Producing Hygienic Raw Milk: Standards, Testing, and Farmer Education

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	USA Grade A conventional milk[1]		DEDICATED FRESH RAW MILK meeting RAWMI common standards[2]
	Pre-pasteurized	Pasteurized	
Pathogens	No set limit	No set limit	No detectable *Campylobacter* , *E. coli* 0157:H7, *Listeria* or *Salmonella*
Coliforms /ml	< 750	< 10	< 10 (rolling three month average)
Standard plate count /ml	< 100,000	< 20,000	< 5,000 (rolling three month average)
Somatic cell count /ml	< 750,000		No set limit
Drug residues	Not detectable		Not detectable
Tuberculosis and Brucella	Herds not tested		Herds verified free from both
Distribution	Farm produces primarily for pasteurization, but incidental sales of raw milk may occur; often pooled with milk from other farms		Farm produces only for direct consumption; milk remains single source

1 Grade "A" Pasteurized Milk Ordinance, 2017 revision, U.S. Dept of Health and Human Services, Public Health Service, Food and Drug Administration
2 Raw Milk Institute 2019. www.rawmilkinstitute.org

Most raw milk studies have been carried out on conventional pre-pasteurized bulk tank milk, yet **DEDICATED FRESH RAW MILK** is produced to significantly higher standards. Producing milk for pasteurization does not provide incentive for minimizing pathogens and bacterial counts. Farmers producing **DEDICATED FRESH RAW MILK** need to implement extra hygienic controls to ensure a safe product.

DEDICATED FRESH RAW MILK **can be produced with significantly lower bacteria, coliform and pathogen counts than what is required for pasteurized milk.**

Studies of conventional pre-pasteurized bulk tank milk in North America have detected pathogens in between 4% and 33% of milk samples. This is the data which regulatory agencies use to conclude that raw milk is inherently dangerous. Studies of **DEDICATED FRESH RAW MILK**, on the other hand, show that it is possible to consistently produce raw milk without detectable pathogens.

	Study	# milk samples tested	# pathogens tested	total # pathogen tests	% Samples Positive for Target Pathogens: Campylo-bacter	E. coli STEC	Listeria monocytogenes	Salmonella spp.	Yersinia spp.	% samples with one or more pathogens	References
Culture-based detection	**Milk produced using conventional dairying methods**										
	Jayarao and Henning (2001)	131	5	524	9.2	4.6	4.6	6.1	5.3	**27**	**BC Herdshare Association 2019**. BC Fresh Milk Project. http://tinyurl.com/bcfm-project
	Jayarao et al (2006)	248	5	992	2.0	2.4	1.2	6.0	1.2	**11**	**Del Collo** LP et al. **2017**. Prevalence, antimicrobial resistance, and molecular characterization of Campylobacter spp. in bulk tank milk and milk filters from US dairies. J Dairy Sci 100:3470-3479
	Rohrbach et al (1992)	292	4	876	12	N/A	4.1	8.9	15.1	**33**	**Jayarao** BM et al. **2001**. Prevalence of Foodborne Pathogens in Bulk Tank Milk. Journal of Dairy Science 84(10):2157 – 2162
	Steele et. al. (1997)	1720	4	6880	0.5	0.9	2.7	0.2	N/A	**4.1**	**Jayarao** BM et al. **2006**. A survey of foodborne pathogens in bulk tank milk and raw milk consumption among farm families in Pennsylvania. J Dairy Sci 89:2451-8
	Van Kessel et al (2004)	861	2	1722	N/A	N/A	6.5	2.6	N/A	**9.1**	**Karns** JS et al. **2007**. Incidence of Escherichia coli O157:H7 and E. coli Virulence Factors in US Bulk Tank Milk as Determined by Polymerase Chain Reaction. J Dairy Sci 90:3212-3219
	Van Kessel et al (2008)	183	1	183	N/A	N/A	N/A	11	N/A	**11**	**Rohrbach** RW et al. **1992**. Prevalence of L. monocytogenes, C. jejuni, Y. enterocolitica and Salmonella in bulk tank milk: Risk factors and risk of human exposure. J. Food Prot. 55:93–97
	Van Kessel et al (2011) [1,2]	536	2	N/A	N/A	N/A	7.1	13	N/A	N/A	**Steele** ML et al. **1997**. Survey of Ontario bulk tank raw milk for food-borne pathogens. J. Food Prot. 60:1341–1346
	Milk produced using HACCP-based RAWMI methods										**Van Kessel** JS et al. **2004**. Prevalence of Salmonellae, Listeria monocytogenes, and fecal coliforms in bulk tank milk on US dairies. J. Dairy Sci. 87:2822–2830
	BC Herdshare Association (2019) [3]	168	4	672	0.0	0.0	0.0	0.0	N/A	**0.0**	**Van Kessel** JS et al. **2008**. Environmental sampling to predict fecal prevalence of Salmonella in an intensively monitored dairy herd. J Food Prot. 71(10):1967-73
PCR-based detection	**Milk produced using conventional dairying methods**										**Van Kessel** JS et al. **2011**. Prevalence of Salmonella enterica, Listeria monocytogenes, and Escherichia coli Virulence Factors in Bulk Tank Milk and In-Line Filters from U.S. Dairies. J Food Prot 74(5):759-768
	Del Collo et al (2017)	234	1	234	25	N/A	N/A	N/A	N/A	**25**	
	Karns et al (2005)	854	1	854	N/A	N/A	N/A	N/A	12	**12**	
	Karns et al (2007) [2]	85	1	N/A	N/A	23	N/A	N/A	N/A	**23**	
	Van Kessel et al (2011) [1,2]	538	2	N/A	N/A	29	N/A	28	N/A	N/A	
	Milk produced using HACCP-based RAWMI methods										
	Organic Pastures Dairy (2019) [4]	3926	4	4252	0.0	0.0	0.0	0.0	N/A	**0.0**	
Notes	(1) Only tests of milk samples, not filters, included in totals. Reported as weighted % of non-random sampling. (2) *E. coli* STEC assay: one or more Shiga-toxin genes detected by PCR. (3) Independent research sponsored by a non-profit association. Participants include both fully RAWMI-trained farmers and those in-training. (4) Daily test & hold results for retail dairy. Only milk samples, not filters included. O157:H7 only E. coli STEC strain tested.										

Grass-to-Glass Farmer Education

The California-based non-profit Raw Milk Institute (RAWMI) has developed an on-farm food safety training and certification system for **DEDICATED FRESH RAW MILK** farmers.

RAWMI training includes the development of a **Risk Analysis and Management Program (RAMP)** tailored to the individual farm. This comprehensive plan identifies potential risks that are present at the farm. With assistance from RAWMI, management practices are set up to reduce, manage, or mitigate those potential risks.

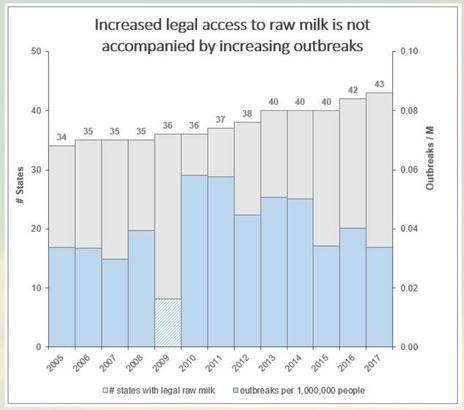
RAWMI-listed farmers maintain **Common Standards**:

- Milk must have no detectable *Salmonella*, *E. coli* 0157:H7, *Campylobacter* or *Listeria monocytogenes*
- Bacterial targets: less than 10 coliforms per ml and standard plate count not more than 5000 cfu/ml
- Herds must be documented as free from Tuberculosis and Brucella; and
- Milk must not be mixed with that of other dairies, to ensure traceability

Test & Hold for Additional Safety

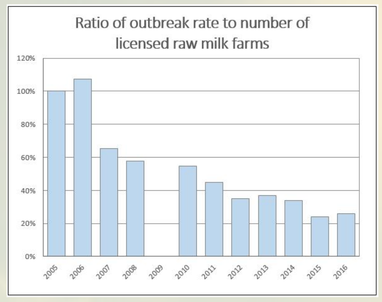
With rapid molecular methods for detection of pathogens and coliforms, as opposed to traditional culture-based detection, it is now possible for farmers to test every batch of raw milk prior to it being released for sale. While this may not be cost-effective for small farms, larger dairies can reduce risk of **DEDICATED FRESH RAW MILK** outbreaks to near zero. The BAX® system, for example, uses real-time PCR assays for detection of major milk contaminants and provides results within hours.

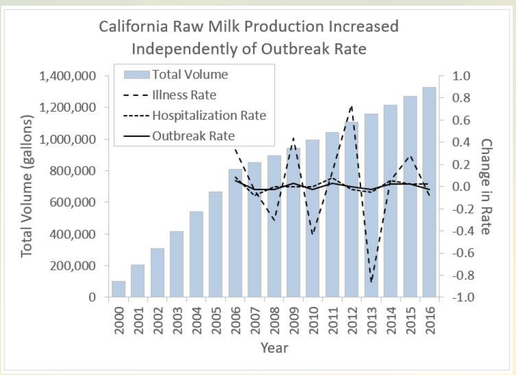
Outbreaks Decreasing as Raw Milk Production Increasing in the USA



Since 2005, the number of states providing legal access to raw milk, through herdshares, farm-gate sales or retail sales, has increased from 34 to 43. Outbreaks of foodborne illness attributed to raw milk and reported to the Centers for Disease Control and Prevention peaked in 2010 and have since decreased significantly [1]. The lack of correlation between legal access and numbers of outbreaks, illnesses and hospitalizations has been independently verified using Poisson regression [2]. The CDC outbreak data does not distinguish between pre-pasteurized and dedicated fresh raw milk.

National data on raw milk production volumes is not recorded, so the number of raw dairy licenses active each year in the 9 states for which data was available was used as a proxy for consumption. While at best an approximation, scaling raw milk outbreak numbers to license numbers shows a dramatic decrease in effective outbreak rates [1].



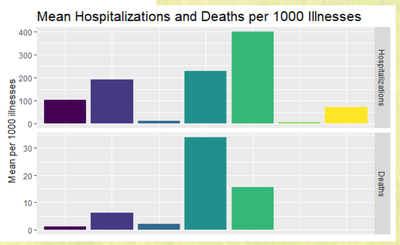


In California, retail raw milk is produced on five licensed farms, for which annual production volumes were obtained; this increased from 100,000 gallons in 2000 to 1.3 million gallons in 2016. Changes in California outbreak, illness and hospitalization rates are shown for 2005 to 2016. Although the number of illnesses fluctuates widely, both outbreak and hospitalization rates have remained unchanged, despite the large increase in production over this time. The 8 outbreaks, 95 illnesses and 14 hospitalizations were not necessarily attributed to these licensed farms; the contaminated milk may have come from pre-pasteurized bulk tanks, unlicensed herdshares, family farms or interstate buying clubs [2].

[1] Whitehead & Lake 2018. Recent Trends in Unpasteurized Fluid Milk Outbreaks, Legalization, and Consumption in the United States. PLOS Currents: Outbreaks, 13 Sept 2018.
[2] Azzolina & Coleman 2019. Evidence and Analysis Debunk Speculations about Raw Milk Risks. Risk Analysis. Under review.

Risk Profiles of Different Dairy Foods

In the United States, more outbreaks are caused by raw milk than other dairy products, but **DEDICATED FRESH RAW MILK** is not distinguished from conventional pre-pasteurized milk in the CDC database. Outbreaks from pasteurized milk can be very large, such as one in 2006 which caused 1644 illnesses in the California prison system. Queso fresco is a significant contributor to hospitalizations and deaths, and pasteurized processed dairy foods caused more deaths than any other dairy commodity. Raw milk caused fewer deaths than any other dairy foods. Shown here are outbreaks reported to the CDC for 2005-2017.



Whitehead & Bomford, 2019. Patterns in pathogenicity: thirteen years of dairy outbreaks. Manuscript in preparation.

The hospitalization rate is highest for queso fresco outbreaks at 399 per 1000 illnesses, as compared to 11 per 1000 for pasteurized milk. Death rate is highest for processed pasteurized dairy at 34 per 1000 illnesses, and lowest for raw milk, at 1.2 per 1000. For processed dairy, pasteurized products caused 5.5X more deaths per 1000 illnesses than unpasteurized, while for fluid milk, pasteurized caused 1.8X more deaths per 1000 illnesses than unpasteurized.

Campylobacter is the most common cause of dairy outbreaks and illnesses, but hospitalizations are often due to *E. coli* and *Salmonella*. Deaths are almost exclusively due to *Listeria*, found most often as a contaminant of processed dairy foods, including queso fresco.

Farmer Training Reduces Bacterial Counts and Prevents Outbreaks

The British Columbia Fresh Milk Project monitors milk from cow and goat herdshares and offers RAWMI training to farmers. Bacterial counts of 168 consecutive milk samples are shown. Those from from fully trained farmers have consistently lower standard plate counts than the 20,000 cfu/ml required for pasteurized milk (61/61 samples below this limit). Farmers still in training generally also have very low counts but occasionally show unacceptable levels of bacteria (101/107 samples below limit). Coliform counts from fully trained farmers fall mostly below the limit of 10 cfu/ml for pasteurized milk (58/61 samples), while farmers still in training are more likely to have coliform contamination (98/107 samples below limit). For any samples with coliform counts above 10 cfu/ml, the point of contamination was discovered and remediated. **Not one of the 168 milk samples tested so far showed any detectable *Campylobacter*, *E. coli* STEC, *Listeria* or *Salmonella*.**

Pennsylvania is one of seven states allowing retail raw milk sales. Outbreaks were relatively frequent up to 2014, but a training session by RAWMI at Pennsylvania State University at the end of 2014 coincided with a significant reduction in outbreaks and illnesses due to raw milk. The farmer of the largest raw dairy in Pennsylvania became certified by RAWMI in 2014; he had been responsible for multiple outbreaks, including 57% of raw milk-related illnesses nationwide in 2012. For 2014 to 2017 there was only a single small raw milk outbreak in the state, which was not from a RAWMI-listed farm.

DEDICATED FRESH RAW MILK: Conclusions & Outlook

- Raw milk outbreaks have been decreasing for several years, while production continues to increase.
- Specific on-farm food safety training provides farmers with the skills to consistently produce safe raw milk.
- New rapid and inexpensive testing enables farmers to be certain that every batch of milk is safe to drink.
- No dairy food (or any food) is entirely free from risk of outbreaks.
- The relative frequency of raw milk outbreaks may be decreasing because dedicated farmers are undertaking on-farm food safety training.
- Systematic implementation of training, certification and monitoring could further reduce raw milk outbreaks.
- Risk management would be a better strategy than prohibition for raw milk regulation.