Ice Cream Properties Affected by Homogenization

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FDC

2024 Annual Technical Conference

About Us: Pavlos Kouroutsidis

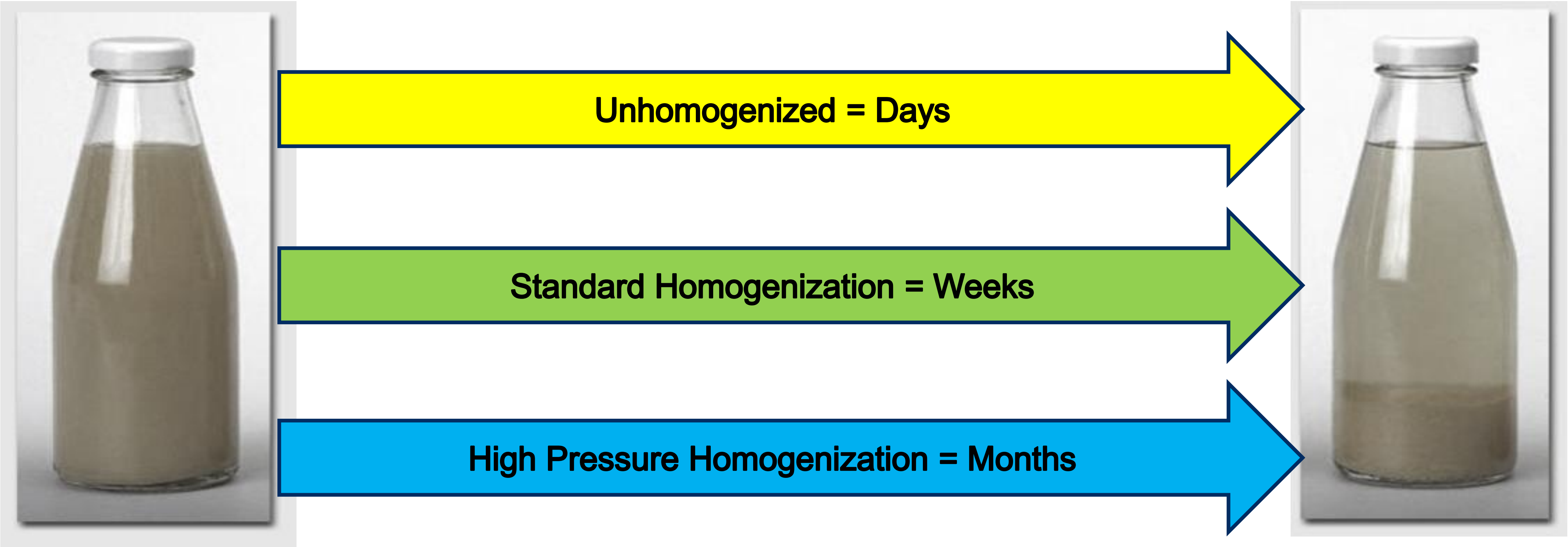
- 18 years as Application Specialist for Homogenizers & HP pumps
- Graduated college with M.S. in Chemical Engineering – Food Science
- Favorite flavor of ice cream:
  - Aggie blue mint

About Us: Darin Dye

- 11 years as Application Engineer for Homogenizers & HP pumps
- Graduated college with B.S. in Mechanical Engineering
- Favorite flavor of ice cream:
  - Chocolate chip cookie dough

Refresher on Homogenizer’s Purpose & Function

Stability of Suspensions



Target Product

Fully separated

Governing Equation (Natural Stability)

Speed of Separation
Lower = Better

Particle Size

Rising or settling velocity of particles is given by

STOKES' LAW

$$V_c = \frac{g\, d^2 (\rho_w - \rho_o)}{18\,\eta}$$

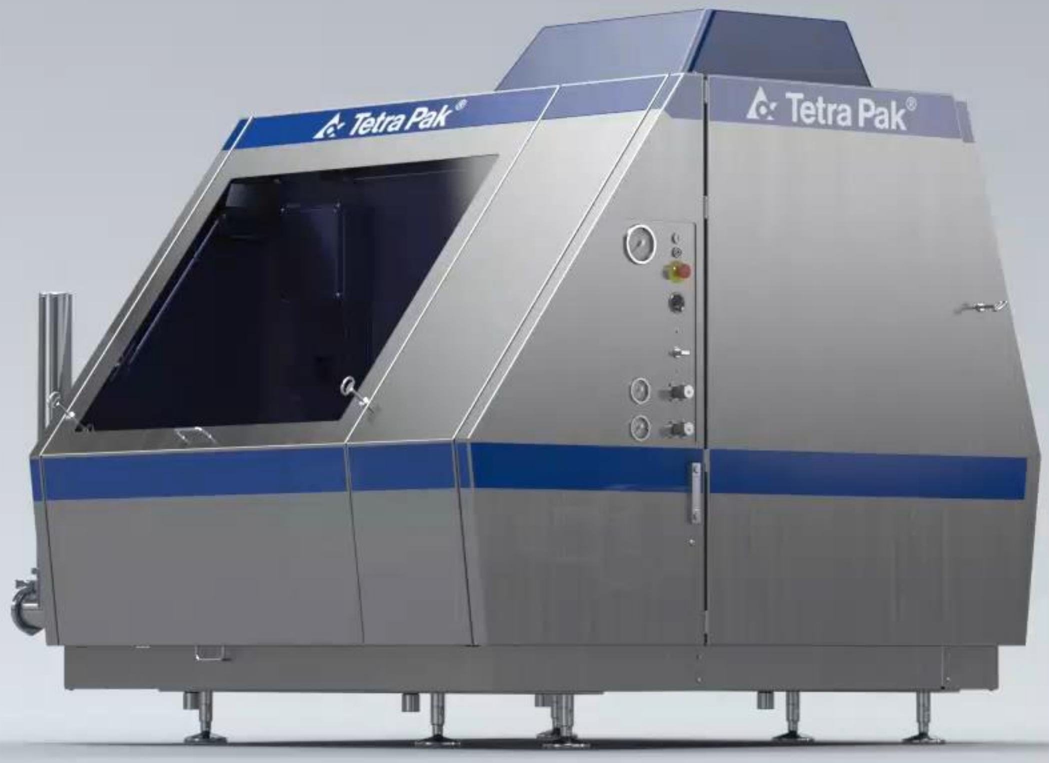
V_c = settling/creaming velocity
d = particle diameter
ρ_w = particle density
ρ_o = fluid density
η = fluid viscosity

Product stability improved **BEFORE** adding gums/emulsifiers/etc

½ size particles = ¼ rate of separation (aka 4x longer shelf life)

Tetra Pak® Homogenizer

Drive end - Working principle



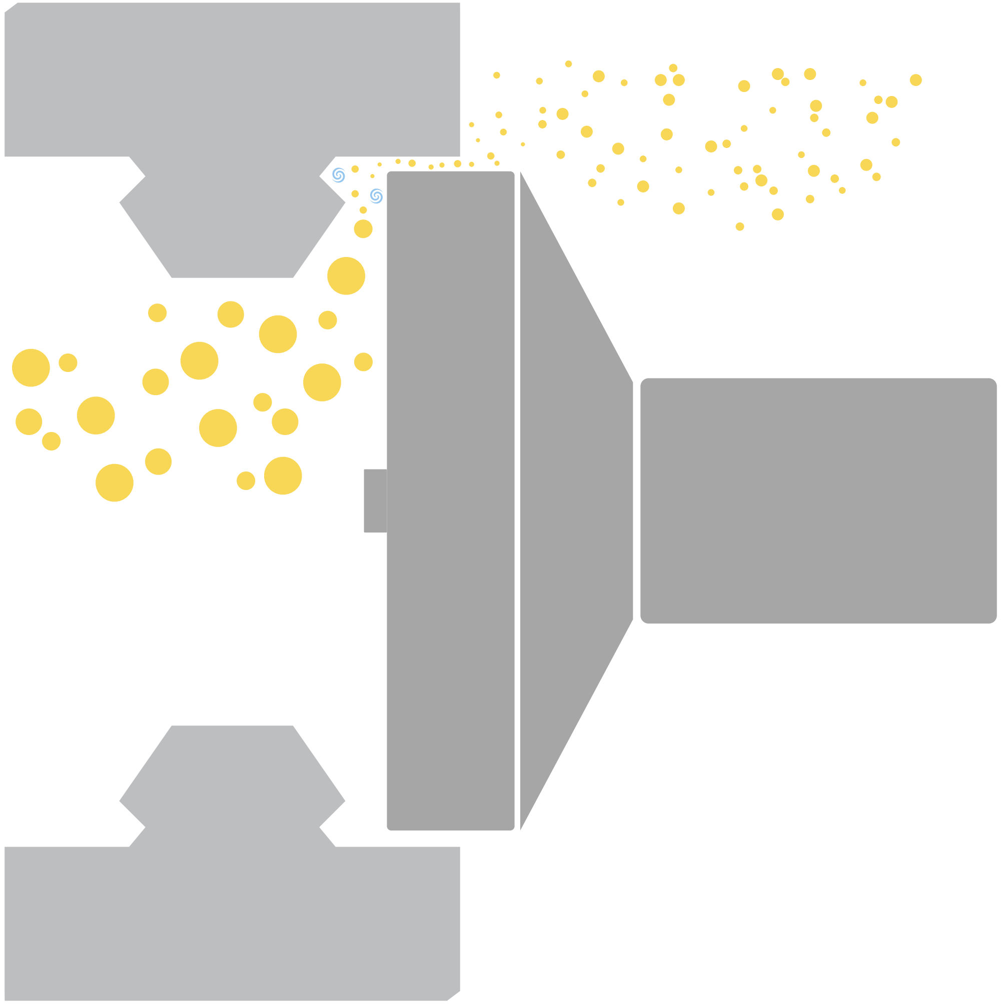
Tetra Pak® Homogenizer

Pump block - Working principle

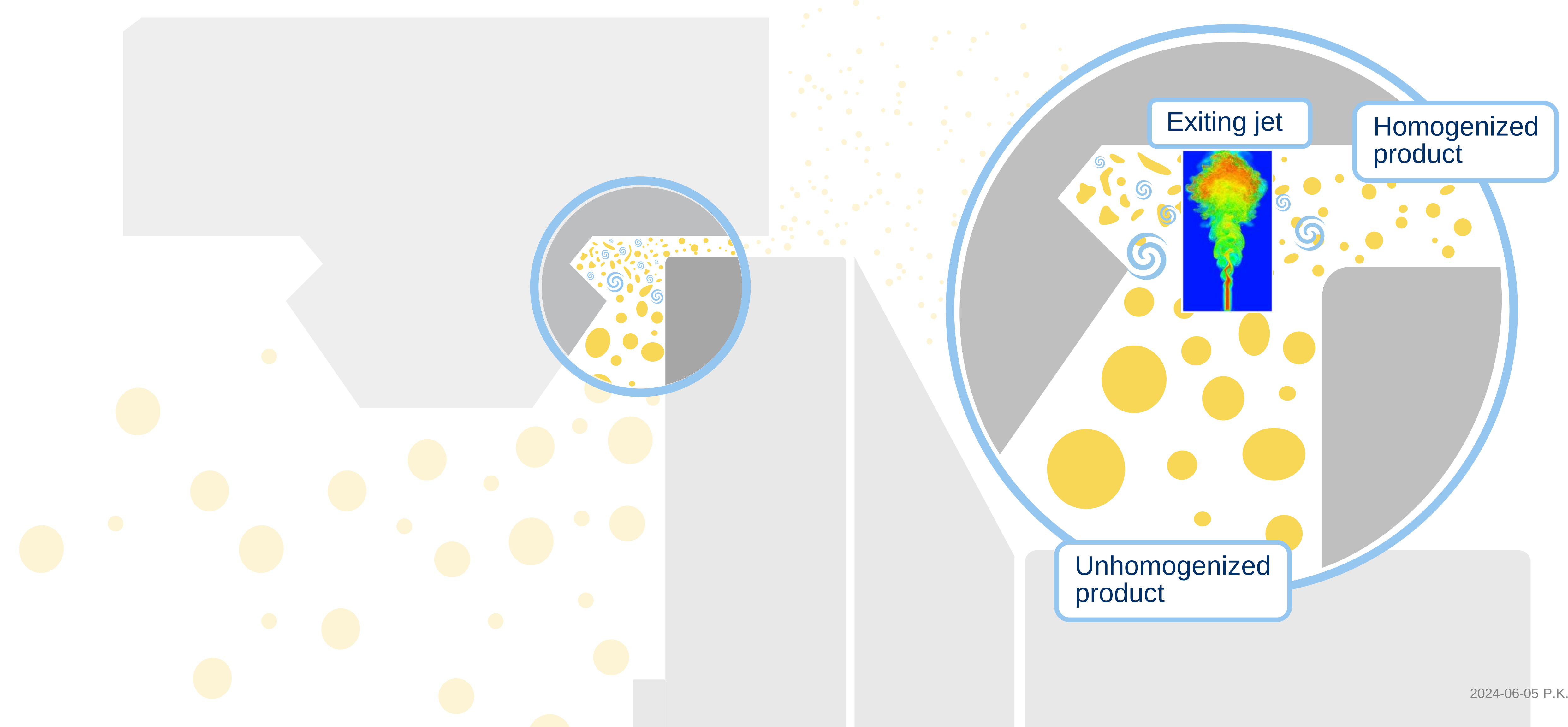
Tetra Pak® Homogenizer

Working principle Homogenization Device (HD 100)

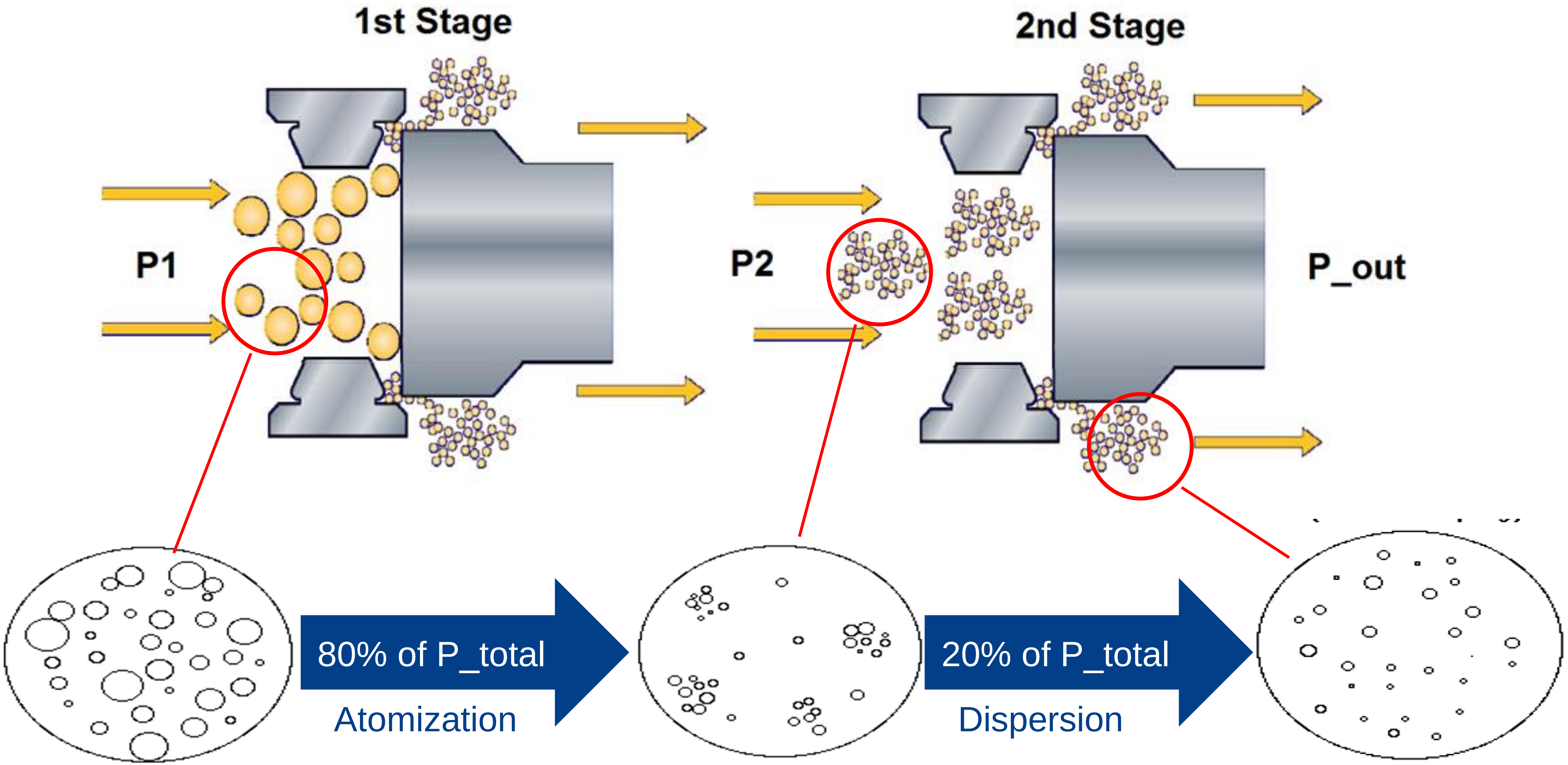
Homogenizing Device – where the “turbulence” happens



Homogenizing Device – where the “turbulence” happens



Two Stage Homogenization



Ice Cream Structure and Fat Globules

Ice Cream Structure – ”it is all about the air bubbles”

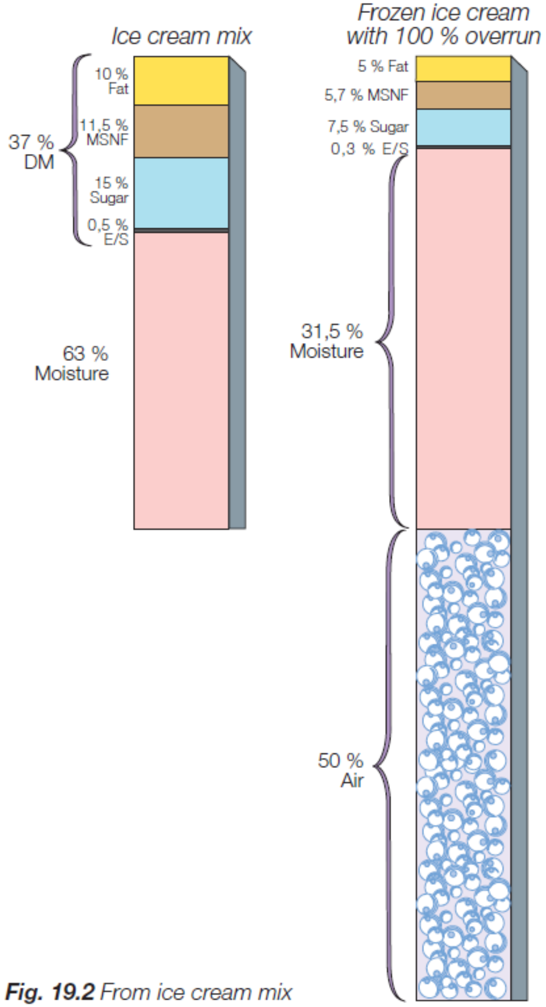
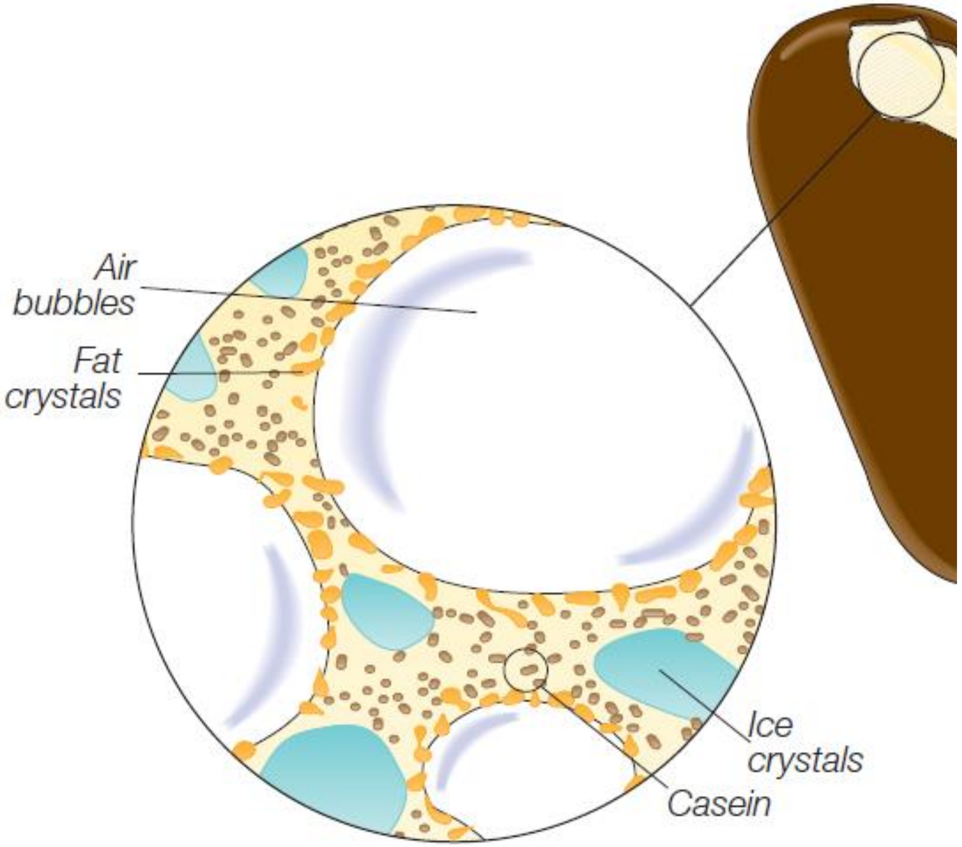
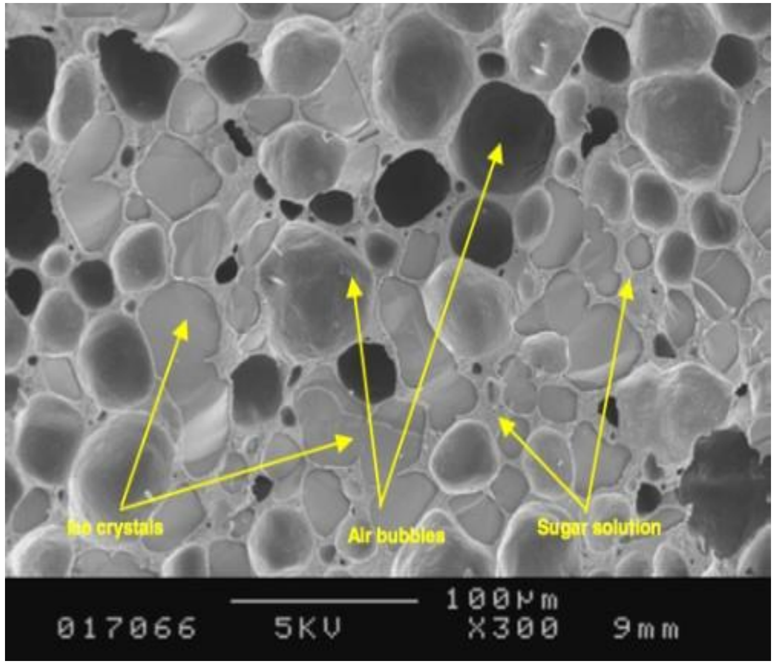


Fig. 19.2 *From ice cream mix to ice cream.*



Dairy processing handbook 2015



Clarke, 2003

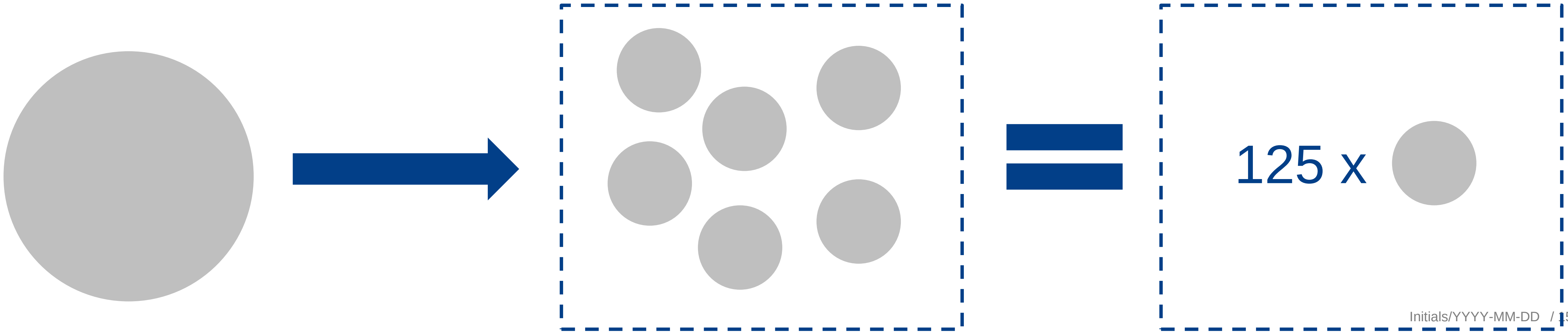
A Quick Thought Experiment

<u>Diameter Ref:</u>
Raw MF = 4.0 um
HTST MF = 0.8 um

- Volume of a sphere = $\frac{4}{3}\pi r^3$

$$V_1 = \left(\frac{r_1}{r_2}\right)^3 x\, V_2$$

- Conservation of Mass: One [1] 4-micron fat globule will become [125] 0.8-micron fat globules



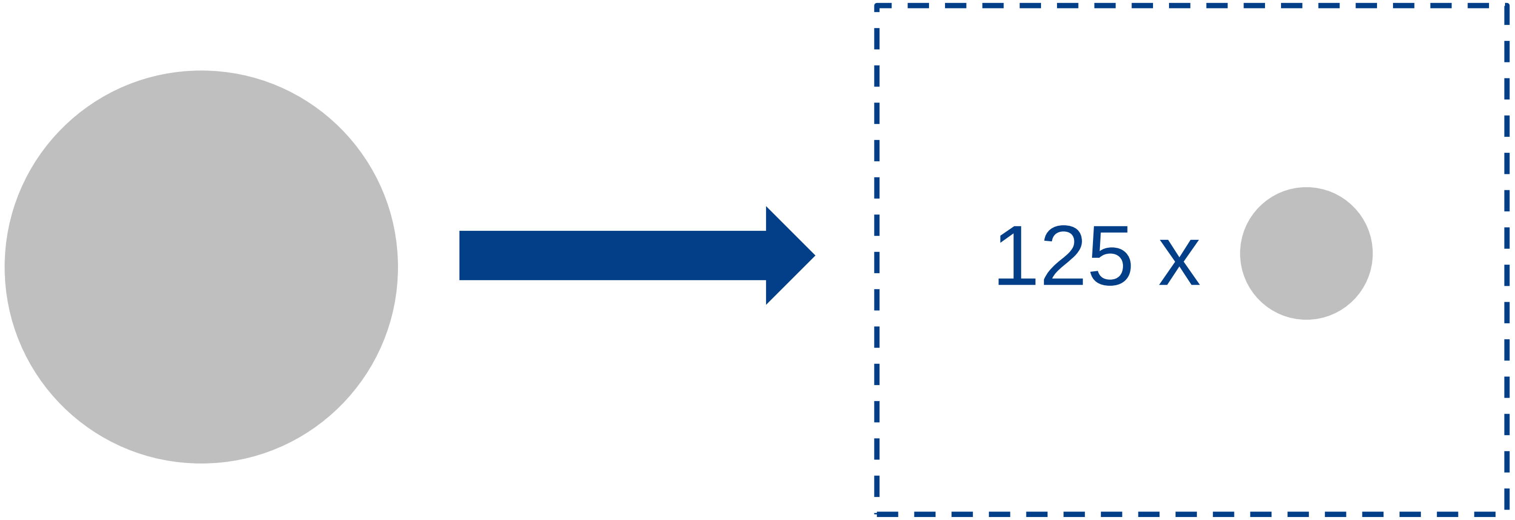
A Quick Thought Experiment (Cont'd)

Diameter Ref:
Raw MF = 4.0 um
HTST MF = 0.8 um

- Surface area of a sphere = $4\pi r^2$

$$A_1 = \left(\frac{r_1}{r_2}\right)^2 x \, A_2$$

- Original globule has 25x the surface area, but smaller globules are 125x more numerous



A Quick Thought Experiment (Cont'd)

- Surface area of original globule

$\sum A_1 = 1\ x\ 4\pi r_1^2 = 4\pi(2\ um)^2 = 50.26\ um^2$

- Sum of surface area from homogenized globules

$\sum A_2 = 125\ x\ 4\pi r_2^2 = 125\ x\ 4\pi(0.4\ um)^2 = 251.33\ um^2$

Result: The total surface area post-homogenization is 5x greater than it was originally.

A Quick Thought Experiment (Conclusion)

- The amount of gained surface area from homogenization is proportional to the degree of size reduction of the ingredients.

$$SA_{gain} = \frac{r_1}{r_2}$$

Implications for Ice Cream

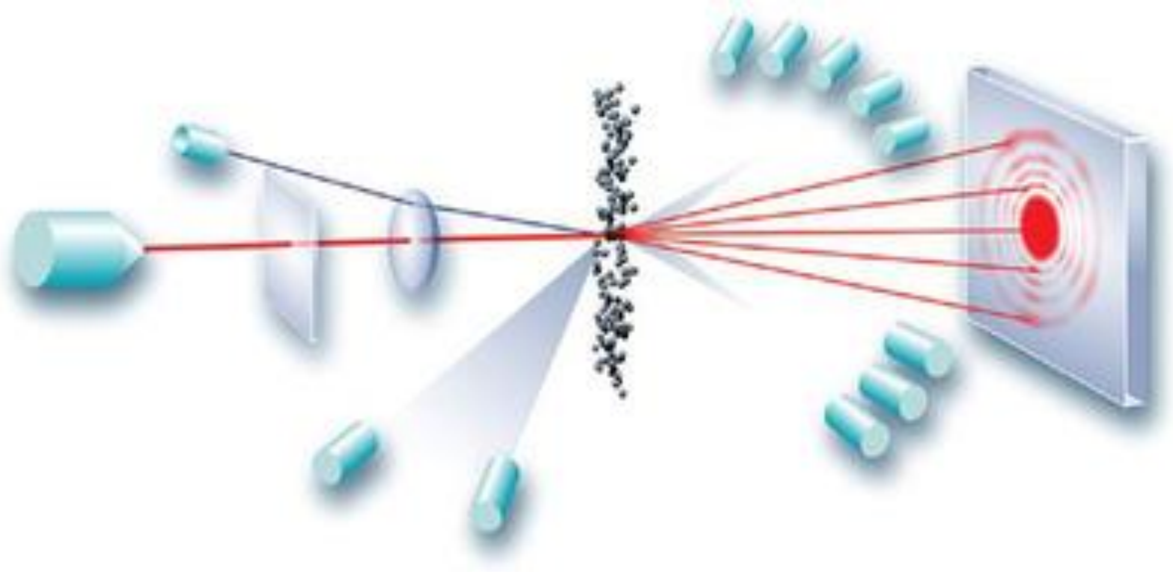
- The increased area that homogenized milk fat covers helps:
  - Make it easier to achieve target overrun
  - Smoother mouth feel of added ingredients (cocoa, etc)
  - Fuller fat texture with less cream
  - Improves melting resistance

Analyzing Homogenization Effect

Measuring the Size of Fat Globules

Laser diffraction technology

www.americanlaboratory.com



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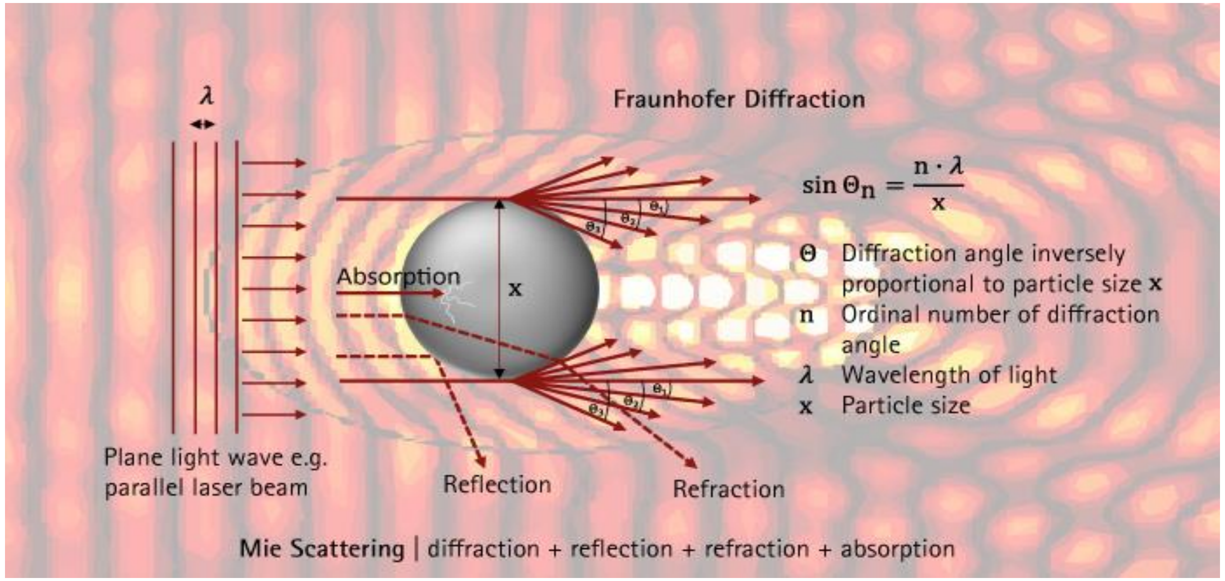
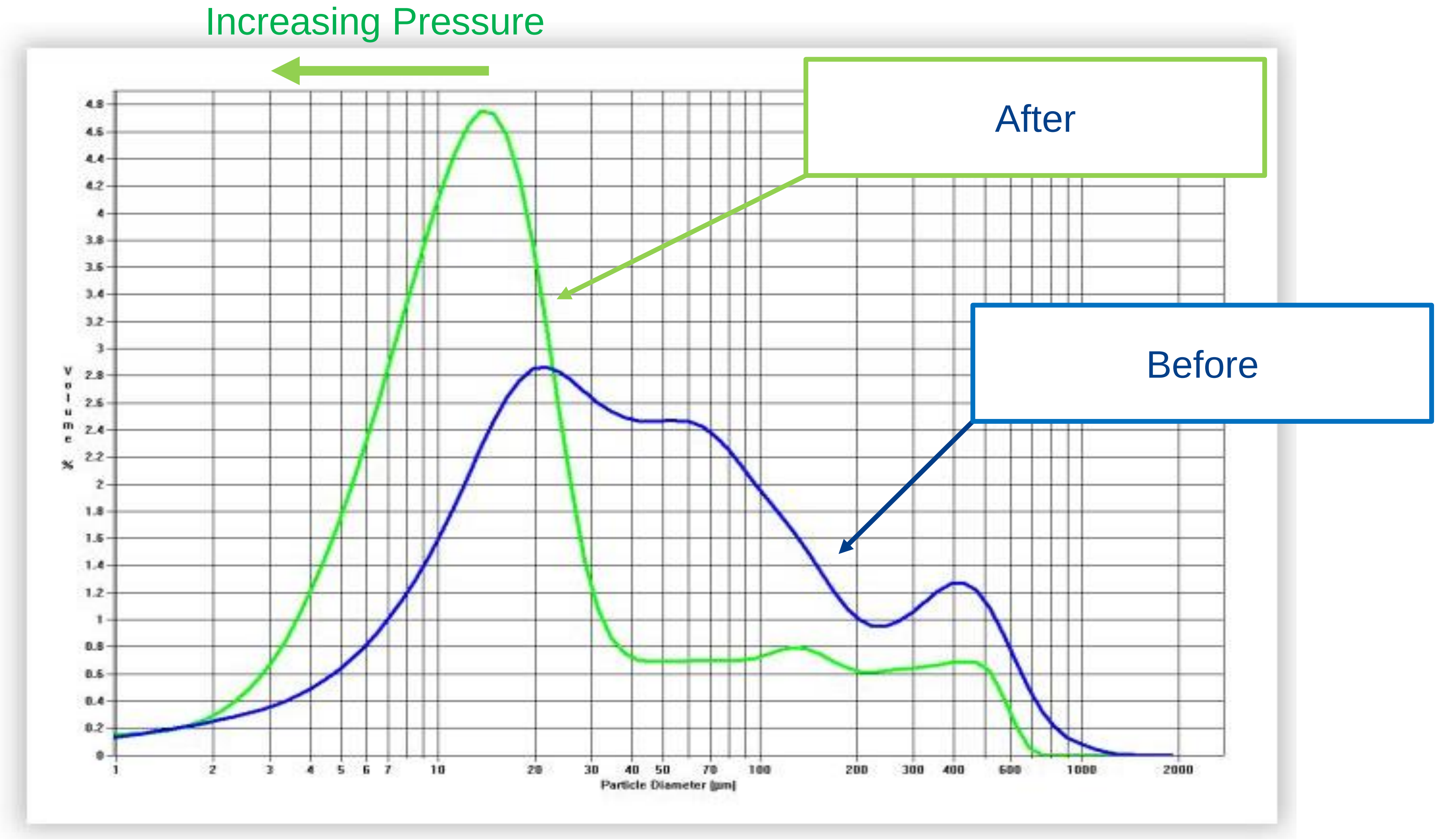


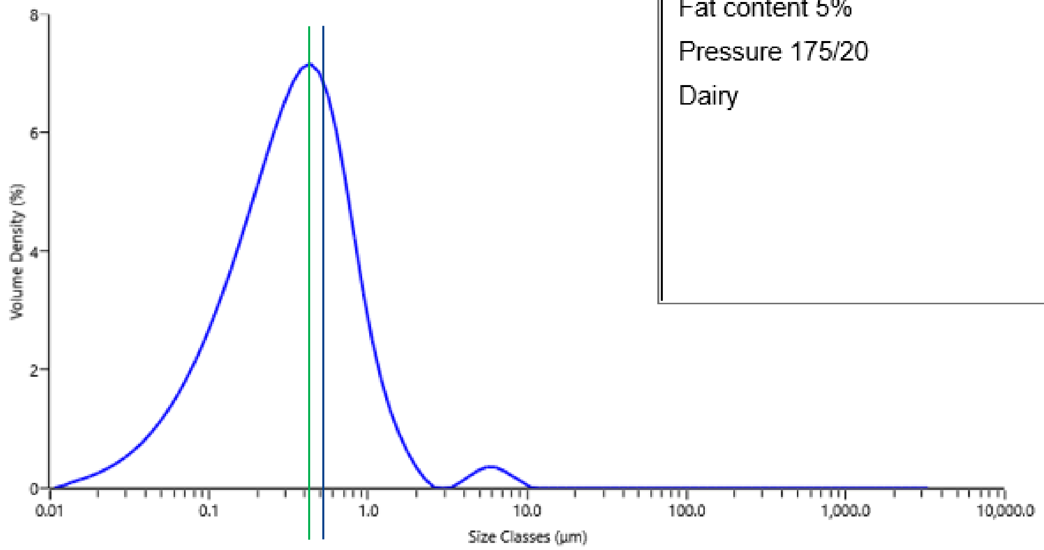
www.sympatec.com

Plotting the Data



Typical Ice Cream Particle Size Distribution: the ”Finger Print”

Sample 3



Fat content 5%

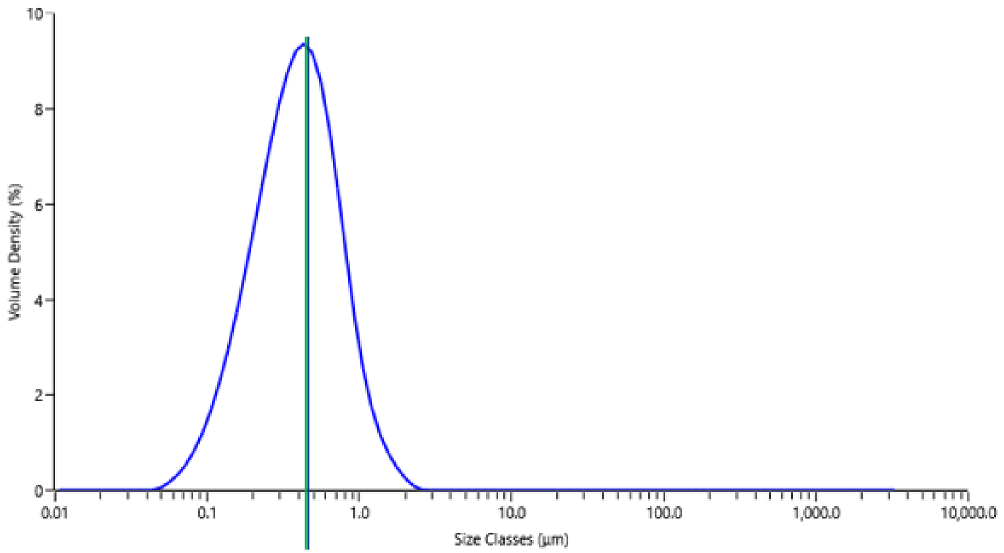
Pressure 175/20

Dairy

[48] Average of '3'-2024-02-21 09:3

Record Number	Sample Name	D [4,3] (μm)	D [5,3] (μm)	Dx (10) (μm)	Dx (50) (μm)	Dx (90) (μm)	Mode (μm)	D [3,2] (μm)	Span
48	Average of '3'	0.504	0.948	0.0855	0.333	0.902	0.424	0.186	2.451

With solA



[54] Average of '3 solA'-2024-02-21

Record Number	Sample Name	D [4,3] (μm)	D [5,3] (μm)	Dx (10) (μm)	Dx (50) (μm)	Dx (90) (μm)	Mode (μm)	D [3,2] (μm)	Span
54	Average of '3 solA'	0.457	0.547	0.157	0.387	0.840	0.430	0.302	1.767

- Documenting the **required particle size distribution** of the homogenized ice cream mix, will eliminate ”guess work” and **safeguard** aginst **energy waste** and **poor production quality**

Factors Influencing Homogenization Efficiency

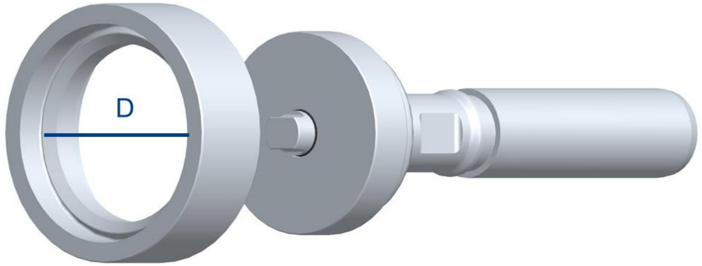
PROTECTS WHAT'S GOOD

Factors Influencing Homogenization Effect

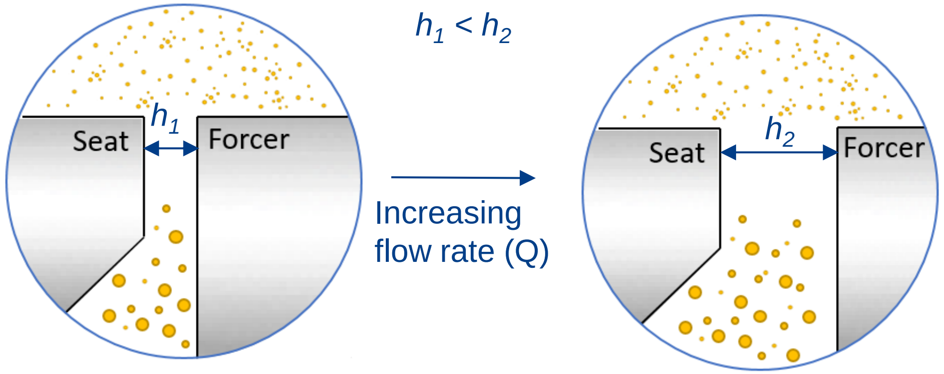
- Homogenizer configuration
- Homogenization pressure
- Relationship between first and second stage pressure (Thoma number)
- Fat content and type
- Temperature
- Wear

Homogenization Configuration

Gap height and product flow



$$Gap\ height(h) \propto \frac{Flowrate\ (Q)}{\sqrt{Pressure}(P) * DeviceDiameter(D)}$$

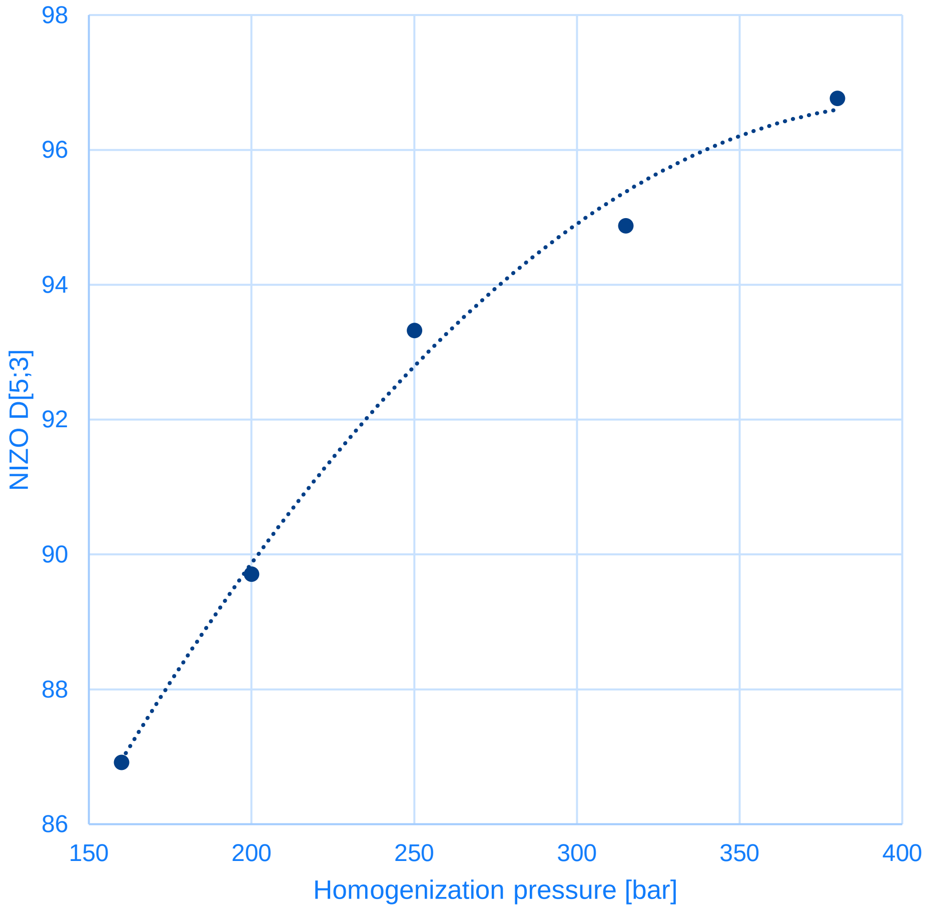


- Product flow and pressure affects the gap height which results in a difference in homogenization efficiency

Flow rate [l/h]	Gap Height [µm]	NIZO [%]
6000	33.2	91.5
9000	49.7	90
13 000	71.8	89

Homogenization Pressure

The higher the pressure the better effect

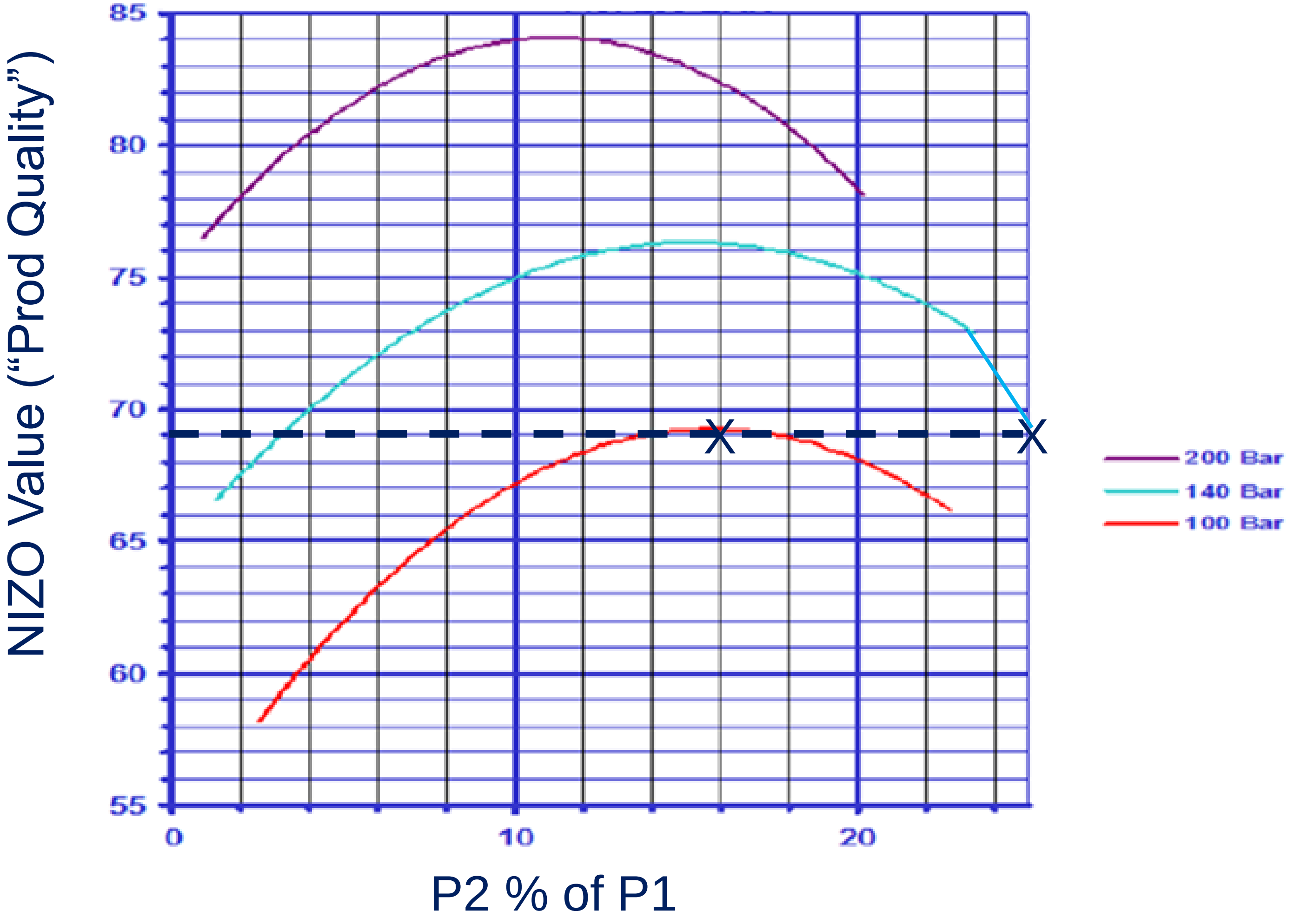


Pressure	NIZO
160	**87**
200	**90**
250	**93**
315	**95**
380	**97**

Relationship Between 1st & 2nd Stage Pressure

Rule of Thumb:

10-20% of total pressure from 2nd stage



Operator #1:

1500 psi_total

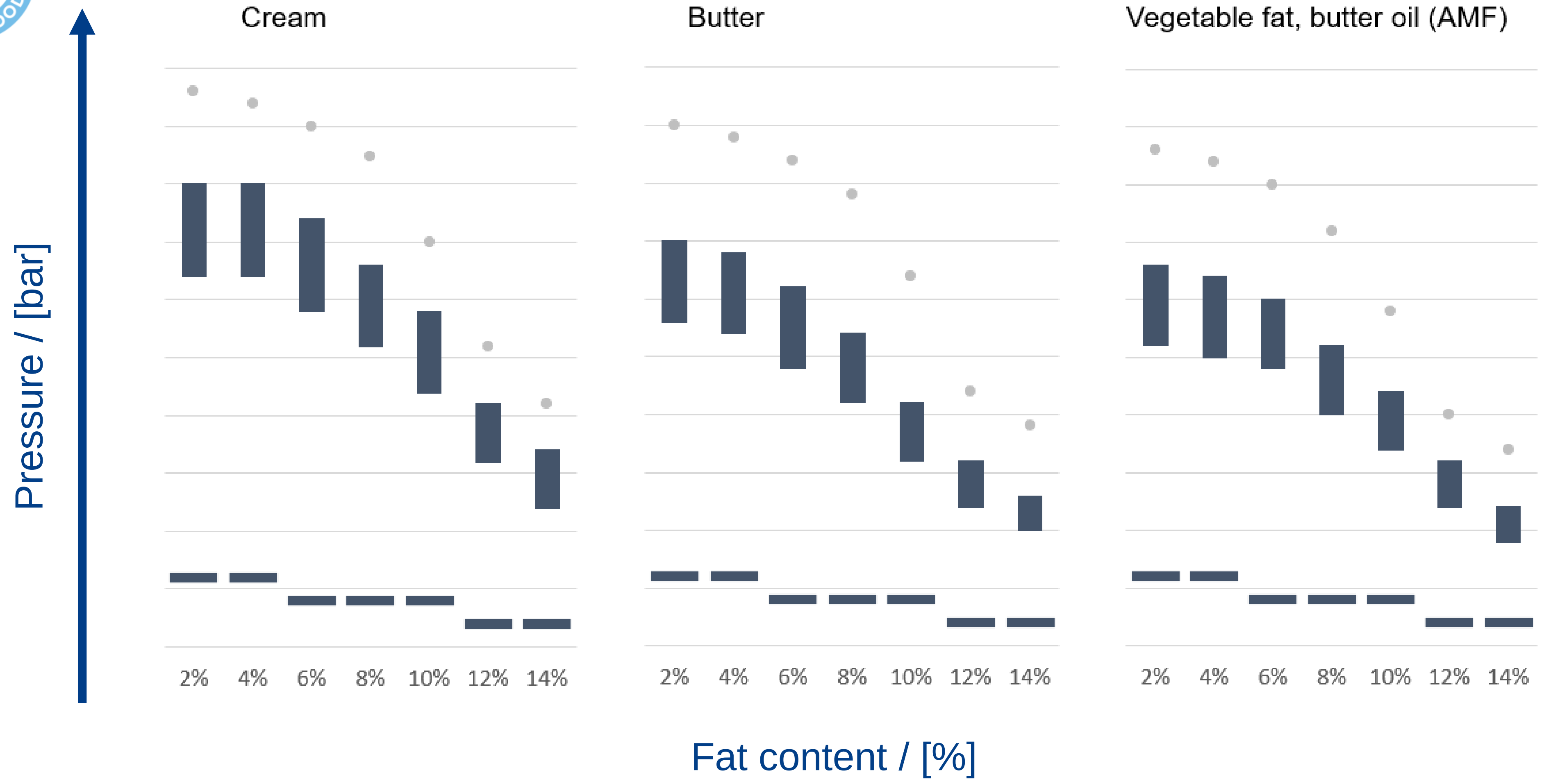
P2 = 16% (230 psi)

Operator #2:

2000 psi_total

P2 = 25% (500 psi)

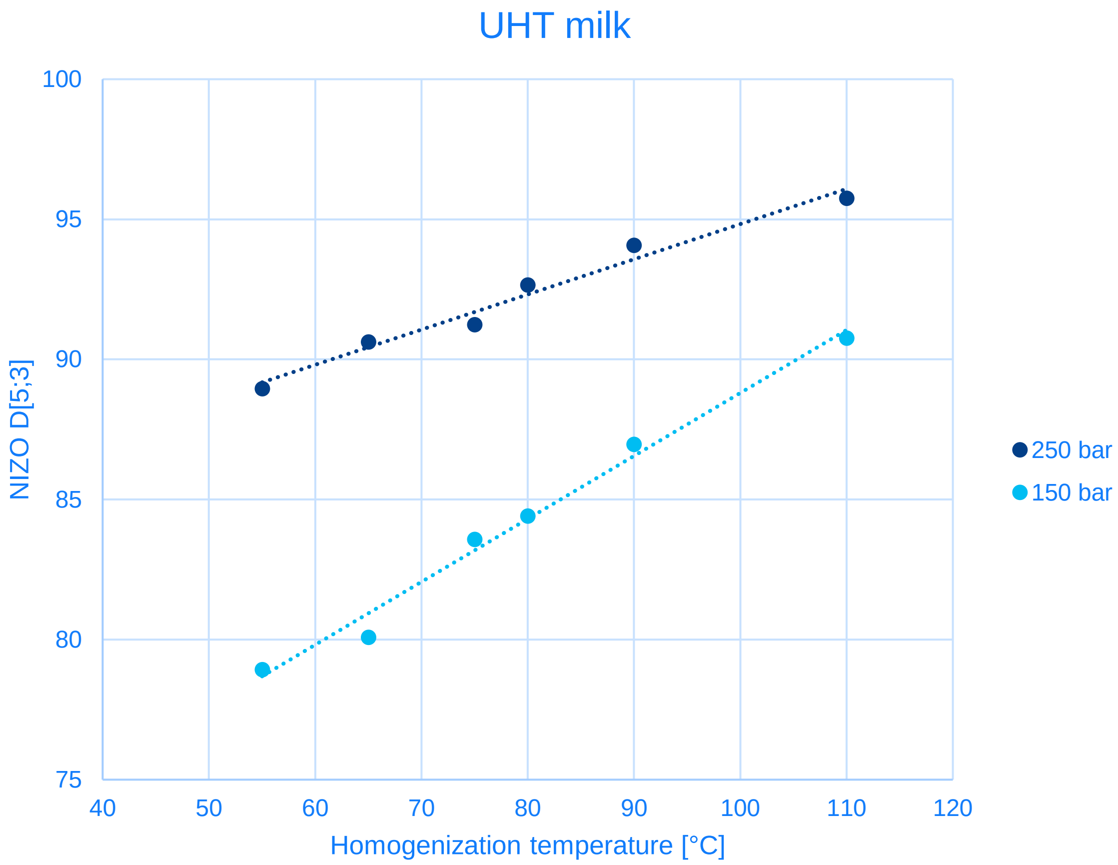
Fat Content and Type



- ▸ Lower pressure with increased fat content
- ▸ Vegtable fats require lower pressures than dairy fat

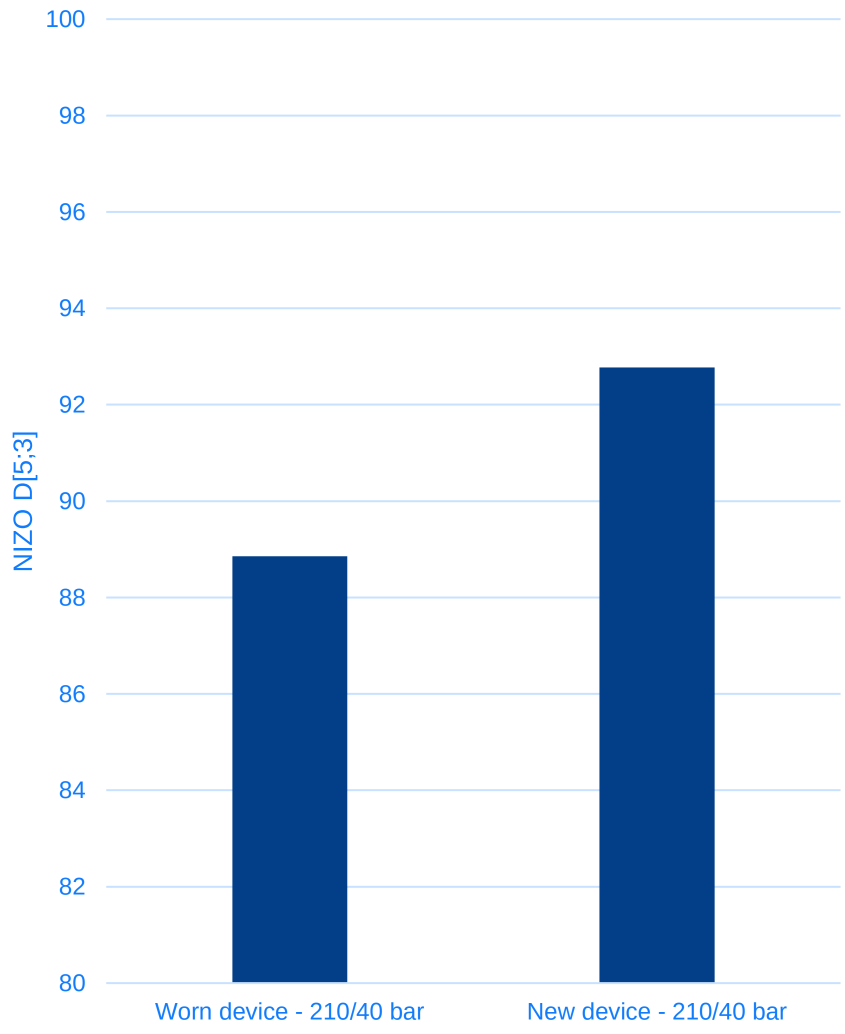
Homogenization Temperature

The higher the temperature the higher efficiency



- ▶ Factors to consider
  - – Burnt / denatured product
  - – Cost of heat
  - – Cost of cleaning (fouling)
  - – Impact on other equipment
  - – Material selection of wear parts

Impact from Wear



Forcer

Thank you!

Tetra Pak®
PROTECTS WHAT'S GOOD