Emerging Food Trend: Plant Based Proteins, healthy fat, sugar
Previously…

“Particle Technologies for Food & Beverage” February, 2014 (AP006)

Covered applications:
1. Traditional mayonnaise
2. Milk homogenization
3. Flavor emulsions
4. Flavor powder
5. Wheat flour
6. Coffee beans
7. Instance coffee
8. Sugar crystals
9. Chocolate
10. Pinto bean paste
What we’ll talk about today...

- The Trend
- FDA Guidance for Industry
- Applications

1. Mayonnaise
2. Cow’s milk
3. Plant based milk
4. Sugar
The Trend...that drives sales

http://www.npr.org/sections/thesalt/2016/05/10/477514200/why-the-fda-is-reevaluating-the-nutty-definition-of-healthy-food
The Trend: Clean Label

- Definition: “…natural ingredients with no artificial ingredients and chemicals…”
- Not regulated
- Ingredients people can recognize and pronounce
e.g. Monosodium Glutamate (MSG), Calcium phosphate, Potassium Bromate
- Food scientists’ tool box is shrinking
- Now what?

* Source: http://www.clean-label.de/index.php?page=that-is-clean-label
FDA Guidance for Industry: Nutrition Facts Label

- Removed calories from fat
- Vitamin D and potassium are required
- Changed serving size
- Declare added sugar
- Applies to vending machines too

- Compliance date: July 28, 2018
- Annual sales < $10M: July 28, 2019
- Adjust!

http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/LabelingNutrition/ucm385663.htm
"Whether you want to call it disruptive or exponential innovation, there's going to be a transformation in the food industry."

-Barb Renner
Vice chairman and US consumer products practice leader
Mayonnaise: Oil in Water (O/W) Emulsion

- Oil (dispersed phase) + vinegar (continuous phase) + egg yolk (emulsifier) + salt (taste)
- 4 ingredients or 15+ ingredients depending on target cost.
- Avoid canola oil and stick with “healthy fat” trend such as extra virgin olive oil, avocado, and almonds.*
- Samples produced with EVOO showed the lowest consistency and firmness when compared to other oils.**
- Physiochemical properties

References:
**Carla Di Mattiaa. Physical properties, microstructure and stability of extra-virgin olive oil based mayonnaise. InsideFood Symposium, 9-12 April 2013, Leuven, Belgium
Physiochemical Properties:

1. Emulsion stability
   *(choosing an appropriate plant-based emulsifier to mimic egg)*
2. Rheological properties
   *(spreadibility)*
3. Sensory characteristics
   *(taste, color, odor, consistency, texture, appearance, and overall acceptability)*
4. Particle size distribution
5. pH
6. Cholesterol content
7. Microstructure
Mayonnaise: FDA Guideline

- The FDA requires that "mayonnaise" contain 65% vegetable oil and at least one egg yolk-containing ingredient (21 CFR 169.140(c)).

- "Mayo" is ok. "Mayonnaise" is not ok.

- Be careful if the "cholesterol free" claim meets 21 CFR 101.62(d).
### Mayonnaise: An overview

<table>
<thead>
<tr>
<th>Data name</th>
<th>Graph type</th>
<th>D(\nu,0.1) (µm)</th>
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<tbody>
<tr>
<td>Regular Mayonnaise avg</td>
<td></td>
<td>5.31778</td>
<td>10.01068</td>
<td>17.62573</td>
<td>10.94328</td>
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<tr>
<td>Japanese Reg Mayonnaise avg</td>
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<td>1.48770</td>
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<td>Avocado Oil Mayo avg</td>
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<td>5.92434</td>
<td>12.20660</td>
<td>21.02451</td>
<td>12.98904</td>
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<tr>
<td>Popular Vegan Mayo avg</td>
<td></td>
<td>5.73724</td>
<td>9.68893</td>
<td>14.73169</td>
<td>10.02218</td>
</tr>
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<td></td>
<td>10.38932</td>
<td>26.92208</td>
<td>66.71149</td>
<td>49.67828</td>
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![Graph showing particle size distribution for different mayonnaise types](image-url)
Mayonnaise:
Plant-based Protein vs. Traditional

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*source: www.amazon.com

$0.10/oz*

$0.36/oz*
Mayonnaise: An overview

$1.19/oz^*$
Cow’s Milk:
Oil in Water (O/W) Emulsion

- 3-4% fat (dispersed phase) + 87% water (continuous phase) + 3.5% protein [casein micelles] (emulsifier) + 5% lactose + other essential nutrients
- 2016 “In the absence of any evidence for the superior effects of low fat dairy, and some evidence that there may be better benefits of whole fat dairy products for diabetes, why are we recommending only low fat dairy?” Dariush Mozaffarian of Dean of Tufts University of Nutrition
- Particle size of fat determines stability, shelf life, taste, and mouth feel
- Homogenization to reduce fat droplet size
  1. Conventional 2 stage Gualin homogenizer
  2. Commonly used high-shear fluid processor/high pressure processor
  3. Typically aim for 0.2-2um particle size range
Cow’s Milk: Fat size measurement methods

• 1980 Emulsion Quality Analyzer (EQA) – measures the amount of light passing through diluted milk sample
  • Dilute milk with EQA solution (5% tetracetic acid, 2% sodium hydroxide, 2% sodium hexametaphosphate in water)
  • Sample prep by adding 10ml diluent to 250ml DI water, heat to 80-100F
  • Transfer 1ml to EAQ sample cell
  • Get the absorbance index reading, go to the chart, locate the fat % content, and finally read the fat globule size diameter.

• Laser diffraction particle size analyzer – measures the angular intensity of the particles scattered from sample
  • Click fill to fill the analyzer with DI water
  • Add milk to approximately 5-10% concentration (aka obscuration)
  • Click measure to read size diameter
# Cow's Milk: An Overview

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<tr>
<td>Popular Whole Milk avg</td>
<td></td>
<td>0.22319 (μm)</td>
<td>0.55434 (μm)</td>
<td>1.20575 (μm)</td>
<td>0.65445 (μm)</td>
</tr>
<tr>
<td>Popular 2 Percent Milk avg</td>
<td></td>
<td>0.11486 (μm)</td>
<td>0.24057 (μm)</td>
<td>1.02227 (μm)</td>
<td>0.40825 (μm)</td>
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<tr>
<td>Popular 1 Percent Milk avg</td>
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<td>0.10564 (μm)</td>
<td>0.19535 (μm)</td>
<td>0.55576 (μm)</td>
<td>0.27659 (μm)</td>
</tr>
<tr>
<td>Popular Fat Free Milk avg</td>
<td></td>
<td>0.08744 (μm)</td>
<td>0.13889 (μm)</td>
<td>0.21124 (μm)</td>
<td>0.14495 (μm)</td>
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<tr>
<td>Non Homogenized Milk avg</td>
<td></td>
<td>2.50955 (μm)</td>
<td>3.95841 (μm)</td>
<td>6.37796 (μm)</td>
<td>4.24636 (μm)</td>
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![Graph showing particle size distribution for different milk types](image-url)
### Cow’s Milk: Store Brand – the Success Story

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<th>D(v,0.9)</th>
<th>Mean size</th>
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<tbody>
<tr>
<td>Generic Whole Milk avg</td>
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<td>0.31187 (µm)</td>
<td>0.44078 (µm)</td>
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<td>Geneic 2Perc Milk avg</td>
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<td>0.30275 (µm)</td>
<td>0.43916 (µm)</td>
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<td>Generic Fat Free Milk avg</td>
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<td>0.21832 (µm)</td>
<td>0.32012 (µm)</td>
<td>0.50600 (µm)</td>
<td>0.59855 (µm)</td>
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<tr>
<td>Non Homogenized Milk avg</td>
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<td>2.37410 (µm)</td>
<td>3.55121 (µm)</td>
<td>5.50663 (µm)</td>
<td>3.79400 (µm)</td>
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</tbody>
</table>

![Graph showing particle size distribution for different milk types](graph.png)
Cow’s Milk: A1 and A2 beta-casein in cow’s milk

- Each cow carries two copies of the gene encoding beta-casein, A1 or A2
- A2 mimics human breast milk – “better” for digestive systems
- “A2 beta-casein is recognized as the original beta-casein protein because it existed before a mutation caused the appearance of A1 beta-casein in European herds a few thousand years ago”

http://www.betacasein.org
Cow’s Milk: FDA Guideline

- All must be pasteurized
- Vitamins fortification should be performed prior to homogenization
- Authorized to increase Vitamin D amount July 18, 2016
  - Up to 84 IU/100g of vitamin D3 to milk (42IU in 2012), 84 IU/100g of vitamin D2 to plant-based beverages intended as milk alternatives and 89 IU/100g of vitamin D2 to plant-based yogurt alternatives
- FDA does not regulate homogenization; U.S. Public Health Service provides guidelines.

Plant Based Protein: Soymilk

• June, 2016
Coca-Cola has entered into an agreement to acquire Unilever’s AdeS soy-based beverage business

• May, 2016
Plant-based food category tops 3.5B. 9% growth for the past 2 years versus 4% for other. Plant-based milk drives the sales, 14% growth.
  [http://www.soyfoods.org/blog/plant-powered-sales-top-3-5-billion](http://www.soyfoods.org/blog/plant-powered-sales-top-3-5-billion)

• July, 2016
DANONE acquired WhiteWave Foods Co. for 10.4 billion, stock jumped 19%
Plant-based Protein: Soymilk Processing

- Traditionally: water extraction of soybeans

- Commercially:
  - “Beany” flavor – arise through lipoxygenase activity of soybean oil.
    - Heat it to deactivate enzyme (e.g. lipoxygenases, trypsin inhibitors)
    - Use defatted soy flour, soybean protein concentrate, or isolated soybean protein
    - Mask it with sugar or other flavors (e.g. coffee, chocolate)
    - Use GMO – those without lipoxidase activity

Plant-based Protein: Importance of PSD in soymilk

- Track grinding processing
- Particle Size determines taste and texture
- Mouth is sensitive to particles >30um
- Particle size also determines the stability and quality of the emulsion
- High pressure heat treatment denatures soy proteins (11S, 7S at different temperature). This leads to rearrangement and denaturation of proteins (40nm> PSD<1um)*
- Milk becomes more viscous with high pressure heat treatment (homogeneous, smooth, and creamy texture)** when compare to traditional method

Plan-based Protein Soymilk
Sugar: Under attack

- Sugar, linked to obesity and diabetes*
- FDA (declare added sugar), American Heart Association (<9tsp/day), World Health Organization (<5% of daily calories). Reality =22-26 tsp
- Sugar reduction strategies – easy said than done.
  “When the company announced last spring that it planned to remove aspartame from Diet Pepsi, it cited declining sales and health concerns stemming from scientific studies linking artificial sweeteners to obesity and cancer in lab rats”….10months later, they’re bringing it back to “give customers a choice” **
- Sugar serves as a flavor enhancer, preservative (think jams), bulking agent, retains moisture, browning process (visual color), controls spread of the biscuit dough (powdered sugar)

Sugar:
Stevia

- 200-450 times sweeter than granulated white sugar* depending on the species
- Spray-dried or vacuum dried
- Particle size affects the flow properties of stevia and defines how much a "spoon full of stevia" actually weighs
- Increase in flowability when PSD > 200um** – agglomeration technology is used
- “Dusty” and harder to mix when particles are <10um

Sugar: Powdered Sugar

- (Hammer) Milled* from white granulated crystals (Application notes AN141, AN175)
  - 2X – defined as 82%<200mesh (74um)
  - 4X – defined as 92%<200mesh
  - 6X – defined as 93.5% <200mesh
  - 8X – defined as 96% <200mesh
  - 10X – defined as 98%<200mesh
  - 12X – defined as 98% <325mesh (45um)
  - Silk Sugar – defined as 97% <20.5um

- Production goals:
  - The efficiency of milling – from pilot size to full production
  - Narrow particle size distributions
    - Uniformity minimizes separation
    - Dissolution/mixing
  - **Flowability** (anti-caking agent 3%)

- Dry Dispersion:
  - Sampling (>100um)
  - Energy – (Pressure Size Titration test)
  - Slope Dv90>Dv50>Dv10

Source: *http://www.hmicronpowder.com/industries/food/sugar
Sugar:
Particle size distribution

![Graph showing particle size distribution and stable region for different sugar samples at various air pressures. The graph includes data for D(0.1), D(0.5), and D(0.9) for different air pressures, with a highlighted stable region.]
Sugar:
Particle size distribution

<table>
<thead>
<tr>
<th>Diameter (um)</th>
<th>ASTM Mesh</th>
<th>Frequency %</th>
<th>Cum %</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>635</td>
<td>69.071</td>
<td>69.071</td>
</tr>
<tr>
<td>25</td>
<td>500</td>
<td>10.644</td>
<td>79.715</td>
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<tr>
<td>32</td>
<td>450</td>
<td>8.164</td>
<td>87.879</td>
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<tr>
<td>38</td>
<td>400</td>
<td>3.865</td>
<td>91.744</td>
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<tr>
<td>45</td>
<td>325</td>
<td>2.768</td>
<td>94.512</td>
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<tr>
<td>53</td>
<td>270</td>
<td>1.872</td>
<td>96.383</td>
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<tr>
<td>63</td>
<td>230</td>
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<td>75</td>
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<td>90</td>
<td>170</td>
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<td>106</td>
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<td>0.331</td>
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<tr>
<td>125</td>
<td>120</td>
<td>0.186</td>
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<tr>
<td>150</td>
<td>100</td>
<td>0.051</td>
<td>100</td>
</tr>
</tbody>
</table>

Data name: Powdered Sugar-3bar avg

Graph type: D(v,0.1) 7.31500 (μm)  D(v,0.5) 14.89861 (μm)  D(v,0.9) 34.84077 (μm)  Cumulative % at diameter(8) 98.718(%)
Questions?

Email us:  Labinfo@horiba.com
Call us:  1800-446-7422
www.horiba.com