on their stability.

Cl aster subtitle style

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Presentation structure

- Introduction :Ultrasonic emulsification

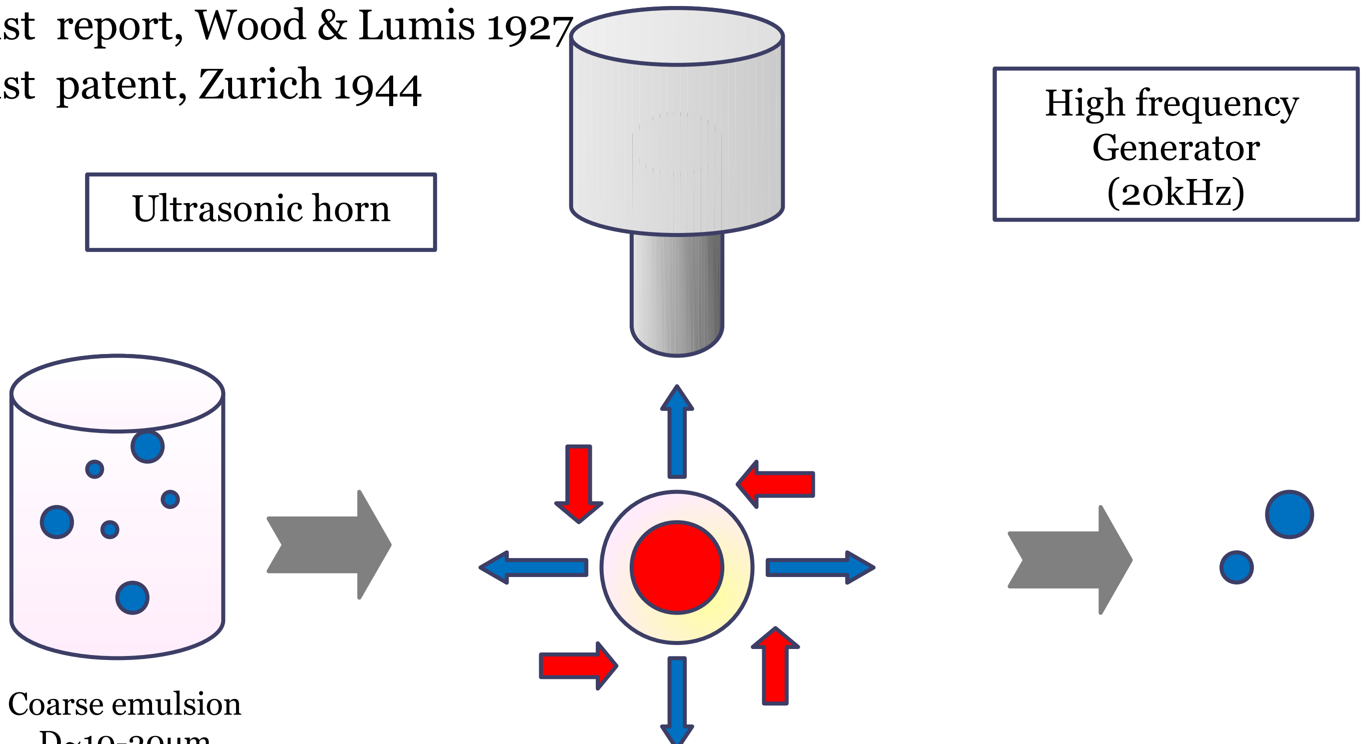
- WPC emulsions pH 7 – Stabilizers
  (model emulsions)

- WPI emulsions pH 4 –Time & Amplitude
(similar conditions with dressings)

Food design : not only calories

Ultrasonic emulsification

- 1st report, Wood & Lumis 1927
- 1st patent, Zurich 1944



Pressure gradients: deformation of droplets
Negative pressure cycle□**elongation**
Compression cycle□**collapse** of cavitation bubble

Ultrasonic emulsification

Advantages (+) Vs Conventional methods

- Small droplet (up to 200nm), narrow distribution □ increased stability
- Little or no surfactant
- Power efficiency

Process considerations

- Rheology limitations (continuous/dispersed phase viscosity, polymer degradation)
- Over-processing (re-coalescence)
- Thermal denaturation (e.g. proteins)

WPC model emulsions, ph 7

- Coarse emulsions : 3% WPC, 20% olive oil, 0.25 & 0.5% gums:

-Xanthan (XG)
-Guar (GG)
-Locust bean (LBG)

- Sonication :

-method A □ 70% amplitude/2min (~11.5 kJ)
-method B □ 70% amplitude/3min+90%-1min (~25.7 kJ)

- Analysis

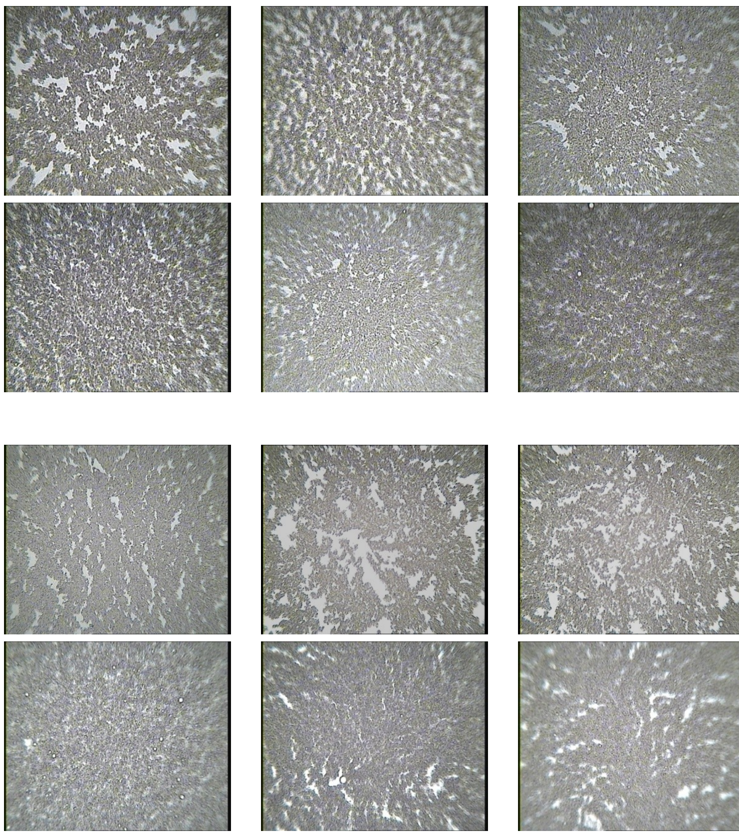
Multiple light scattering (MLS), Diffusion NMR, Light Microscopy, Stress-controlled rheology.

Microstructure

XG GG LBG

0.25%

0.5%



0.25%

0.5%

Method A

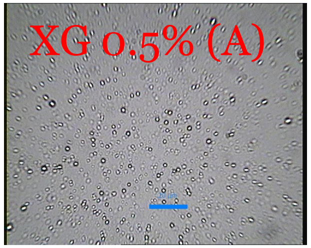
Method B

- Ultrasound disrupts gum flocs
- 0.25%□weak structure, induce depletion flocculation
- 0.5%□ stronger network, fewer gaps, methods A&B similar structure

Oil droplet size

% Gum		Method A D50 (μm)	Method B D50 (μm)
XG	**0.25**	1.107a	0.832a
	0.5	1.325b	0.786a
GG	**0.25**	1.093a	0.843a
	0.5	1.330b	0.771a
LBG	**0.25**	1.018c	0.876a
	0.5	1.077a	0.615b

- Gum concentration affects droplet size (method A), viscosity limitation
- method B ☐ D50<1 μm
- LBG ☐ most effective in reducing droplet size



Effect of sonication method on emulsion viscosity

- Viscosity:XG>LBG>GG
- Increase of sonication time and amplitude (method B) reduces viscosity

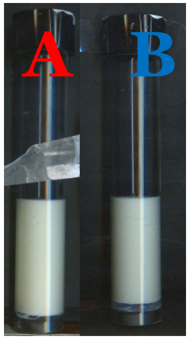
XG: k 2.208□0.859
n 0.407□0.534

Viscosity of emulsions containing 0.5% gums

Stability of 0.25% emulsions

- Xanthan, more stable emulsions, Creaming Index follows viscosity trend XG<LBG<GG

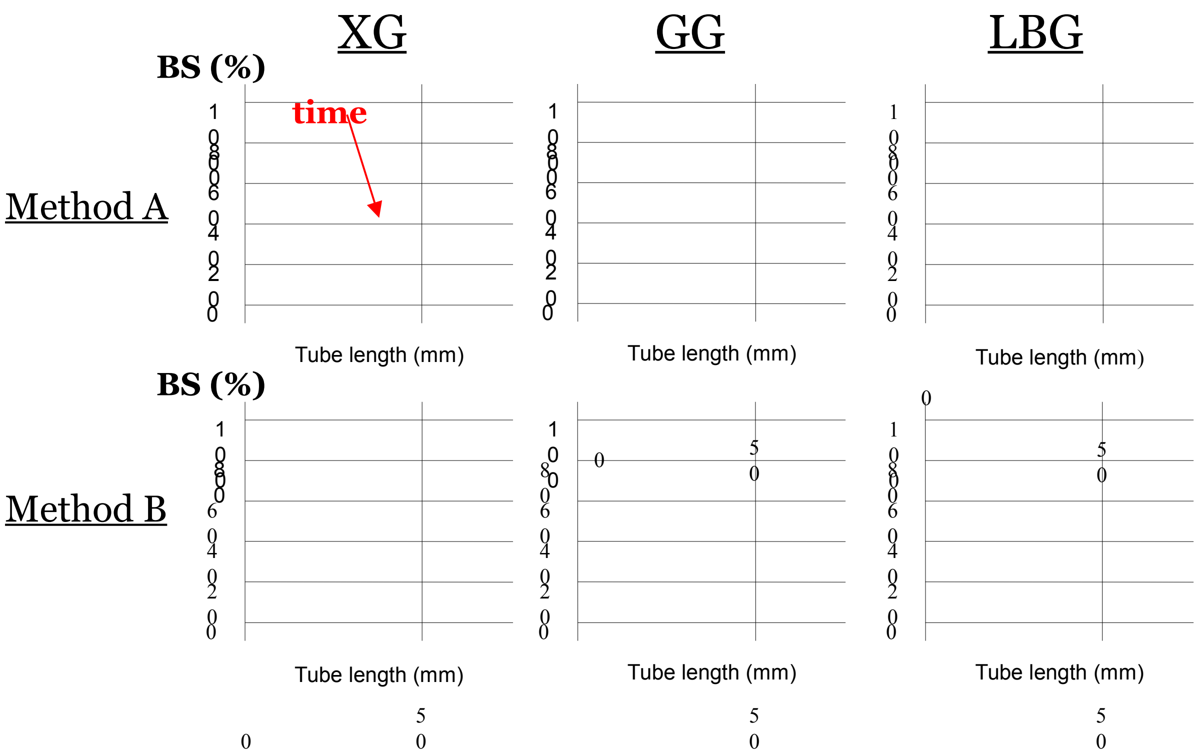
- Increase of time and amplitude decreased stability (XG)



XG 0.25%

Creaming evolution of 0.25% emulsions (10days/50C)

Stability of 0.5% emulsions



Back scattering profiles of 0.5% emulsions (10days/50C)

- Decrease of back scattering (dBS)ƒ(time)
  □coalescence

- Method B

-no significant influence for XG, D50 1.3□ 0.8 μm
(dBS 1.30□1.06%)

-for GG, LBG improved droplet coalescence, smaller droplet size

(GG :dBS 8.65□1.31%,
LBG:dBS 8.99□0.90%)

WPI emulsions, ph~4

- Coarse emulsions : 2.7% WPI, 20% olive oil, 0.25%XG
- Ultrasonic emulsification treatments

-**40** to **100%** amplitude (constant time, 1min)

-**1** to **4min** (constant amplitude, 70%)

Energy input
☐linear regression with amplitude & time

Temperature rise☐
Power law trend

- Energy release and temperature rise as a function of sonication amplitude and time

Effect of sonication on viscosity

- Viscosity properties as affected by sonication treatment

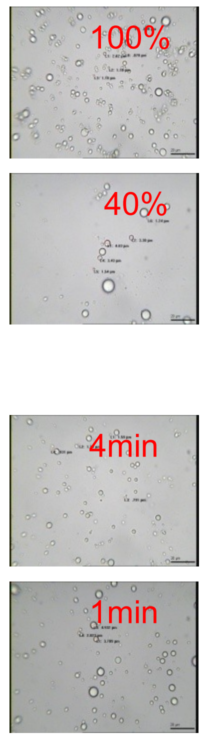
Sonication treatment	k (Pa-s^n)	n (-)
No Ultra	24.00	0.181
40%-1min	11.16	0.196
60%-1min	4.37	0.309
80%-1min	3.18	0.331
100%-1min	2.58	0.354
70%-1min	4.12	0.308
70%-2min	2.38	0.359
70%-3min	1.49	0.420
70%-4min	(-)*	(-)*

*Power law model not applicable

Influence of sonication treatment on the viscosity of 1% XG solutions.

- (100%-1min) similar effect with (70%-2min)☐ 10 times reduction of K,
- 3 times increase of n (less shear-thinning)

Effect of sonication on droplet size



Influence of sonication treatment on droplet size

- Disruption is a kinetic event thus, a minimum sonication time is required to achieve droplet disruption
- Temperature rise facilated droplet disruption
- Higher amplitude and extended time leads to larger droplet disruption (D43)

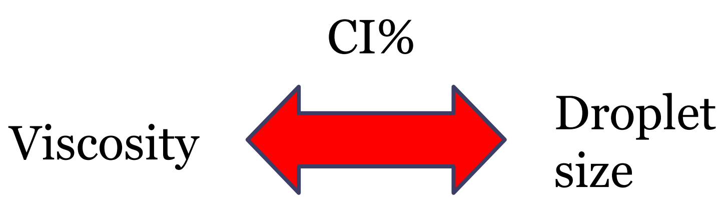
- 40% □D50 1.583, D43 4.530
- 100%□ D50 0.982, D43 1.793

- 1min□ D50 1.242, D43 2.776
- 4min□ D50 0.878, D43 1.268

Effect of sonication on creaming

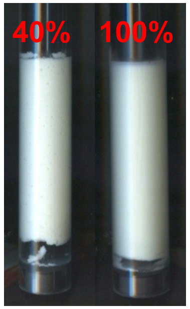
·Increase of amplitude and time☐ decrease CI

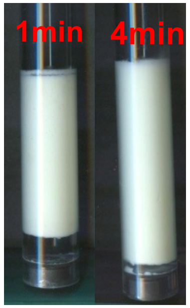
·Small increase of CI at 4min ☐ more related to viscosity reduction, droplet size was reduced



Influence of sonication treatment on stability during storage

Effect of sonication on creaming





3 min (70%) □CI 4.16%, 17.6 kJ

2min (70%) □CI 7.25%, ~11.7kJ

100%(1min) □CI 7.2%, ~8.4kJ

28% Power saving
50% Process time

- Creaming Index (on day 10) as a function of sonication treatment.

Influence of NaCl addition

- 0 mM NaCl☐ CI 29.5%
- 100 mM NaCl☐CI 19.8%

- “The addition
- of electrolytes, such as sodium increases the viscosity and stability, 0.1% salt for optimum viscosity”

Effect of NaCl addition (method B sonication)

Current work

- AUA: Incorporation of different fractions of fenugreek galactomannans (coarse or purified from protein). Effect of sonication on surface tension properties.

- WUR : Olive oil sub-micron emulsions (WPI& low molecular weight emulsifiers, LbL technique)

Evi Paximada, Elke Scholten, Erik van der Linden.

Thank you!
Questions?

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