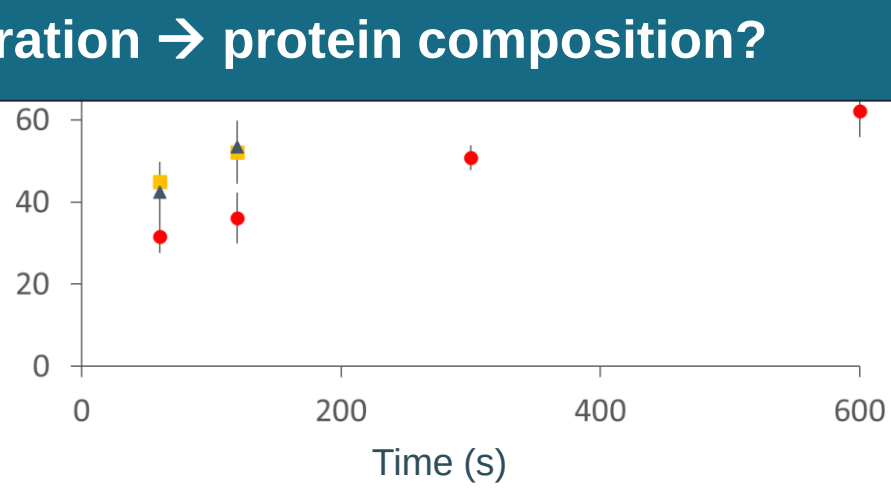
- Foaming via standardized stirring test
- Air-water interfacial properties via oscillating pendant drop tensiometry

N fertilization results in better foam stability

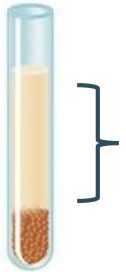
Good foam stability is accompanied by high dilatational moduli

Functional tests at constant protein concentration → protein composition?

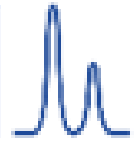




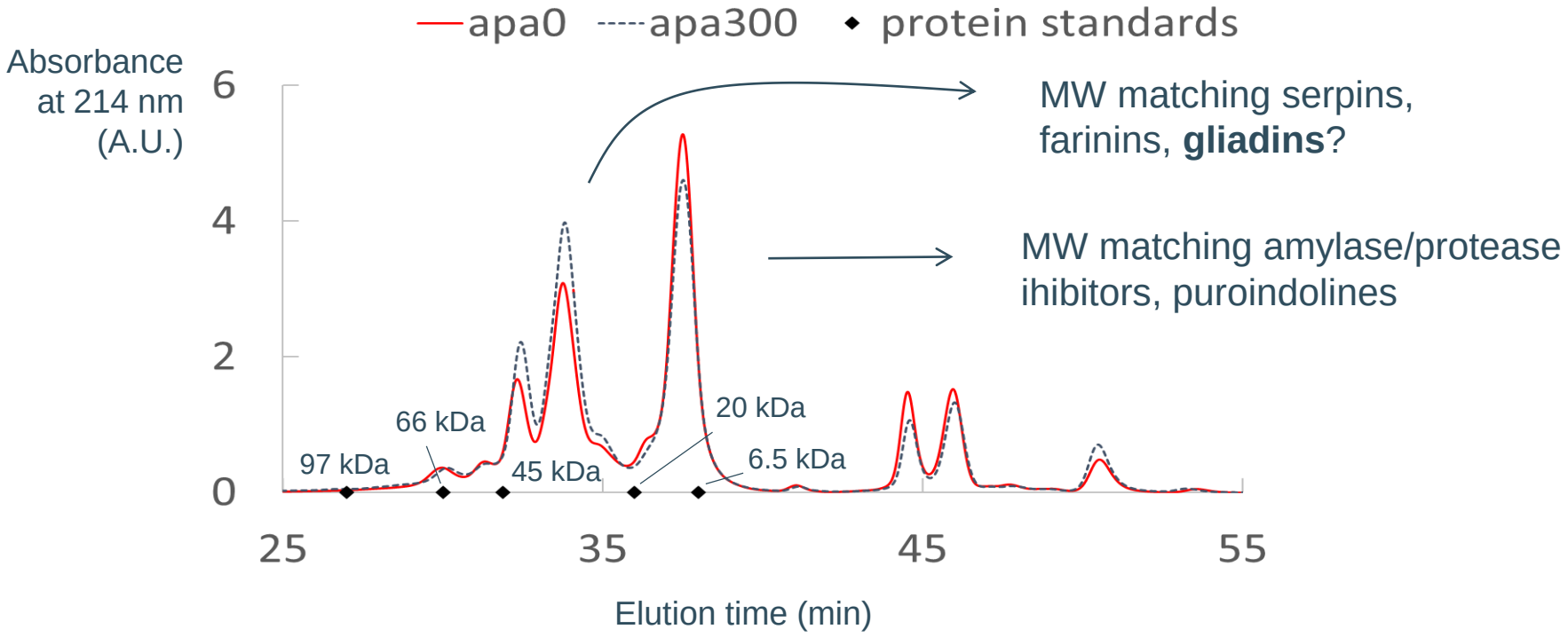
Results
Protein composition



Wheat flour aqueous extract

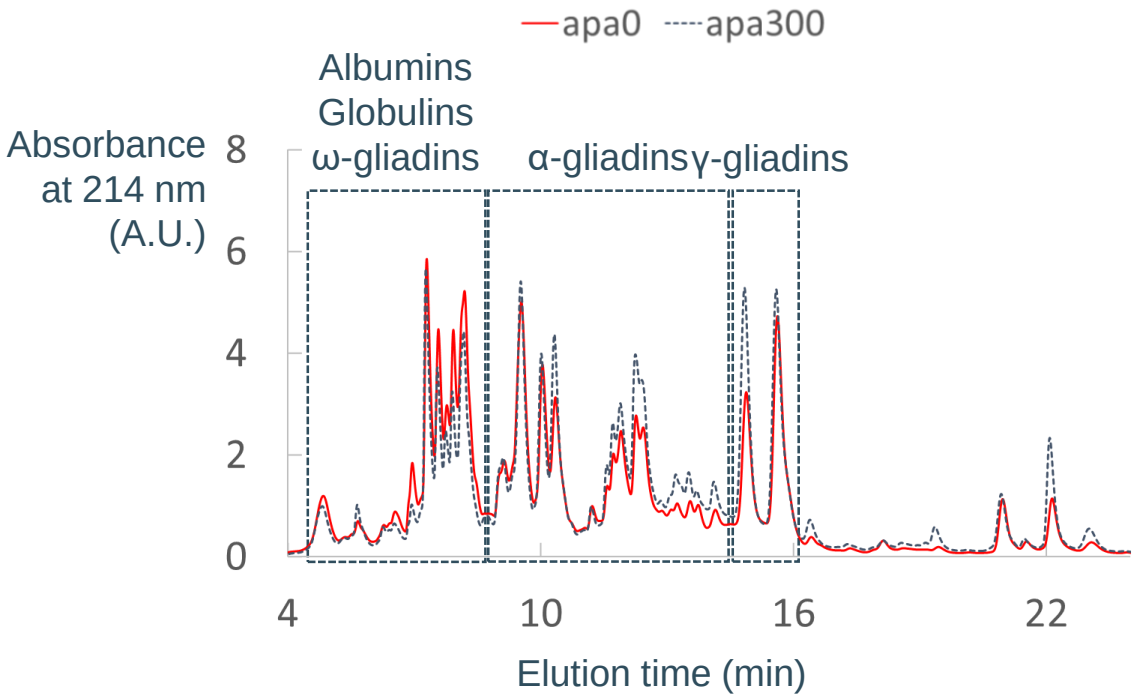


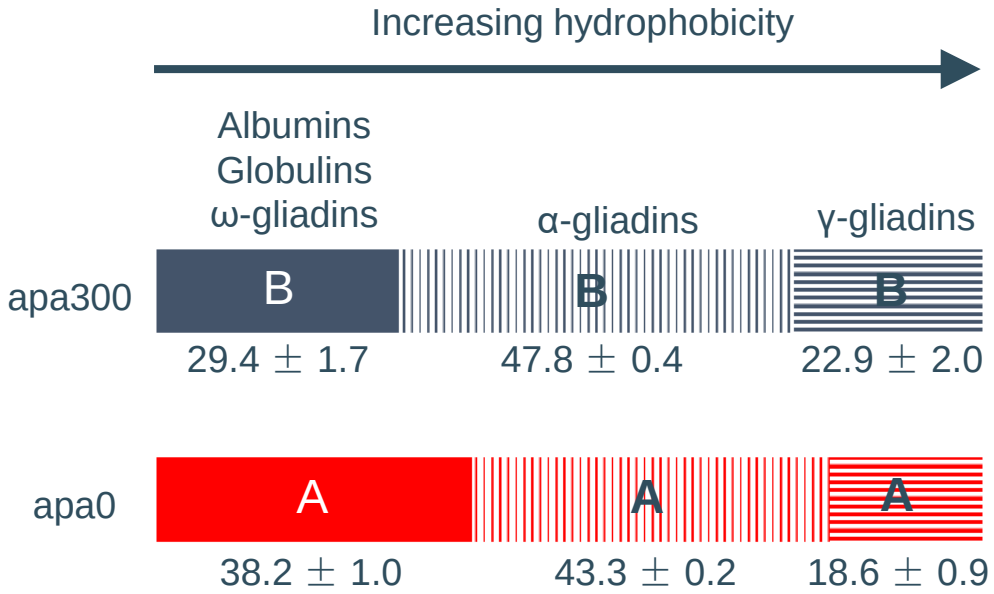
- Apparent molecular weight distribution (SE-HPLC)
  - Dried extracts were dissolved in 0.05 M sodium phosphate buffer containing 2.0% SDS



Results
Protein composition

- Hydrophobicity distribution (RP-HPLC)
  - Dissolved in 60% v/v ethanol





Wieser et al. (1994)

Connecting letter indicate significant ($P < 0.05$) differences between relative gliadin type levels for a given N fertilization level

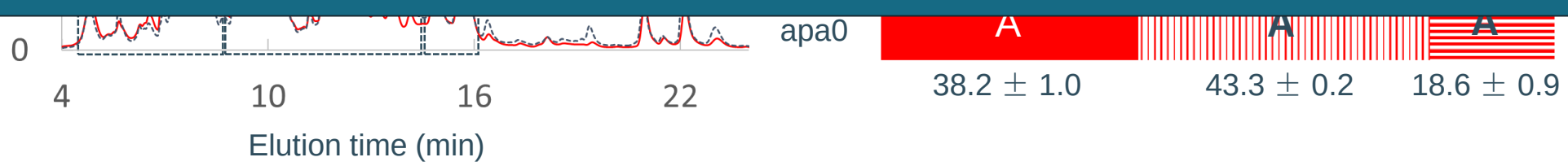
Results
Protein composition

- Hydrophobicity distribution (RP-HPLC)
  - Dissolved in 60% v/v ethanol

N fertilization increases the relative amount of proteins with MWs matching those of gliadins

RP-HPLC confirmed that considerable gliadin levels (up to ~70%) were present in extracts

N fertilization resulted in an increase in the relative level of α- and γ-gliadins



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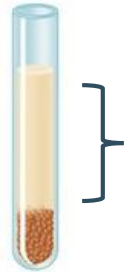
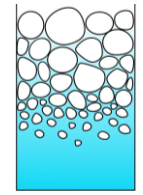
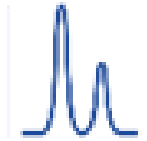
Results
Foam fractionation

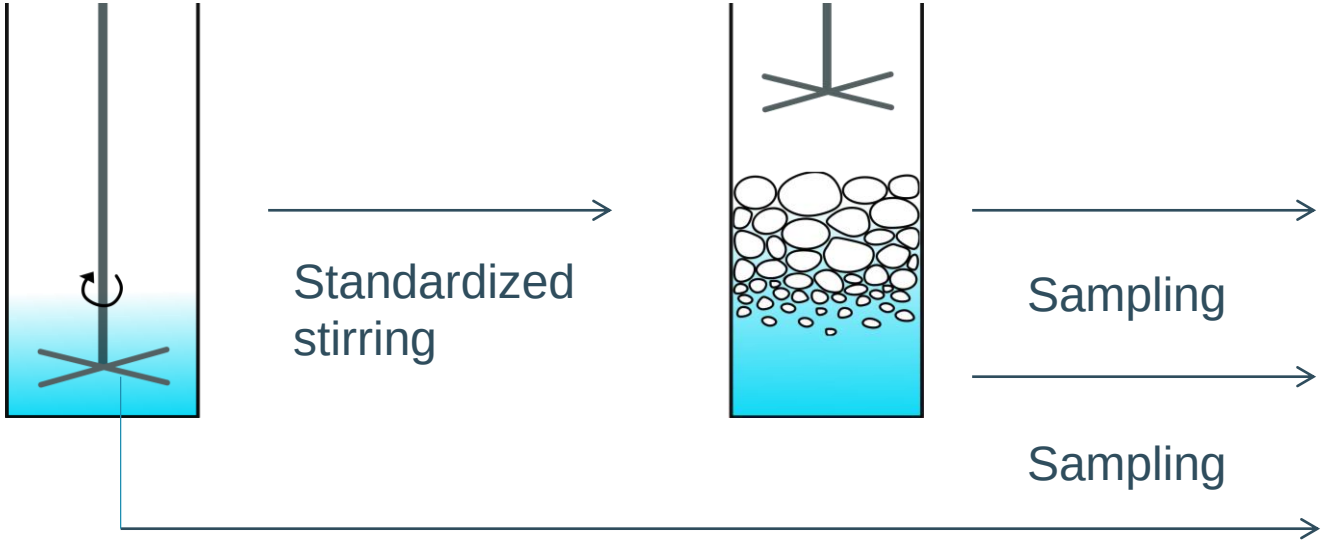


Wheat flour aqueous extract





- Identification of surface-active protein species
- Foam fractionation approach



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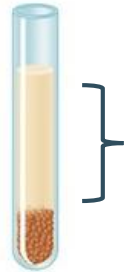

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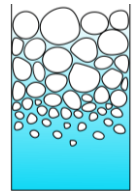

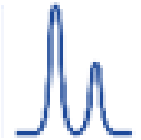

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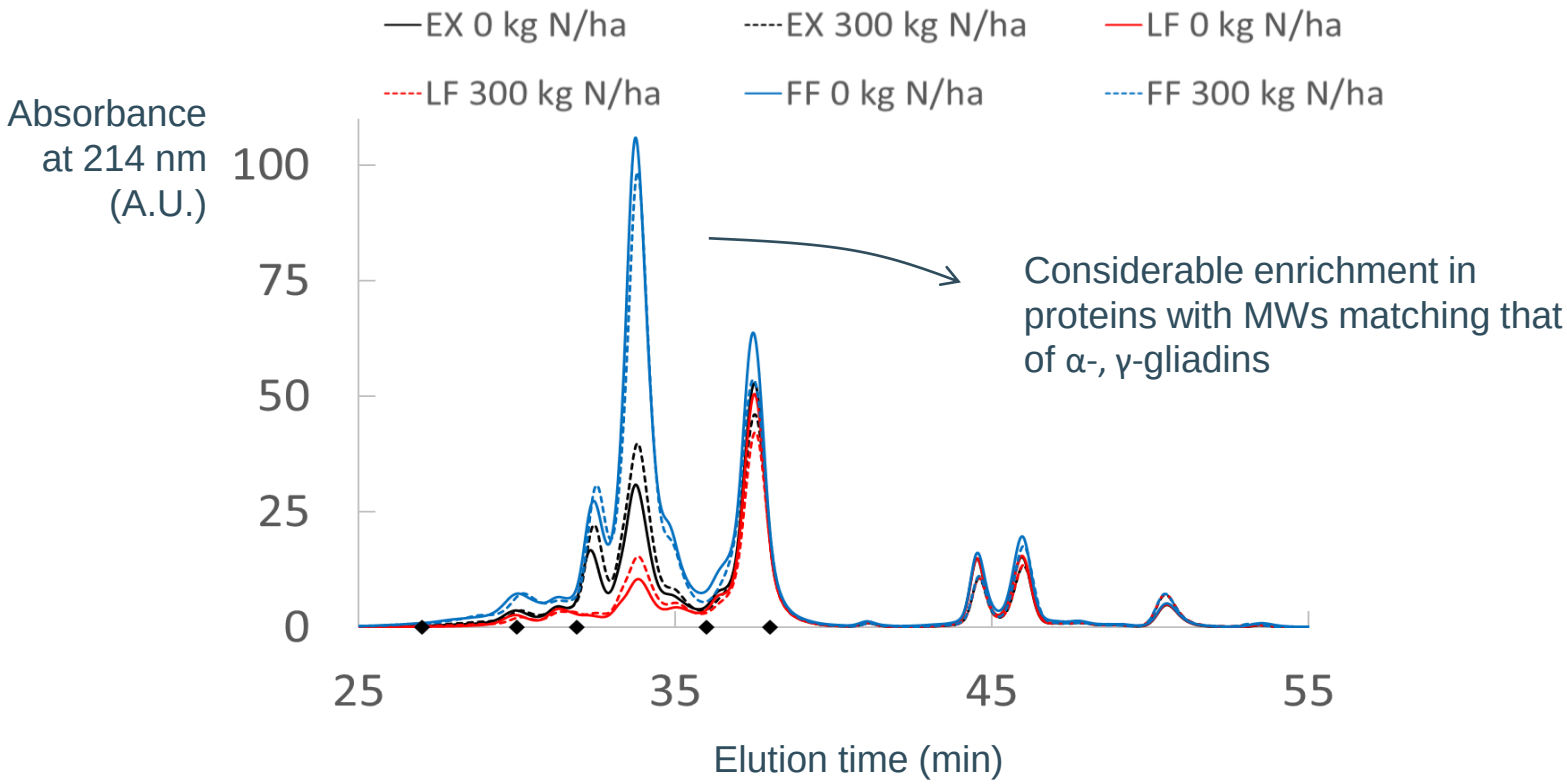

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Conclusions

- N fertilization results in an increase in both water-extractable and non-water-extractable proteins in wheat flour
- Considerable levels of gliadins are present in water extracts from wheat flour
  - *Other cultivars?*
- Relative α- and γ-gliadin levels increase upon N fertilization
- N fertilization leads to improved foam stabilization of wheat extracts
- Gliadins are probably key in this regard
  - *Interaction with other extract constituents?*
  - *Functional contribution of gliadins in cereal based food systems?*
  - *Effect of dough/batter making?*

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Thank you !!

More details:

Janssen F., Mesure E., Wouters A.G.B. Relating the protein composition and air-water interfacial properties of aqueous flour extracts from wheats grown at different nitrogen fertilization levels. Food Chemistry, in press, 2022.

Results

Wheat extract chemical composition

- Concentrations of key constituents when dissolved at 0.05% $w_{protein}$/v

Wheat sample		Proteins (mg dm/50 mL)	Dry matter (mg/50 mL)	Lipids (mg dm/50 mL)	Arabinoxylan (mg dm/50 mL)	Protein/lipid ratio (-)
akteur	0	25.00	64.50	1.28	4.91	19
	150	25.00	63.98	1.24	3.75	20
	300	25.00	58.85	0.93	3.19	27
apache	0	25.00	93.41	2.30	6.88	11
	150	25.00	59.80	1.26	3.99	20
	300	25.00	60.82	1.15	3.90	22

Results

Wheat extract chemical composition

- Comparison of a RP-HPLC profile of a wheat extract with a 60% v/v ethanol gliadin extract from commercial wheat gluten