Supplementary Information (SI) for Soft Matter.

Supplementary Information for "The Bubbly Life and Death of Animal and Plant-based Milk Foams"

Lena Hassan,[1] Monse Reynoso,[1] Chenxian Xu,[1] Karim Al Zahabi,[1] Ramiro Maldonado,[1] Reed A. Nicholson,[2] Michael W. Boehm,[2] Stefan K. Baier,[2,3] and Vivek Sharma[1,*]

[1] Department of Chemical Engineering, University of Illinois Chicago, Chicago, IL, 60608.

[2] Motif FoodWorks Inc., Boston, MA. 02210

[3]School of Chemical Engineering, The University of Queensland, Brisbane, QLD 4072,

Australia.

[*]Address correspondence to: viveks@uic.edu

ST1. Nutritional comparison of animal and plant-based milk alternatives

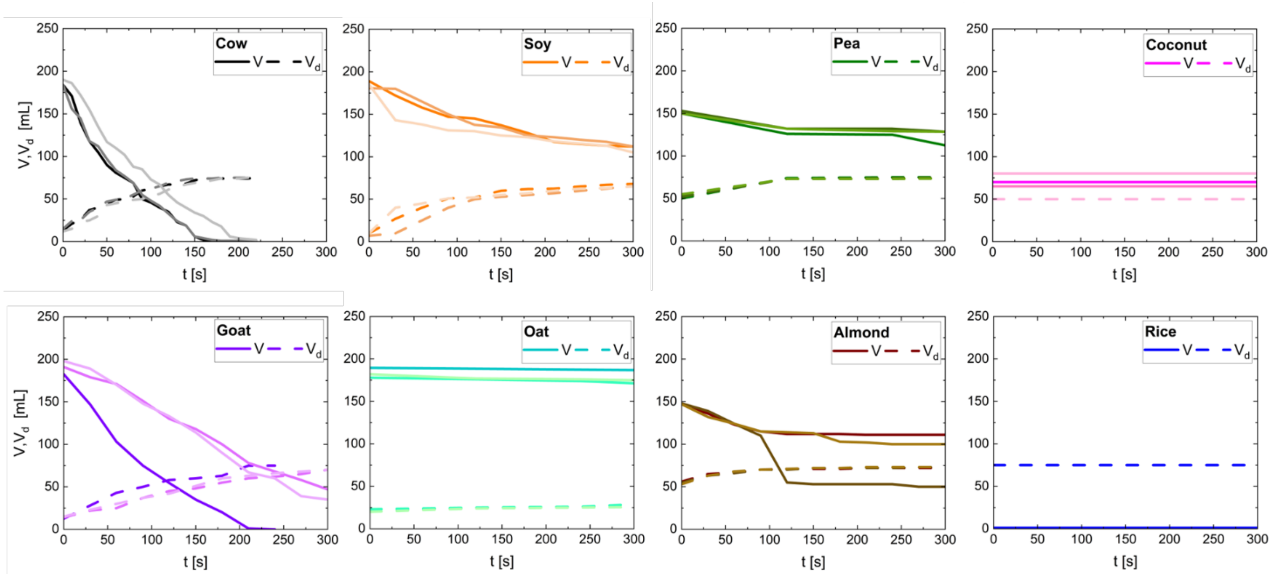
Milks	**PDCAAS**	**DIAAS**
Cow	142	141
Goat	N/A	N/A
Soy	102	98
Pea	84	73
Oat	77***	75**
Almond	< 25	N/A
Coconut	N/A	N/A
Rice	63***	60**

(**) DIAAS (*54-57*); (***) PDCAAS (*58*)

ST2. Surface tension and droplet size of animal and plant-based milks

Measured using pendant drop tensiometry.

Milks	$\boldsymbol{\sigma} \left[\frac{\boldsymbol{mN}}{\boldsymbol{m}}\right]$ **t= 60 min**	$\boldsymbol{d_{3,2}}$ $[\boldsymbol{\mu}m]$	$\boldsymbol{d_{50}}[\mu m]$
Cow	47.1	1.00	0.77
Goat	47.6	0.66	0.58
Soy	46.1	0.63	0.51
Pea	43.0	0.64	0.51
Oat	38.9	1.18	0.77
Coconut	45.1	1.10	0.88
Almond	48.5	0.86	0.67
Rice	[]	0.82	0.58



S1. Volume-time plots for eight milks. Reasonable repeatability was observed for foams made with animal and plant-based milk using the electric frother in the cold setting.

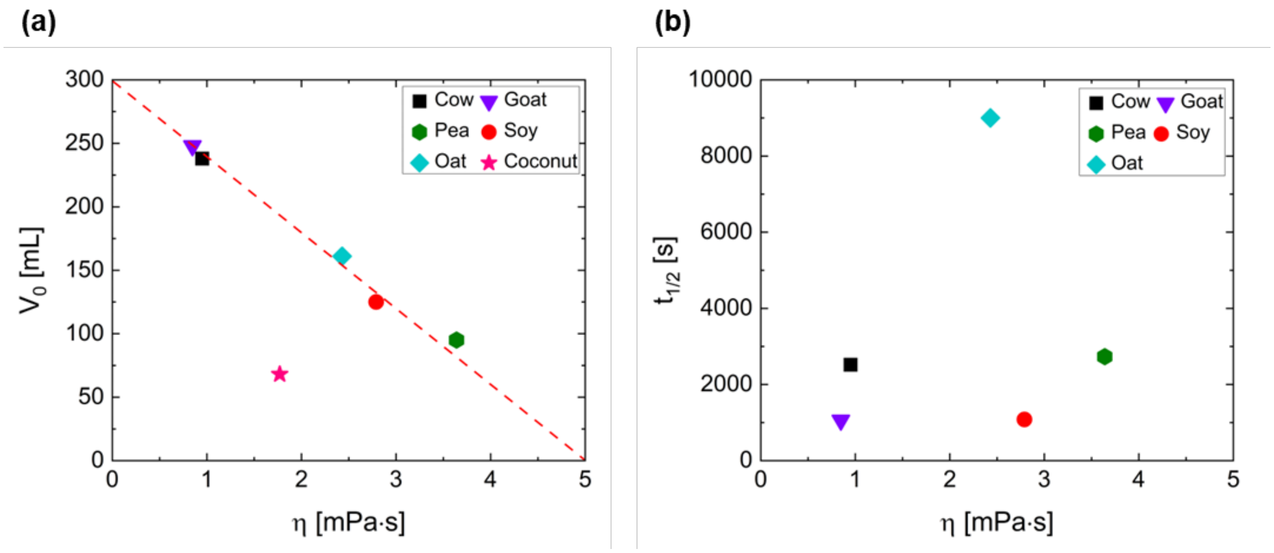
Milk rheology: The shear viscosity of milks was characterized using Anton-Paar MCR 302 rheometer with double-gap geometry (DG) for cold and hot temperatures of 10 °C and 65 °C, respectively. The viscosity measurements show the influence of protein aggregates at high temperatures and interfacial viscoelasticity contributions at low rates.[4, 77-79] A detailed discussion of these effects and rheological properties will be presented in a future publication.

ST3: The apparent viscosity of milk at a shear rate of 1 s^{-1} and 10 s^{-1} at the cold, room temperature and hot settings.

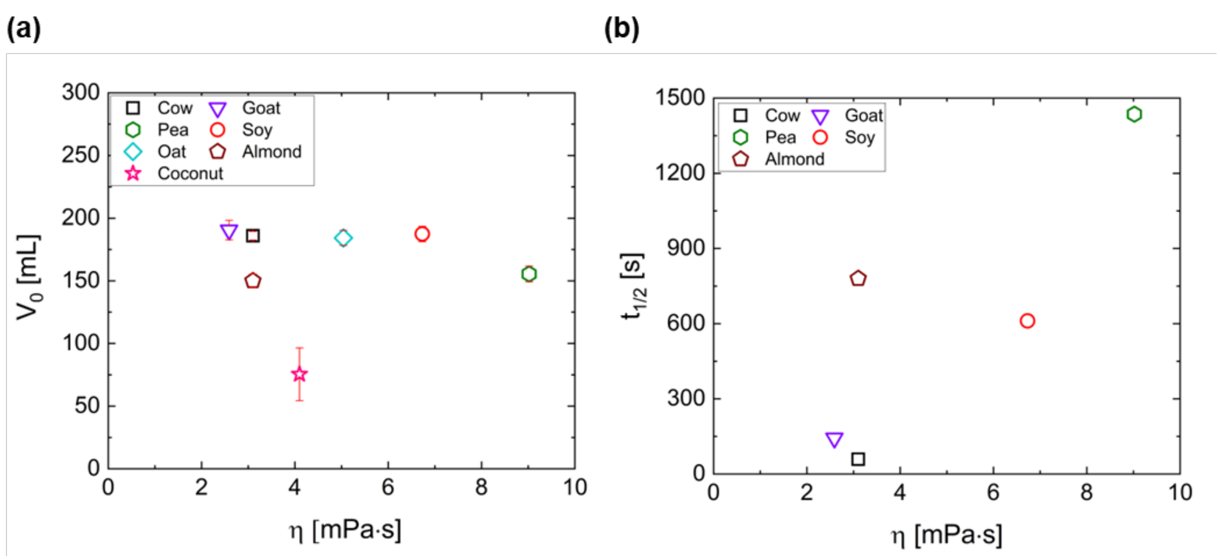
Milk $\dot{\gamma}$ **=1** s^{-1}	**η [mPa·s] 10°C**	**η [mPa·s] 25°C**	**η [mPa· s] 65°C**	**Milk** $\dot{\gamma}$ **=10** s^{-1}	**η [mPa·s] 10°C**	**η [mPa·s] 25°C**	**η [mPa· s] 65°C**
Cow	3.29	1.72	6.32	Cow	3.24	1.91	2.38
Goat	5.34	1.56	240	Goat	3.86	1.77	18
Pea	74	46	773	Pea	31.3	19.3	59.5
Soy	23.7	17.4	696	Soy	13.4	10.1	56.4
Oat	20.5	19.3	49.8	Oat	11.3	9.2	5
Almond	6.9	15.7	3.34	Almond	6.32	6.49	1.12
Coconut	38.8	13.3	11.2	Coconut	11.9	6.69	4.85
Rice	7.29	1.52	0.67	Rice	2.96	1.56	0.67

ST4: Maximum foam volume (V_0) and half-lifetime ($t_{1/2}$) of milk foams at two different temperatures in the electric frother and the apparent viscosity of milk at a shear rate of 500 s^{-1} at the cold and hot settings.

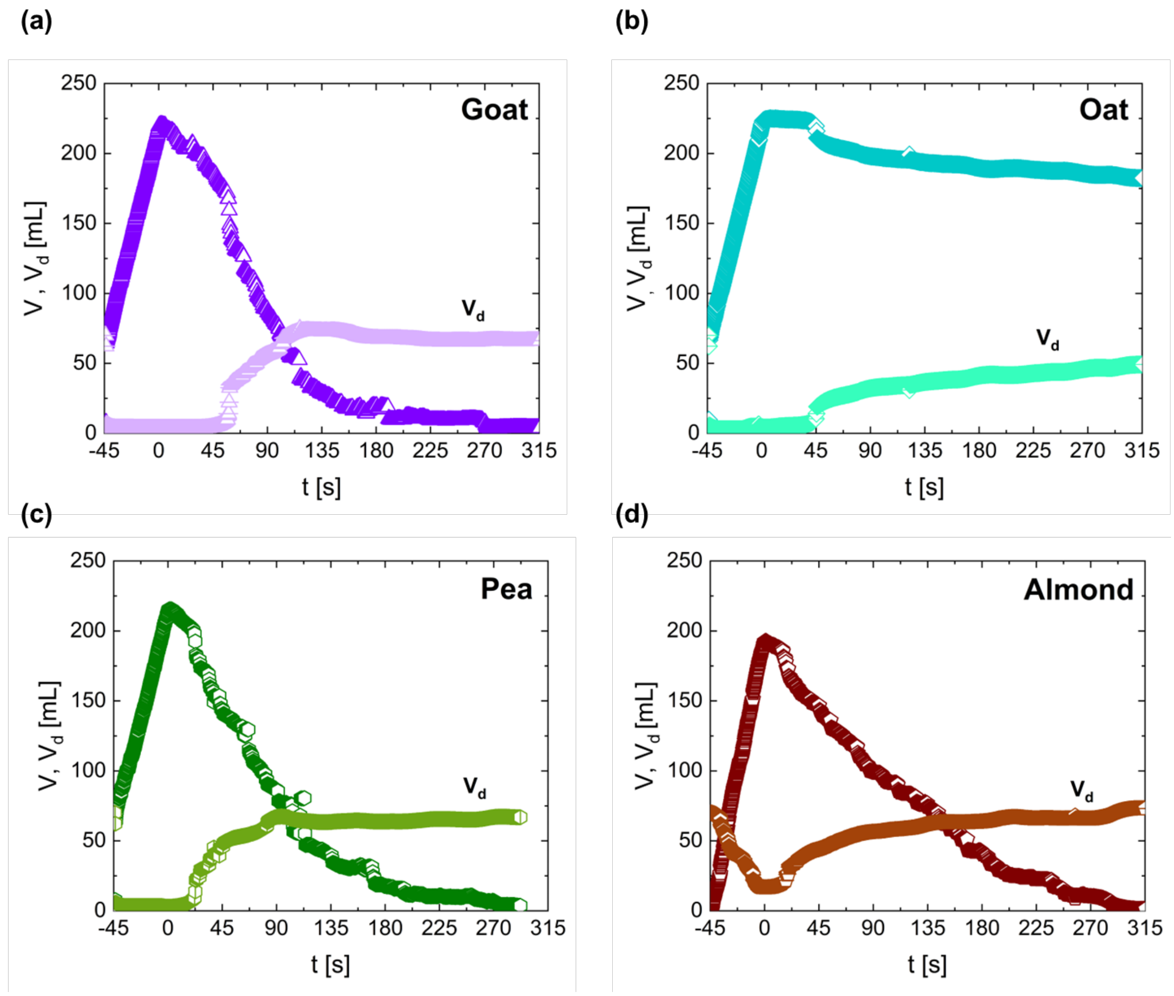
Milk	**V_0 [mL] 65°C**	**$t_{½}$ [s] 65°C**	**η [mPa· s] 65°C**	**V_0 [mL] 10°C**	**$t_{½}$ [s] 10°C**	**η [mPa· s] 10°C**
Cow	238	2520	0.95	186	59	3.1
Goat	248	1062	0.85	191	143	2.6
Pea	95	2730	3.6	156	1436	9.0
Soy	125	1080	2.8	187	611	6.7
Oat	161	9000	2.4	185	>9000	5.0
Almond	0	N/A	0.98	150	780	3.1
Coconut	68	>9000	1.8	75	>9000	4.1
Rice	0	N/A	0.74	0	N/A	1.9



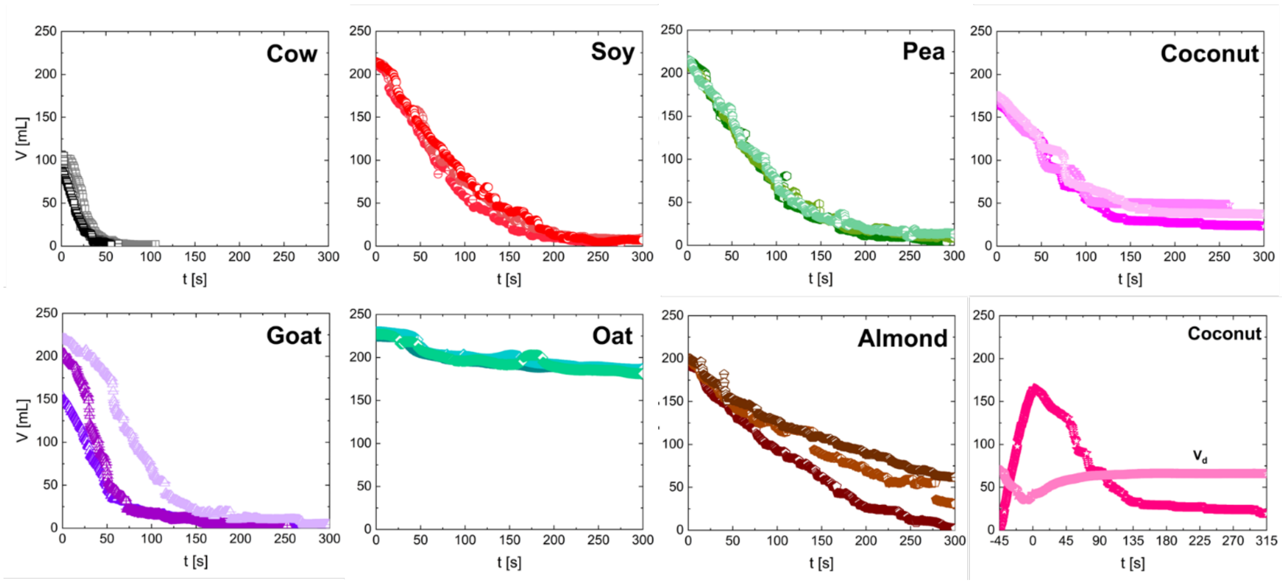
S2. Max volume and half-life vs viscosity at T= 65°C and $\dot{\gamma} = 501\ s^{-1}$. (a) Two animal based milks and four plant-based milks are shown. Almond and rice milk are excluded due to no foam formation at the hot setting. An inverse linear relationship with volume and viscosity seems to emerge. (b) Two animal and only three plant-based milks are shown. Coconut milk is excluded as the foam was very stable and did not decay to half the max foam volume.



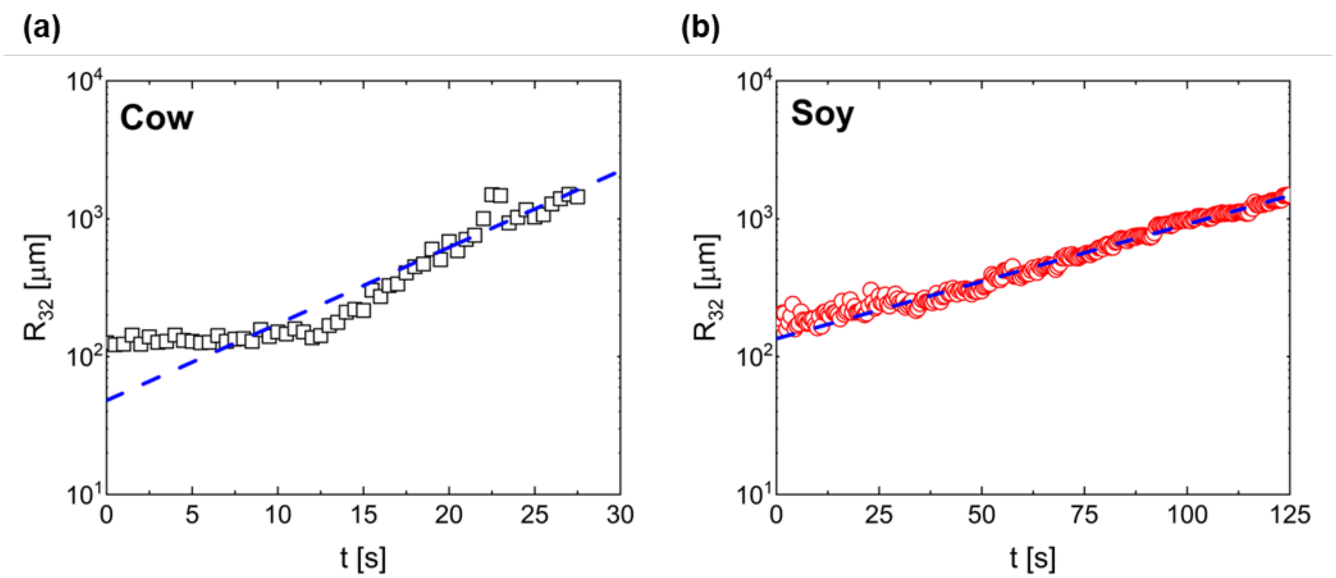
S3. Max volume and half-life vs viscosity at T= 10°C and $\dot{\gamma} = 501\ s^{-1}$. (a) Two animal based milks and five plant-based milks are shown. Rice milk is excluded as no foam formed at the cold setting. A fairly constant maximum foam volume of about V_0 = 200 mL is obtained for most of the milks despite differences in viscosity. (b) Two animal and only three plant-based milks are shown. Oat and coconut milk are excluded as the foam was very stable and did not decay to half the max foam volume.



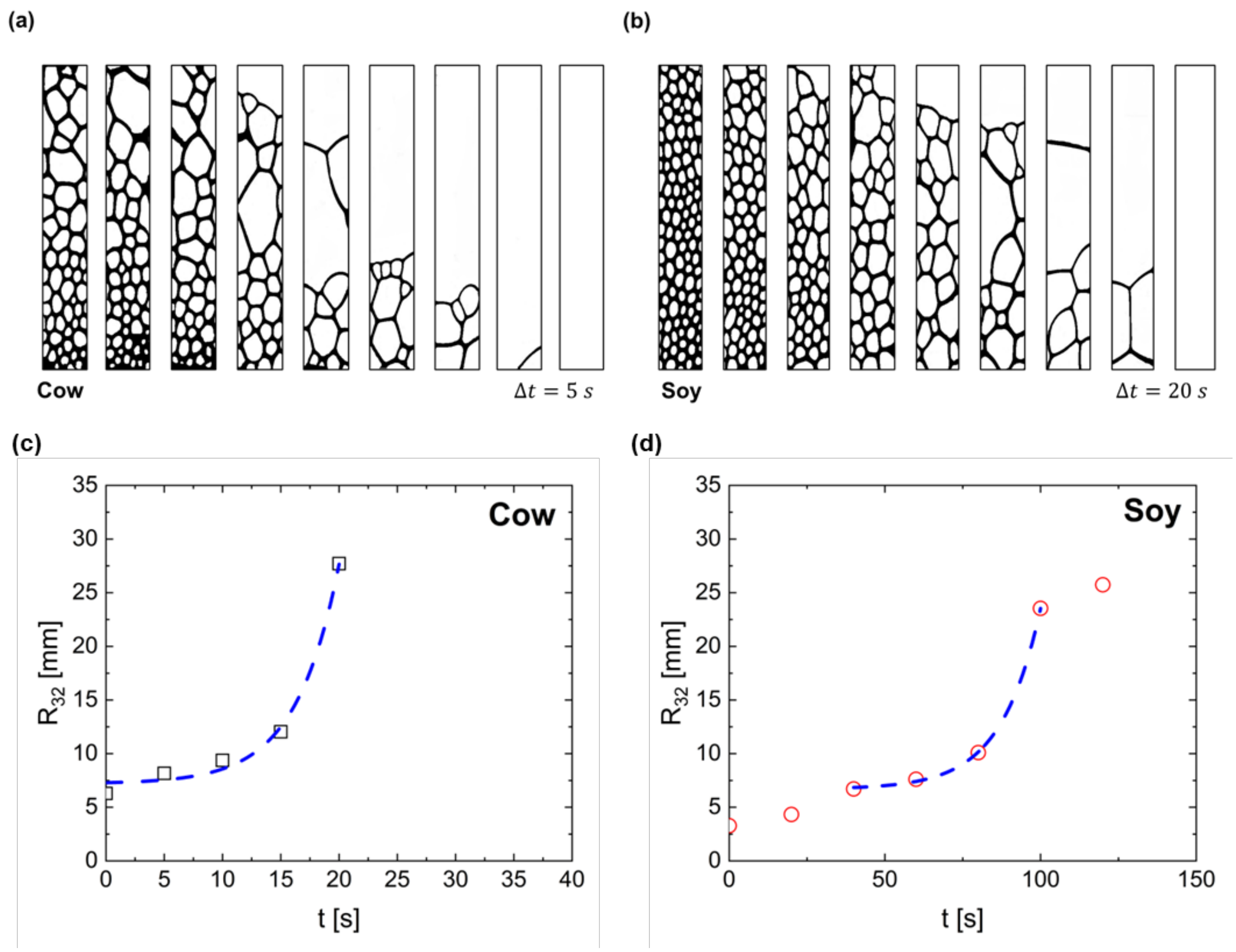
S4. V and V_d vs time for the rest of the milks (excluding coconut and rice milk) obtained from DFA. (a) Goat milk (b) Oat milk (c) Pea milk (d) Almond milk



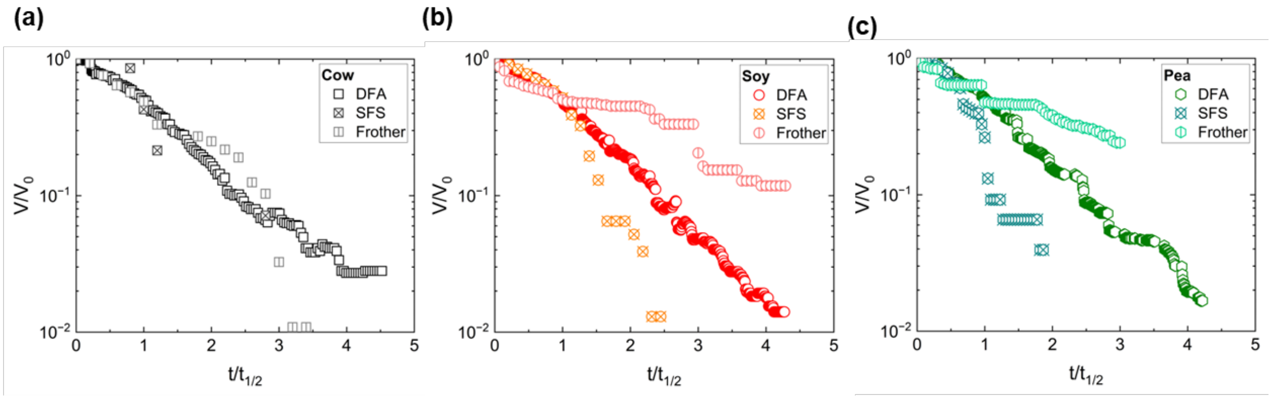
S5. Repeatability of animal and plant-based milk foam produced using the dynamic foam analyzer (DFA-100).



S6. Replot of Figure 7 with (c) and (d) on semi log scale.



S7. R_{32} (mean Sauter radius) vs time for cow and soy milk foam imaged with Fizzics scope for Figure 8. (a) Binary image sequences of cow milk foam after sparging has stopped from t = 0 s to t= 40 s with time interval of 5 s. (b) Binary image sequences of soy milk foam after sparging has stopped from t = 0 s to t= 140 s with time interval of 20 s. (c) R_{32} vs time for cow milk foam obtained from ImageJ particle analysis feature displays an exponential growth of bubble radius with time before collapse. (d) R_{32} vs time for soy milk foam obtained from ImageJ particle analysis feature displays an exponential growth of bubble radius with time before collapse.



S8. Replot of Figure 9a-c on a semi-log plot.