The role of lipids in determining gas bubble retention in wheat dough

Peter Shewry, Paola Tosi and Richard Haslam
(Rothamsted Research)

Pete Wilde (IFR)

Simon Penson (Campden BRI)

BBSRC CIRC
36 months
£600K

Breadmaking requires:

1. Formation of visco-elastic gluten network during dough mixing.
2. Expansion of the gluten network by entrapment of CO_2 during proofing
3. Retention of gas bubble structure through to baking

These are determined by:

1. Gluten viscoelasticity (dough strength)
2. Surface active components at the gas bubble interface

Hypothesis

we can rationally manipulate the endogenous lipid composition of wheat to improve breadmaking performance through increasing the stability of gas cells and therefore their resistance to coalescence.

Work Planned

1. Identification of functional components (RRes, IFR)
   Isolate gas bubble interface
   Lipidomics platform

2. Determination of mechanism of action (IFR)
   Microconductivity
   Interfacial analysis
   Microscopy (EM, confocal)

3. Determine functionality (Campden BRI)
   Farinograph, Alveograph, test baking, C cell

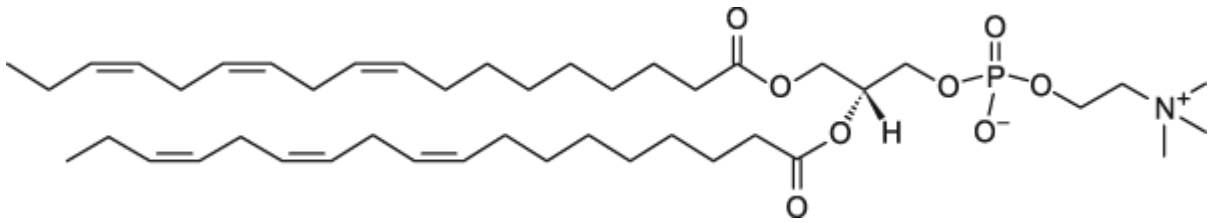
4. Determine variation and genetic control (RRes)
   WGIN lines
   Parents of DH populations

PhD STUDENT

Campden BRI
food and drink innovation

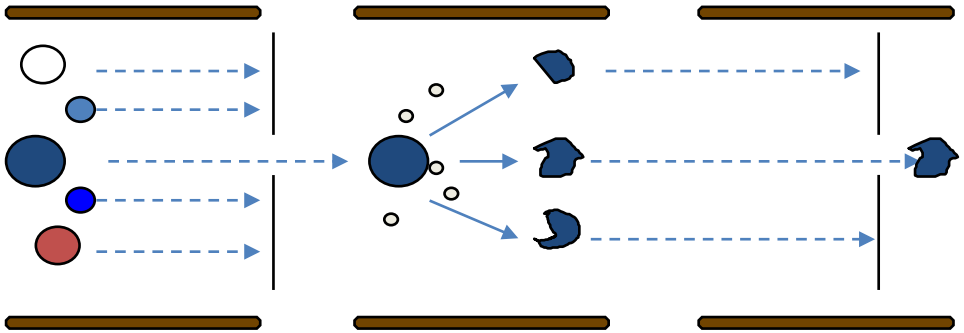
BBSRC
bioscience for the future

Structure of Plant Polar Lipids



Phosphatidylcholine (PC) 36:6

Analysis of Plant Lipids



Precursor ion fixed

Fragmentation (CAD)

Product ion fixed

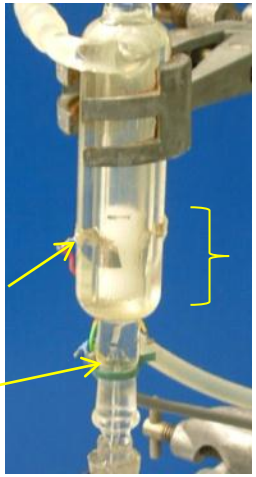
We can quantify144 lipid molecular species of polar lipid

PG 32:1	PA 36:2	PI 34:1	PS 40:1	PC 40:2	MGDG 36:3
PG 32:0	PE 34:4	PI 36:6	PS 42:4	LysoPE 16:1	MGDG 36:2
PG 34:4	PE 34:3	PI 36:5	PS 42:3	LysoPE 16:0	MGDG 36:1
PG 34:3	PE 34:2	PI 36:4	PS 42:2	LysoPE 18:3	MGDG 38:6
PG 34:2	PE 34:1	PI 36:3	PS 42:1	LysoPE 18:2	MGDG 38:5
PG 34:1	PE 36:6	PI 36:2	PS 44:3	LysoPE 18:1	MGDG 38:4
PG 34:0	PE 36:5	PI 36:1	PS 44:2	LysoPC 16:1	MGDG 38:3
PG 34:5-O	PE 36:4	PS 34:4	PC 32:0	LysoPC 16:0	DGDG 34:6
PG 34:4-O	PE 36:3	PS 34:3	PC 34:4	LysoPC 18:3	DGDG 34:5
PG 36:6	PE 36:2	PS 34:2	PC 34:3	LysoPC 18:2	DGDG 34:4
PG 36:5	PE 36:1	PS 34:1	PC 34:2	LysoPC 18:1	DGDG 34:3
PG 36:4	PE 38:6	PS 36:6	PC 34:1	LysoPC 18:0	DGDG 34:2
PG 36:3	PE 38:5	PS 36:5	PC 36:6	LysoPG 16:1	DGDG 34:1
PG 36:2	PE 38:4	PS 36:4	PC 36:5	LysoPG 16:0	DGDG 36:6
PG 36:1	PE 38:3	PS 36:3	PC 36:4	LysoPG 18:3	DGDG 36:5
PA 32:0	PE 38:2	PS 36:2	PC 36:3	LysoPG 18:2	DGDG 36:4
PA 34:6	PE 40:3	PS 36:1	PC 36:2	LysoPG 18:1	DGDG 36:3
PA 34:5	PE 40:2	PS 38:6	PC 36:1	MGDG 34:6	DGDG 36:2
PA 34:4	PE 42:4	PS 38:5	PC 38:6	MGDG 34:5	DGDG 36:1
PA 34:3	PE 42:3	PS 38:4	PC 38:5	MGDG 34:4	DGDG 38:6
PA 34:2	PE 42:2	PS 38:3	PC 38:4	MGDG 34:3	DGDG 38:5
PA 34:1	PI 32:1	PS 38:2	PC 38:3	MGDG 34:2	DGDG 38:4
PA 36:6	PI 32:0	PS 38:1	PC 38:2	MGDG 34:1	DGDG 38:3
PA 36:5	PI 34:4	PS 40:4	PC 40:5	MGDG 36:6	SQDG 32:0*
PA 36:4	PI 34:3	PS 40:3	PC 40:4	MGDG 36:5	SQDG 34:3*
PA 36:3	PI 34:2	PS 40:2	PC 40:3	MGDG 36:4	SQDG 36:6*

Dough liquor characterisation

Dough liquor

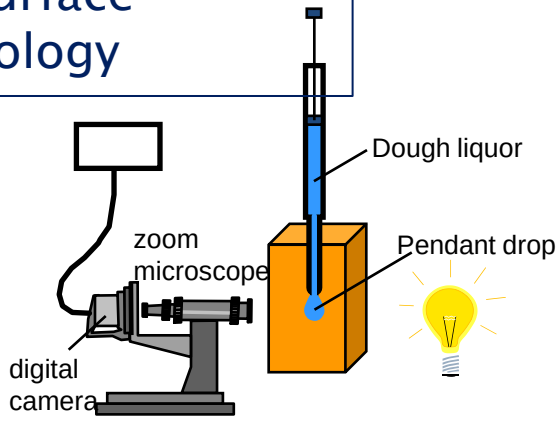
Foam stability



Foam micro-conductivity measures stability.

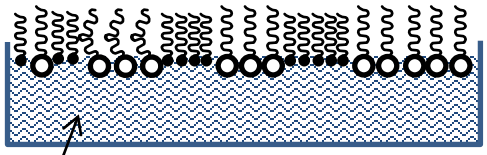
Over -foaming can allow separation and collection of foam active lipids.

Surface tension & surface rheology



Calculated from shape and size of pendant drop. Sensitive to surface composition and dynamics.

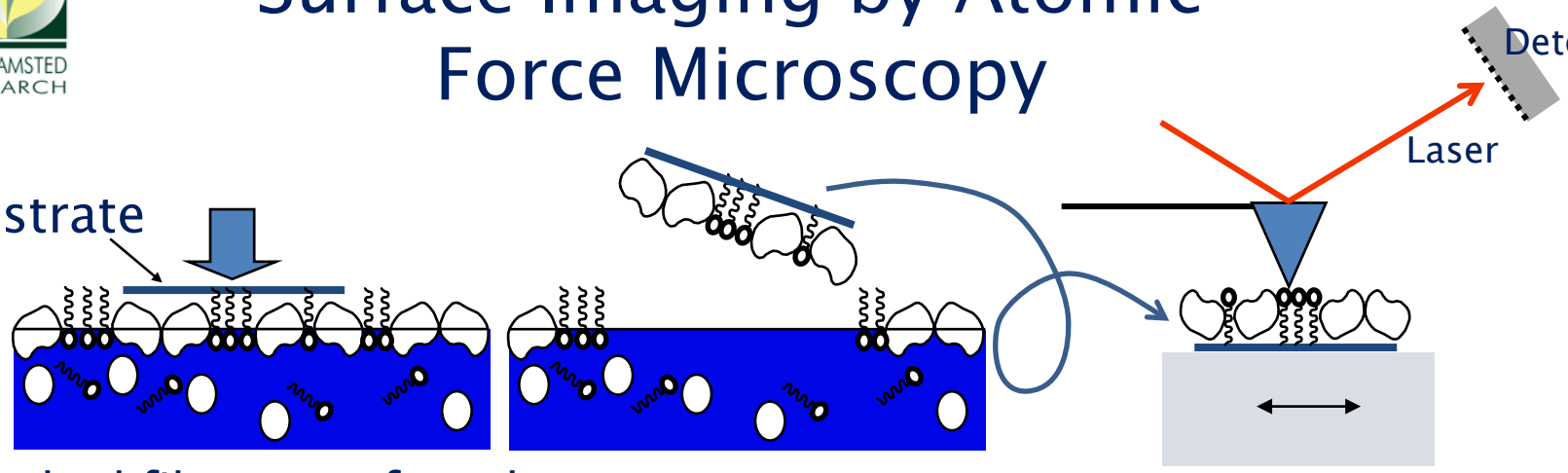
Surface composition and structure



Dough liquor

Langmuir trough allows sampling of surface lipids for MS analysis and Atomic Force Microscopy (AFM)

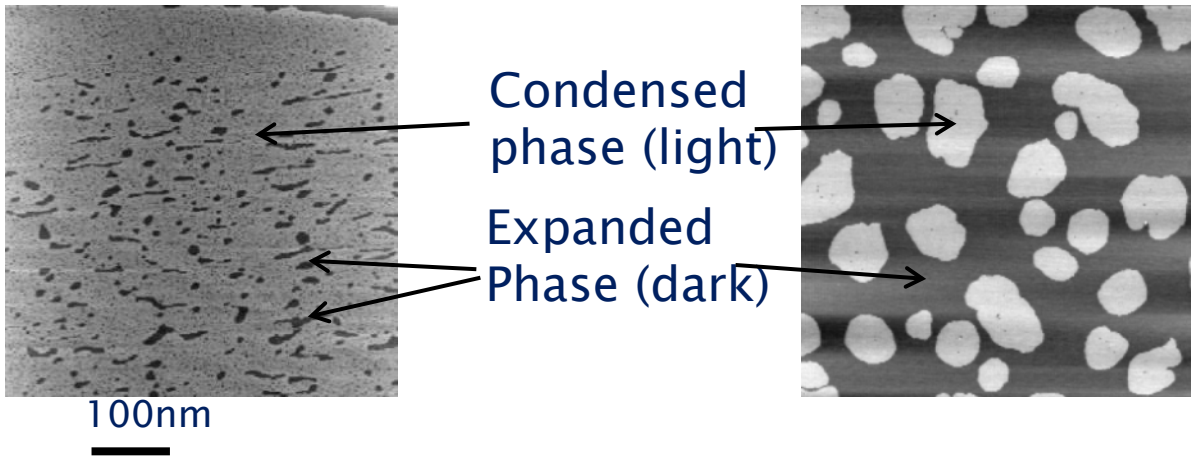
Surface Imaging by Atomic Force Microscopy



Adsorbed films transferred onto solid substrate using Langmuir-Blodgett (dipping) or Langmuir-Schafer (as above).

AFM is sensitive to morphology of surface and phase behaviour.

AFM image of phospholipid (PC) interface + added surfactant



Sensitive to changes in surface structure and phase behaviour to explain changes in functionality

Outcomes

1. Improved processing
   - reduced salt
   - reduced improvers and emulsifiers
   - “clean labels”

2. Improved wheat varieties
   - higher and more stable quality