HORIBA

Explore the future

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

July 21, 2016

Previously...

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

http://www.horiba.com/scientific/products/particle-characterization/download-center/webinars

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?

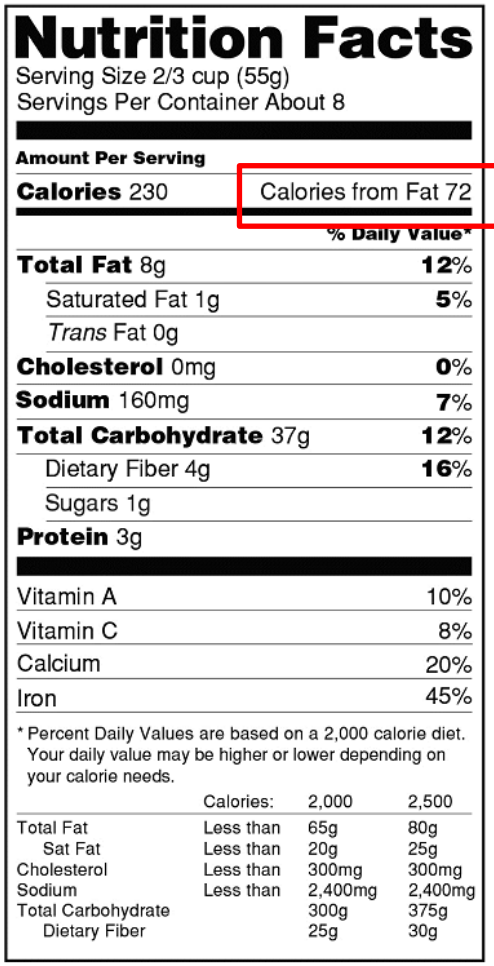
* Source: http://www.clean-label.de/index.php?page=that-is-clean-label

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!



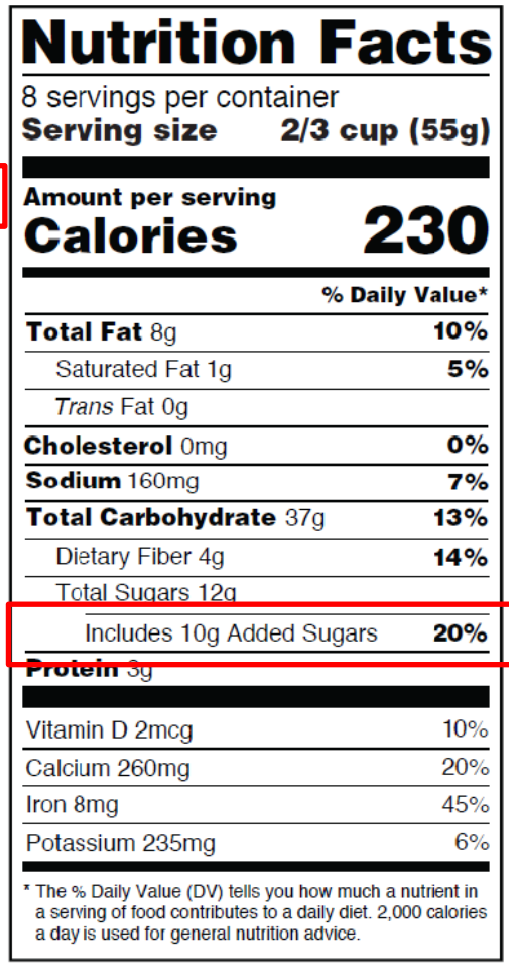
Nutrition Facts

Serving Size 2/3 cup (55g)
Servings Per Container About 8

Amount Per Serving	
Calories 230	Calories from Fat 72
	% Daily Value*
Total Fat 8g	**12%**
Saturated Fat 1g	**5%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 160mg	**7%**
Total Carbohydrate 37g	**12%**
Dietary Fiber 4g	**16%**
Sugars 1g	
Protein 3g	
Vitamin A	10%
Vitamin C	8%
Calcium	20%
Iron	45%

* Percent Daily Values are based on a 2,000 calorie diet. Your daily value may be higher or lower depending on your calorie needs.

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g



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8 servings per container
Serving size **2/3 cup (55g)**

Amount per serving
Calories **230**

	% Daily Value*
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Saturated Fat 1g	**5%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 160mg	**7%**
Total Carbohydrate 37g	**13%**
Dietary Fiber 4g	**14%**
Total Sugars 12g	
Includes 10g Added Sugars	**20%**
Protein 3g	
Vitamin D 2mcg	10%
Calcium 260mg	20%
Iron 8mg	45%
Potassium 235mg	6%

* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

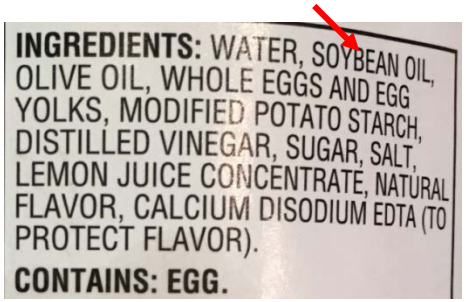
http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/LabelingNutrition/ucm385663.htm

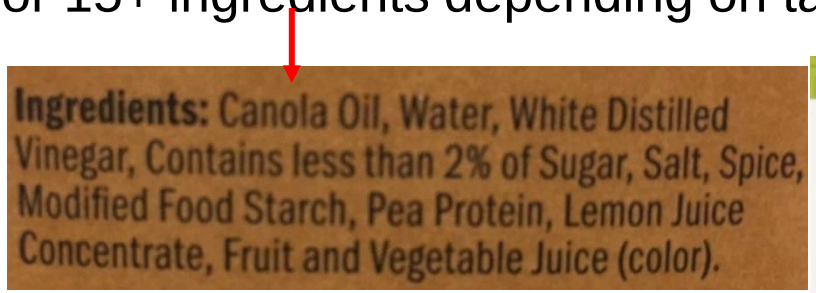
"Whether you want to call it disruptive or exponential innovation, there's going to be a transformation in the food industry."

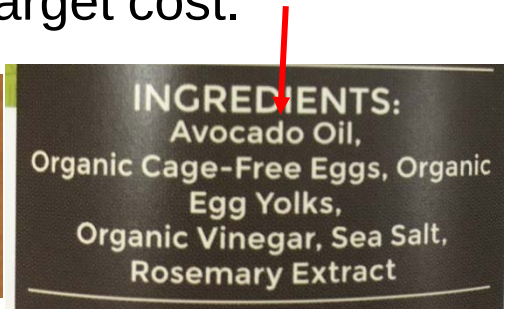
-Barb Renner
Vice chairman and US consumer products practice leader

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:
*Hyman, Mark. *Eat Fat, Get Thin*. New York: Little Brown and Company, 2016. Print pg.77 *Key TJ, Appleby PN, Davey GK, Allen NE, Spencer EA, Travis RC. Mortality in British Vegetarians: review and prelimiary result from EPIC-Oxford. Am J Clin Nutr 2003 Sep; 78 **Carla Di Mattiaa. Physical properties, microstructure and stability of extra-virgin olive oil based mayonnaise. InsideFood Symposium, 9-12 April 2013, Leuven, Belgium

Mayonnaise:
Physiochemical Properties

- 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

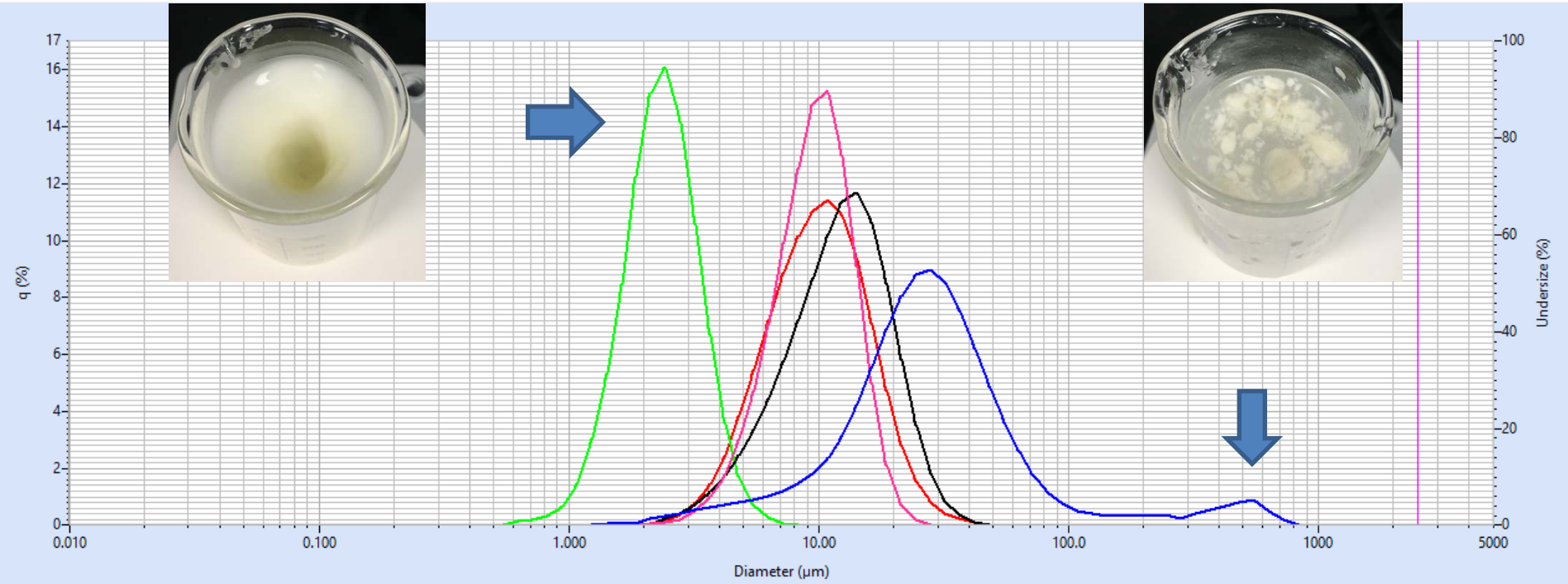
Mayonnaise:
FDA Guideline

- 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).

Sources:
http://www.fda.gov/ICECI/EnforcementActions/WarningLetters/2015/ucm458824.htm

Mayonnaise:
An overview

Data name	Graph type	D(v,0.1)	D(v,0.5)	D(v,0.9)	Mean size
[redacted] Regular Mayonnaise avg		5.31778 (µm)	10.01068 (µm)	17.62573 (µm)	10.94328 (µm)
Japanese Reg Mayonnaise avg		1.48770 (µm)	2.34760 (µm)	3.62315 (µm)	2.47053 (µm)
Avocado Oil Mayo avg		5.92434 (µm)	12.20660 (µm)	21.02451 (µm)	12.98904 (µm)
Popular Vegan Mayo avg		5.73724 (µm)	9.68893 (µm)	14.73169 (µm)	10.02218 (µm)
Generic Vegan Mayo avg		10.38932 (µm)	26.92208 (µm)	66.71149 (µm)	49.67828 (µm)



Mayonnaise:
Plant-based Protein vs. Traditional

$ 0.10/oz*

Data name	Graph type	D(v,0.1)	D(v,0.5)	D(v,0.9)	Mean size
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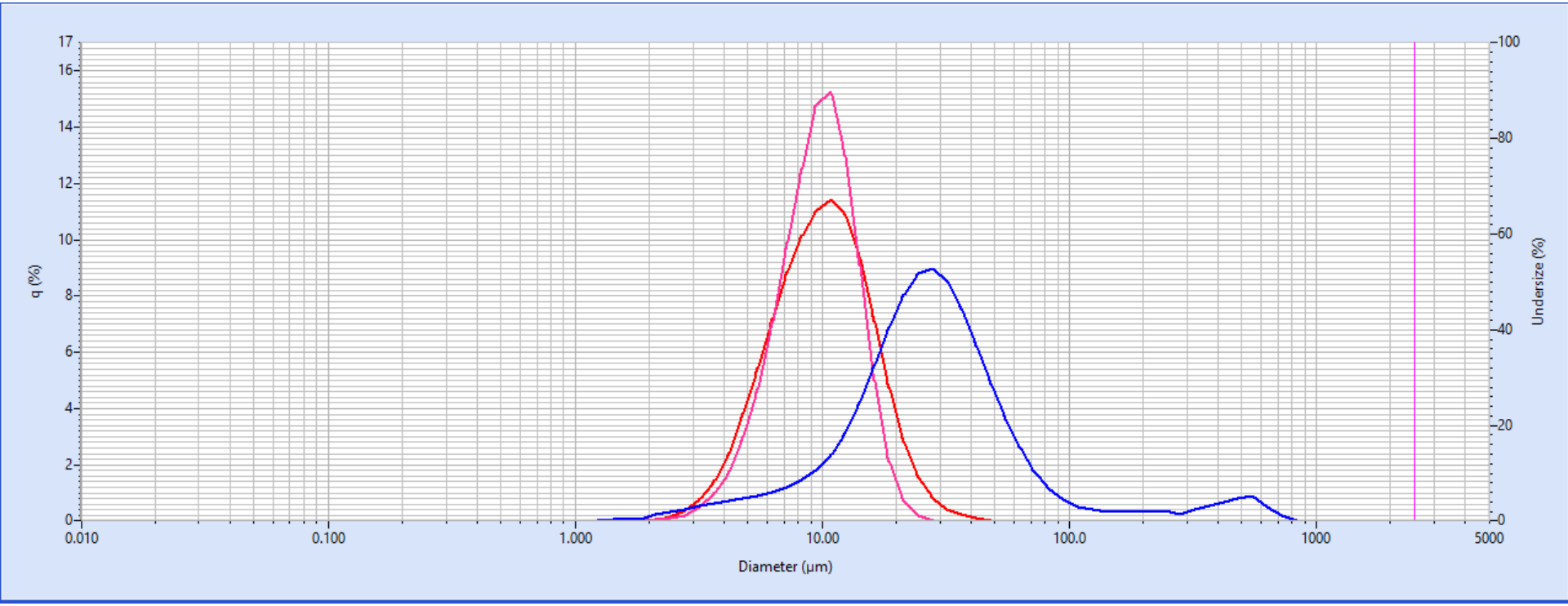
$ 0.36/oz*



*source: www.amazon.com

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$ 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 diary?"* 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

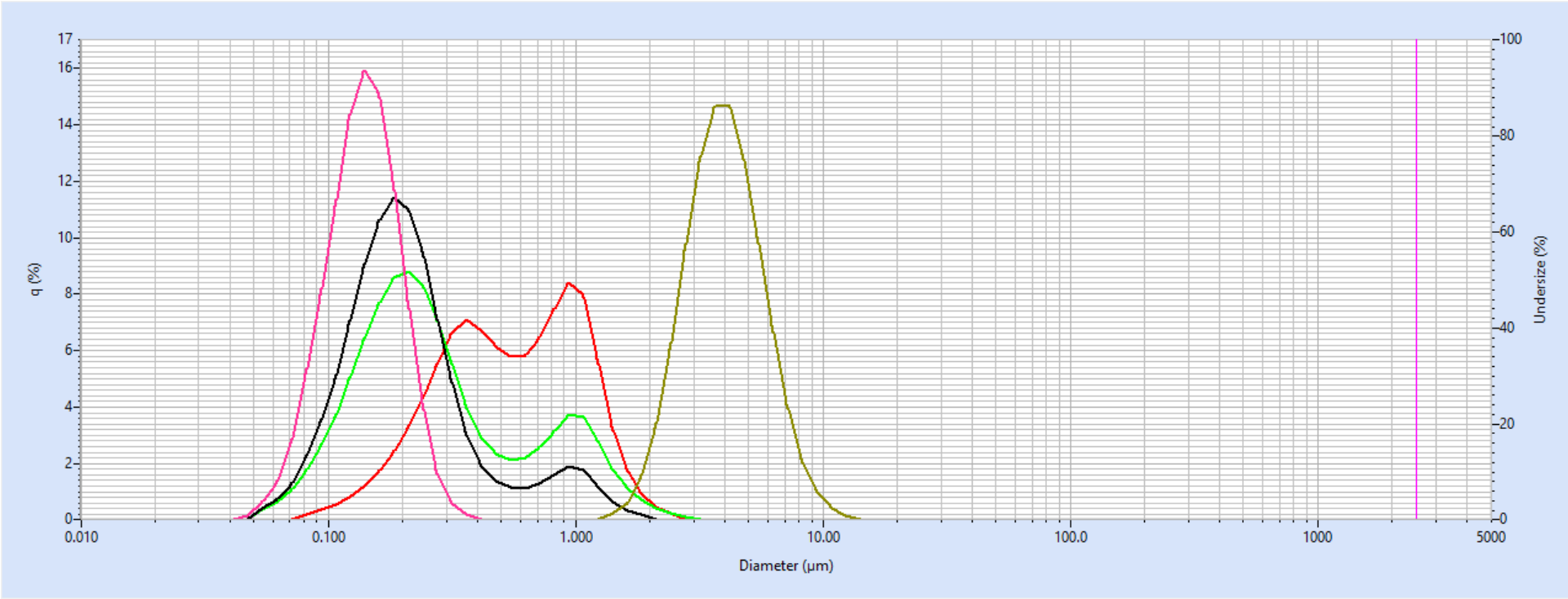
Cow's Milk:
Fat size measurement methods

- 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

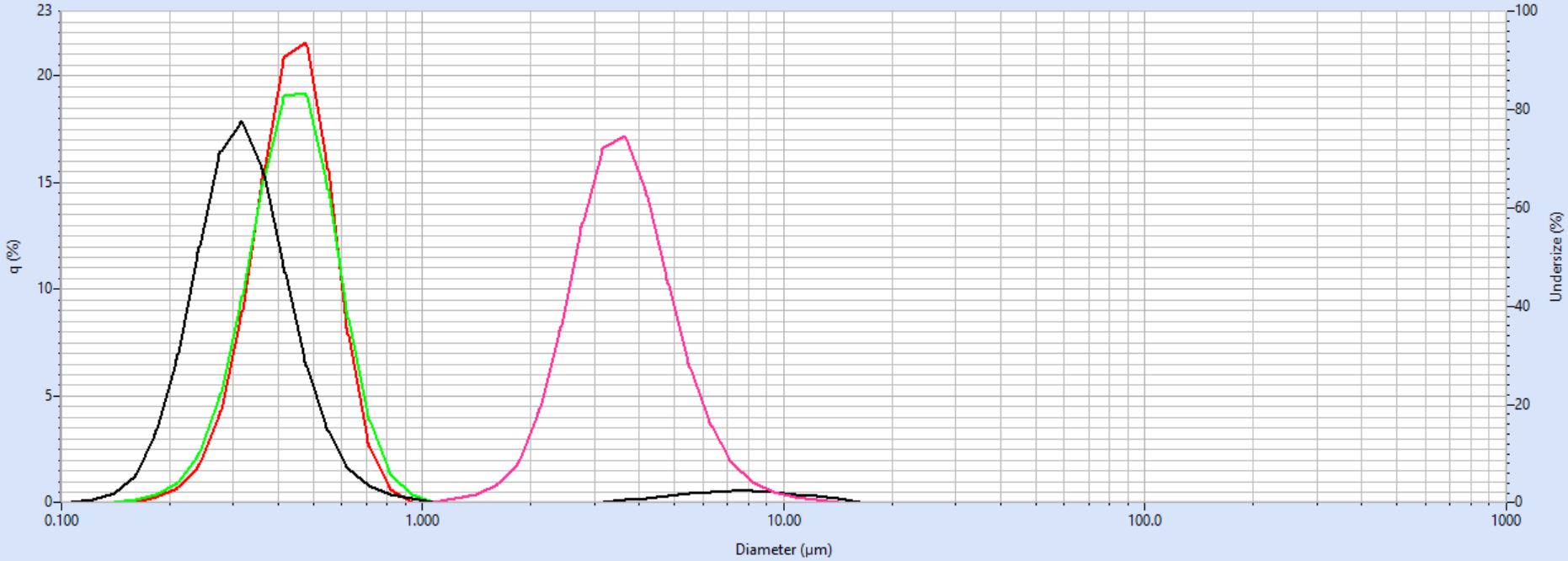
Cow's Milk:
An Overview

Data name	Graph type	D(v,0.1)	D(v,0.5)	D(v,0.9)	Mean size
Popular Whole Milk avg		0.22319 (µm)	0.55434 (µm)	1.20575 (µm)	0.65445 (µm)
Popular 2 Percent Milk avg		0.11486 (µm)	0.24057 (µm)	1.02227 (µm)	0.40825 (µm)
Popular 1 Percent Milk avg		0.10564 (µm)	0.19535 (µm)	0.55576 (µm)	0.27659 (µm)
Popular Fat Free Milk avg		0.08744 (µm)	0.13889 (µm)	0.21124 (µm)	0.14495 (µm)
Non Homogenized Milk avg		2.50955 (µm)	3.95841 (µm)	6.37796 (µm)	4.24636 (µm)



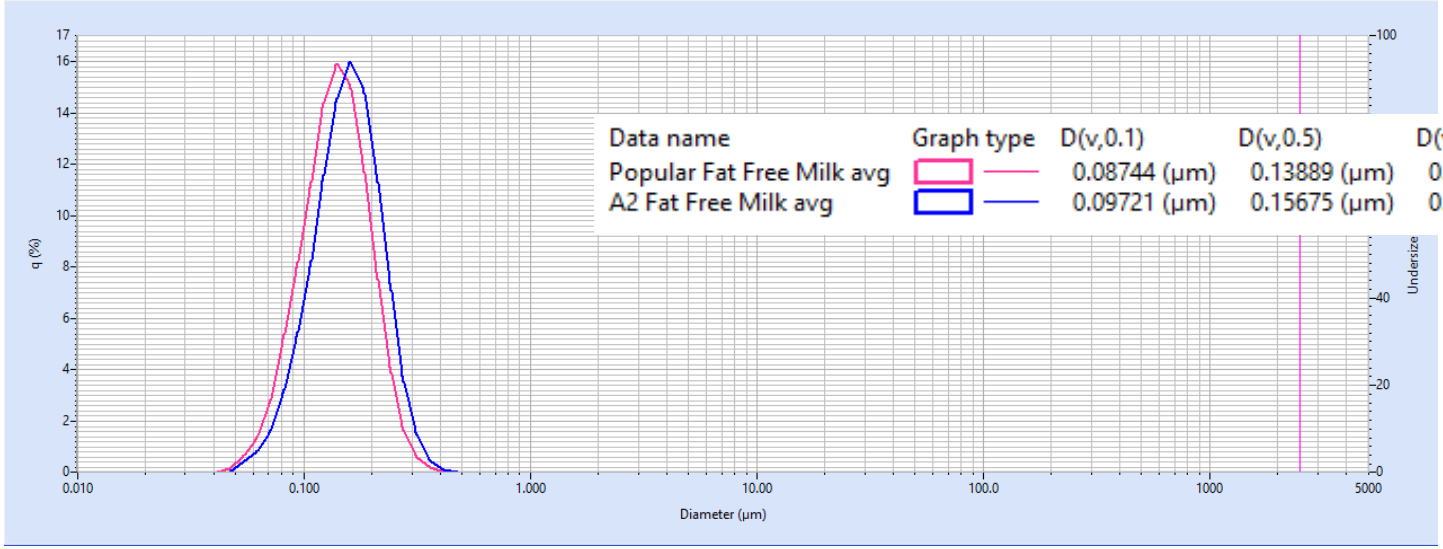
Cow's Milk:
Store Brand – the Success Story

Data name	Graph type	D(v,0.1)	D(v,0.5)	D(v,0.9)	Mean size
Generic Whole Milk avg		0.31187 (µm)	0.44078 (µm)	0.59574 (µm)	0.44910 (µm)
Geneic 2Perc Milk avg		0.30275 (µm)	0.43916 (µm)	0.62299 (µm)	0.45248 (µm)
Generic Fat Free Milk avg		0.21832 (µm)	0.32012 (µm)	0.50600 (µm)	0.59855 (µm)
Non Homogenized Milk avg		2.37410 (µm)	3.55121 (µm)	5.50663 (µm)	3.79400 (µm)



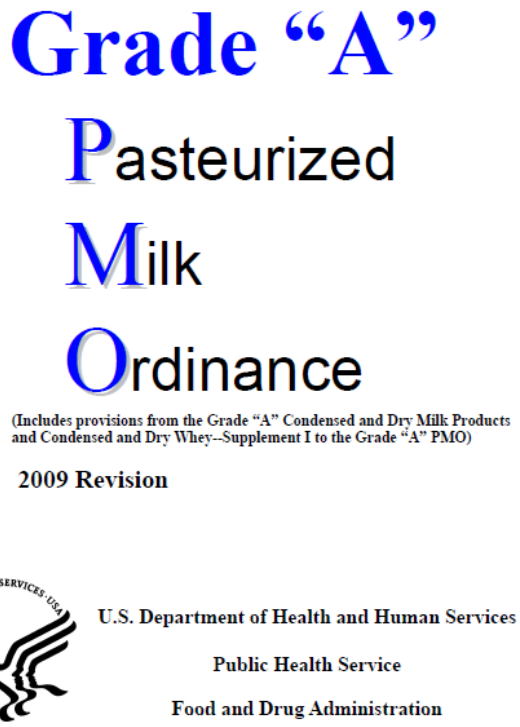
Cow's Milk:
A1 and A2 beta-casein in cow's milk

- Each cow carries two copies of the gene encoding beta-casein, A1 or A2g
- 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.



Source: http://www.fda.gov/downloads/Food/GuidanceRegulation/UCM209789.pdf

Plant Based Protein:
Soymilk

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

  http://www.coca-colacompany.com/coca-cola-unbottled/the-coca-cola-company-and-coca-cola-femsa-to-acquire-ades-soy-based-beverage-business-from-unilever

- 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

- July, 2016
- DANONE acquired WhiteWave Foods Co. for 10.4 billion, stock jumped 19%

  http://www.wsj.com/articles/danone-boosts-u-s-business-with-whitewave-deal-1467870422

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

Source: http://www.madehow.com/Volume-5/Soy-Milk.html#ixzz4ED6SuLY7

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

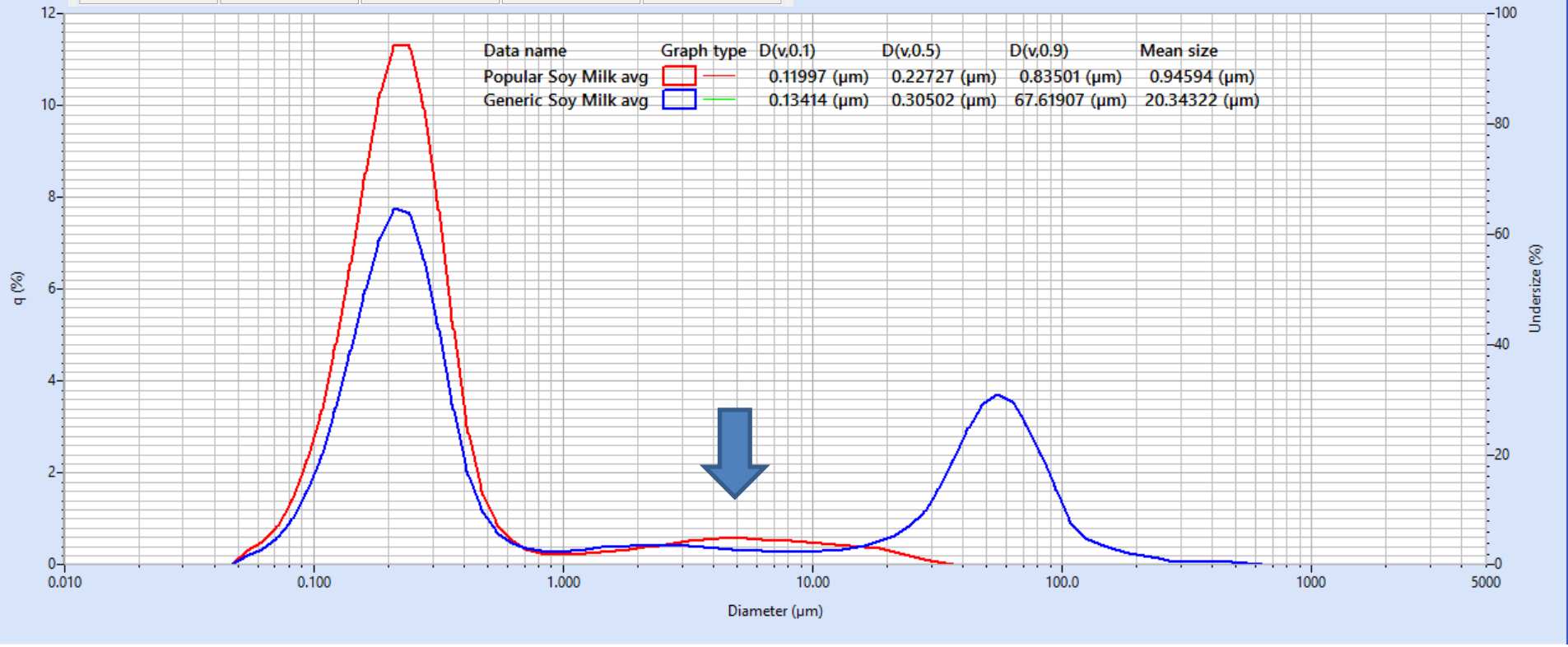
Sources: *Malaki Nik, A., Tosh, S., Poysa, V., Woodrow, L., & Corredig, M. (2008). Physicochemical characterization of soymilk after step-wise centrifugation. Food Research International, 41: 286-294. **Zuo Feng a,b, Peng Xingyun a, Shi Xiaodi a, Guo Shuntang a (2016). Effects of high-temperature pressure cooking and traditional cooking on soymilk: Protein particles formation and sensory quality

Plan-based Protein

Soymilk

Summary | Frequency | Statistics

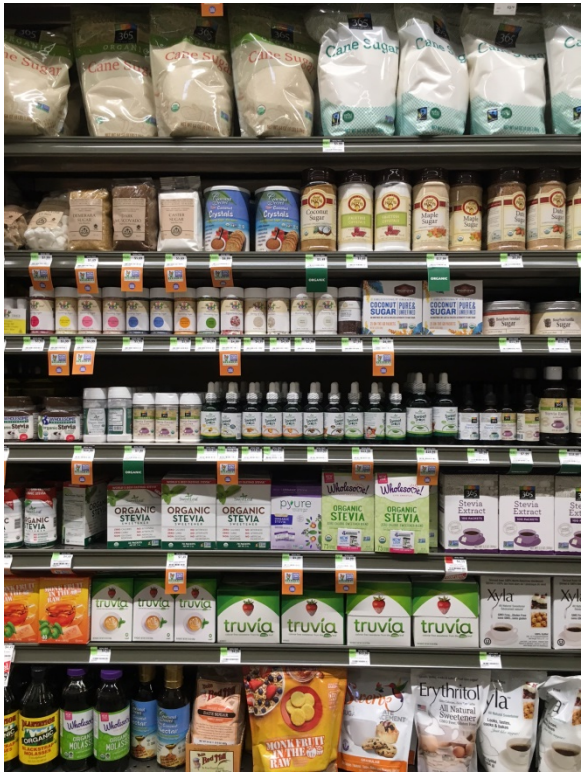
Sample distribution	Distribution 1	Distribution 2	Distribution 3	Residual
Display	Display	Display	Display	Sum of squares : 2.73
D50 : 0.23 (µm)	D50 : 0.22 (µm)	D50 : 5.45 (µm)	D50 : ---.-- (µm)	Area ratio:
D10 : 0.12 (µm)	D10 : 0.12 (µm)	D10 : 1.61 (µm)	D10 : ---.-- (µm)	Residual (abs):Sample : 0.08
D90 : 0.84 (µm)	D90 : 0.37 (µm)	D90 : 18.48 (µm)	D90 : ---.-- (µm)	Residual (abs):Dist1 : 0.09
Average : 0.95 (µm)	Average : 0.24 (µm)	Average : 8.57 (µm)	Average : ---.-- (µm)	Residual (abs):Dist2 : 0.75
Mode : 0.21 (µm)	Mode : 0.21 (µm)	Mode : 5.48 (µm)	Mode : ---.-- (µm)	Residual (abs):Dist3 : ---.--
St. Dev. : 2.91 (µm)	St. Dev. : 0.11 (µm)	St. Dev. : 10.39 (µm)	St. Dev. : ---.-- (µm)	
Span : No value	Span : No value	Span : No value	Span : ---.-- (µm)	



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.

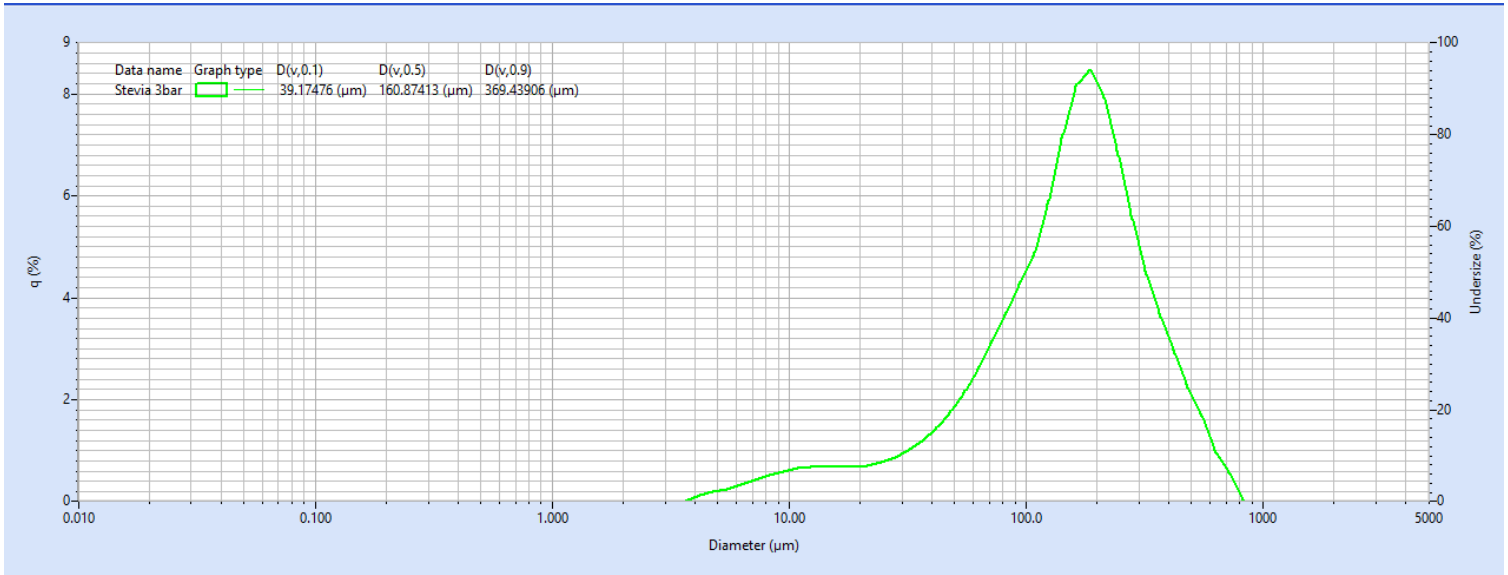
  *"When the company announced last spring that it planned to remove aspartame from Diet Pepsi, it cited declining sales and health concerns stemming from scientific studies linking artificial sweeteners to obesity and cancer in lab rats"….10months later, they're bringing it back to "give customers a choice" ***
- 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)



Source: *http://www.ift.org/food-technology/past-issues/2016/may/features/science-of-taste.aspx
**http://money.cnn.com/2016/06/27/news/companies/pepsi-diet-aspartame/

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



Source: *http://www.google.com/patents/EP2498625A1?cl=en **Comparison of critical particle diameters and its effect on flowability in stevia and sucrose, International conference on science and technique based on applied and fundamental research T. Dozan, M. Benkovic, I. Bauman ICoSTAF, 2014

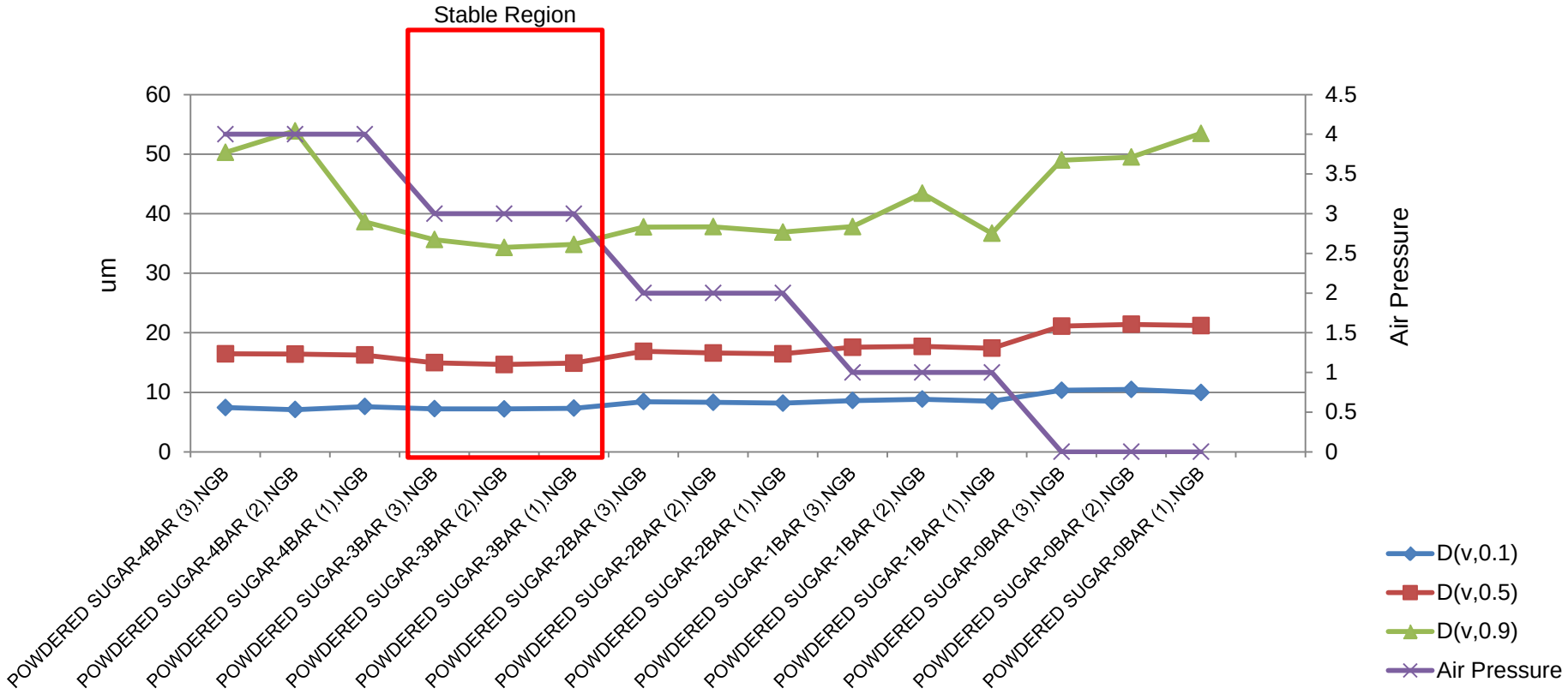
Sugar:
Powdered Sugar

- (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:

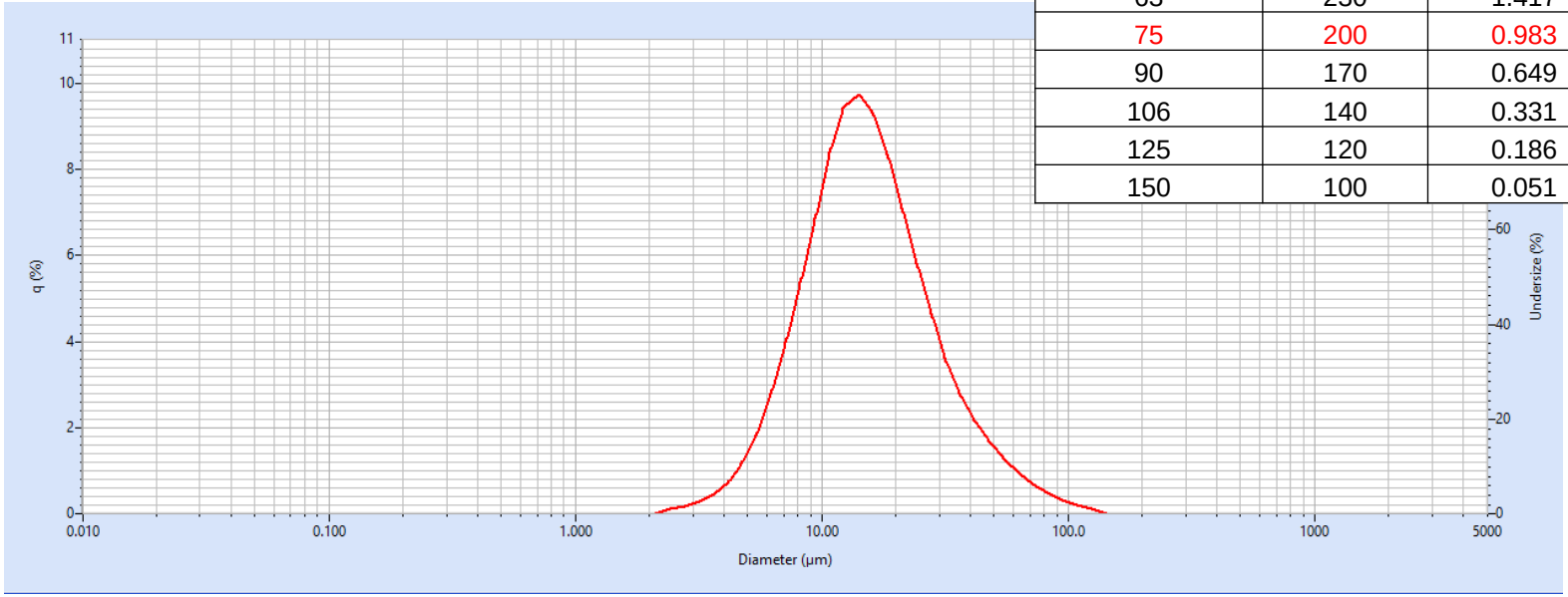
Particle size distribution



Sugar:

Particle size distribution

Diameter (um)	ASTM Mesh	Frequency %	Cum %
20	635	69.071	69.071
25	500	10.644	79.715
32	450	8.164	87.879
38	400	3.865	91.744
45	325	2.768	94.512
53	270	1.872	96.383
63	230	1.417	97.801
75	200	0.983	98.783
90	170	0.649	99.432
106	140	0.331	99.763
125	120	0.186	99.949
150	100	0.051	100



Data name	Graph type	D(v,0.1)	D(v,0.5)	D(v,0.9)	Cumulative % at diameter(8)
Powdered Sugar-3bar avg		7.31500 (µm)	14.89861 (µm)	34.84077 (µm)	(8)74.00 (µm)- 98.718(%)

Questions?

Email us: Labinfo@horiba.com

Call us: 1800-446-7422

www.horiba.com

Thank you

Omoshiro-okashiku
Joy and Fun

眞峰

감사합니다

Cảm ơn

ありがとうございました

Dziękuję

धन्यवाद

Grazie

Merci

谢谢

நன்ற

ขอบคุณครับ

Obrigado

Σας ευχαριστούμε

شُكْرا

Tack ska ni ha

Большое спасибо

Danke

Gracias