This month's issue features a tribute, reducing body inflammation with dairy, milk lutein's role in breastmilk, the risks of perfluoroalkyl substances, and methods of freezing milk.

In Memoriam: Legacy Lives On

In boxing, a one-two punch is a combination of two blows delivered in rapid succession. The milk community has recently suffered a one-two punch with the loss of Gregory "Butch" Dias, Jr., California dairy farmer and chairman of the board of the California Dairy Research Foundation (CDRF) in December, and of Dr. Gonca Pasin the Executive Director of CDRF this month.

To those who may not know, Gonca via CDRF has been the primary funder of our newsletter, “SPLASH!® milk science update,” since its inception in 2012. With her financial and spiritual support, we have published more than 280 articles on topics in milk science for the lay public. Year after year, her commitment to exceptionalism pushed us to be our best.

SPLASH! is the official newsletter of the International Milk Genomics Consortium (IMGC). The IMGC was established 15 years ago jointly between academic and dairy centers around the world with a broad mission to advance the scientific understanding of milk and lactation. Gonca and Butch were two of the IMGC’s most active and vocal supporters. Both Gonca and Butch saw a bold role for IMGC and a means to stand apart from the rest of the dairy programs. Their dedication has been instrumental in the singular success of IMGC, and while they were unheralded while doing it, their loss will be deeply felt.

One of Gonca’s visions for CDRF was for a world-wide surveillance system that could keep the industry apprised of the latest breakthroughs in all of the scientific disciplines related to milk. This is a daunting task to contemplate much less execute. Gonca saw IMGC’s SPLASH! as an unprecedented opportunity to position milk in the center of the debate on health research and simultaneously keep the dairy industry strategically alerted to all opportunities. Gonca supported SPLASH! to become a world class, academically-independent entity dedicated to the unbiased evaluation and communication of all scientific advances related to milk. Gonca was conspicuously courageous in supporting SPLASH!, not as the means to speak for the dairy industry but as the means to accelerate the progress of milk science and human health globally.

Gonca and Butch were a dynamic and active engine driving human interactions. They realized that scientists need to come together from different parts of the world, from different parts of the scientific research community, from different parts of the academic and industrial sectors, and from different ages and experiences. Gonca and Butch pushed the annual meetings of the IMGC with their unique set of people skills. When it could have been easy to standardize a common annual meeting place, they defended their vision of collaboration. Ignoring the challenges and efforts required, IMGC remains a truly international concept, moving the meeting sites every year around the world to locations in Europe, Australia, and North America.

The hallmark of a great host is someone who makes everyone feel welcome, who encourages conversation and open access to all opinions, and who makes work fun and every meeting an occasion. Gonca Pasin and Butch Dias have been the hosts of the IMGC. While we will miss them, they have established a
program and a momentum that will keep their vision and enthusiasm alive and well as a living legacy.

J. Bruce German, PhD
Founder, International Milk Genomics Consortium
&
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Founder & Executive Editor, “SPASH!® milk science update”

Food and Medicine: Dairy Reduces Markers of Chronic Inflammation

• Overweight and obesity are associated with low-grade inflammation, a condition that increases the risk for developing cardiovascular disease and insulin resistance.
• Nutrients influence the body’s inflammatory status, particularly dairy foods like low-fat milk and yogurt that contain a high concentration of calcium and numerous bioactive proteins.
• Several studies demonstrate that the addition of just two servings of dairy a day to the diet can significantly alter the levels of inflammatory markers, even without weight loss.

Cow milk evolved to best meet the needs of baby cows, but lucky for human consumers of milk and dairy products, many of those needs cut across species’ boundaries. Take, for example, the numerous anti-inflammatory agents found in cows milk. Although slightly different in degree and type from those found in human milk, several studies demonstrate that these factors, including calcium and the amino acid leucine, influence human markers of inflammation, particularly those related to obesity and the metabolic syndrome [1-6]. And unlike baby cows, humans need not consume a milk-only diet to reap these benefits—even adding just two servings of dairy a day [1-3] can have positive effects on inflammation and, by extension, human health.

The Good Guys and the Bad Guys

When you get a paper cut, you know your immune system is working properly if the site of the cut turns red and swells. These are telltale signs of an acute inflammatory response: increased blood flow to bring in pathogen-fighting white blood cells turns the site red, and the extra fluid moving to the site of the injury makes the area swell. The cellular signals that start this inflammatory response are known as pro-inflammatory cytokines. As long as they are only put into action when needed, they are considered the good guys. These chemical signals earn their black hats, however, when they are found circulating around the body without a hall pass.

Pro-inflammatory cytokine production is most commonly associated with immune cells, but they are also secreted by adipocytes (aka fat cells). The more fat cells you have, the greater the expression of pro-inflammatory signals such as interleukin 6 (IL-6) and tumor necrosis factor alpha (TNF-α) [7]. As a result, overweight (BMI between 25 and 29.9) and obesity (BMI over 30.0) are often associated with elevated levels of inflammatory markers, referred to as low-grade chronic inflammation.

With no specific injury to respond to, these inflammatory signals circulate the body and wreak havoc on healthy cells and normal metabolic processes. Low-grade chronic inflammation is associated with an increased risk for developing metabolic syndrome—a condition characterized by cardiovascular disease, insulin resistance, and type 2 diabetes [1-6]. Currently, these diseases top the list of preventable causes of death [9]. Although the inflammatory response may be a normal part of the immune system, the chemical signals associated with it have the potential to be extremely dangerous to human health.

Food as Medicine

As paradoxical as it may sound, food may be one of the best ways to treat obesity-related inflammation. Clearly, weight loss is the ultimate goal—less adipose tissue means fewer fat cells producing inflammatory signals. But small dietary changes may be easier for clinicians and physicians to implement and easier for patients to incorporate into their daily lives than the large-scale changes required for successful weight loss. Moreover, there is strong evidence demonstrating that nutrients are able to modulate an individual’s inflammatory status even in the absence of weight loss [3, 4].

Human milk is well known for its anti-inflammatory properties. Although present in lower concentrations (due to differing needs of baby cows compared to baby humans), cow milk contains many similar anti-
inflammatory agents, which may affect human consumers. In addition, cow milk contains many nutrients that also have potent anti-inflammatory actions, including vitamin E, calcium, and the amino acid leucine [1, 3, 4]. Although you can get each of these nutrients from other foods, dairy is unique in providing them simultaneously.

The results of both prospective studies (follow subjects and see what happens to them) and intervention studies (give some subjects an intervention and others a control, test, and compare) both support an anti-inflammatory effect of dairy. The ATTICA study [9], which followed approximately 3000 adults near Athens, Greece for 10 years, found that the concentrations of IL-6 and TNF-α were 9% and 20% lower, respectively, in individuals that consumed >14 servings of dairy per week compared with those consuming <8 servings per week. These results suggest that the addition of just one serving of dairy per day has the potential to modulate an individual’s inflammatory status.

Several intervention studies [1-3] support this finding. Each measured changes in inflammatory markers after the addition of two to three servings of dairy a day versus a soya-based food that was equal in calories. Study subjects consumed both diets, with a washout period in between. Thus, researchers were able to compare the reactions of the same individuals to the same dietary interventions. In a 2010 study, Zemel et al. [3] found that the consumption of 3 dairy smoothies a day for 4 weeks in overweight and obese adult males and females was associated with a significant decrease in IL-6 and TNF-α (and several other markers of inflammation) but found no positive biomarker changes with the soy control. The effect was evident after only one week of the dairy intervention, and the changes increased in magnitude over time (i.e., they never plateaued) [3]. Importantly, the subjects in this study did not lose weight during the study period. Thus, changes in inflammatory markers could not be explained by a reduction in adipose tissue. Food could modulate immune status without concomitant weight loss [3].

A 2017 study by Pei et al. [1] came to similar conclusions as Zemel et al. [3] but did so using an amount and type of dairy similar to what an individual may normally consume. Sixty healthy, premenopausal women were randomized to consume approximately 1.5 cups of low-fat Yoplait yogurt (or roughly two servings of dairy) or soya pudding a day, with each intervention period lasting 9 weeks. Regardless of whether they did the dairy intervention first or second, low-fat yogurt was associated with a reduction in TNF-α, a biomarker of chronic inflammation [1]. Importantly, this finding was true for both obese and non-obese women, suggesting that yogurt may not just treat chronic inflammation but could also be useful in its prevention.

**Refrigerator Rx?**

Perhaps one of the more important aspects of Pei et al.’s [1] study design was the use of a commonly consumed yogurt as opposed to one that was fortified with additional probiotics. It demonstrates that important health changes can result from foods that you already have in your refrigerator and consume in quantities that are in line with current U.S. guidelines—no major dietary overhauls required. It will be interesting to see if the results of Pei et al. [1] can be replicated in individuals with type 2 diabetes or cardiovascular disease. If yogurt has similar effects in these individuals as it did in healthy—albeit obese—subjects, there is great potential for yogurt to transcend snack food status and become better known as medicine.

Human Milk’s Lutein Content Adds to the Evidence for Breastfeeding

- Lutein is a vitamin A-like compound that appears to be important in the development of the brain and eyes in fetuses and infants.
- Lutein is passed from mother to the fetus via the placenta, and from mother to infant via human milk.
- While esters of compounds such as lutein are more common in colostrum than in mature milk, lutein is present in mature milk in far greater quantities than in infant formula.

Everyone knows that fruit and vegetables are crucial components of a healthy diet, but few have heard of lutein, a substance that is structurally similar to vitamin A and found in spinach and kale. Because the human body cannot make lutein, the amount that one swallows determines how much is available to protect the skin from ultraviolet light, lower the risk of some cancers, and—if relevant—moderate the progression of atherosclerosis. There is also mounting evidence that lutein is important in fetal and infant development. Fetuses and infants receive lutein directly from their mother—via blood that passes through the placenta and by consuming human milk. The reasons lutein appears to be necessary for fetuses and infants are, in the main, the proper development of the brain and the eyes. Lutein’s mechanistic role in the expansion and maturation of the very young brain is not well understood, although it has been well established that the substance is concentrated in areas associated with learning and memory: the hippocampus, and the frontal and occipital cortices [1]. In the eye, lutein (along with its isomer, zeaxanthin) constitutes the yellow pigment at the central part of the retina known as the macula, where color vision is at its keenest. Being yellow, this part absorbs energetic blue light, and therefore protects retinal cells from harmful rays. Lutein supplementation has indeed been shown to reduce the occurrence of retinopathies in premature infants [2] and is known to lower the odds of adults developing macular degeneration [3].

Lutein’s probable role in neurodevelopment recently motivated Simonetta Picone of Policlinico Casilino, in Rome, Italy, and her colleagues to measure its levels in the arterial blood of umbilical cords [4]. The study, published in late 2017, found more lutein in the arterial cord blood of healthy infants born at 33–36 weeks than in the arterial cord blood of healthy infants born at any point after 37 weeks when lutein levels started to progressively decrease. Picone and her colleagues argue that these results are consistent with a role for lutein in brain development since its varying supply mirrors the timing of increases in brain volume and weight. Curiously, the study also identified sex differences in the levels of lutein. Among both the preterm and term infants, females received higher levels of lutein supplied through the umbilical cord.

Determining and making sense of the amount of lutein in human milk is far from a straightforward business. This is largely because the lutein in milk has a tendency to degenerate during storage. How best to measure milk lutein and just how much it degenerates when subjected to different storage techniques were the central questions of a 2017 study by Jing Tan of Abbott Nutrition Research and Development in Singapore and her colleagues based at nearby universities [5]. They found that it perished quickly as a result of human milk being frozen and then defrosted, but that chilling at 8ºC for a couple of days did not compromise milk’s lutein content.

This advice was heeded by a team in Seville, Spain, who set out to quantify the esterified xanthophyll content of colostrum—a sugary milk produced during the first three to five days after giving birth. (Xanthophylls are a group of compounds of which lutein is a prominent member.) The researchers then sought to compare colostrum’s content to that of mature milk [6] and recruited 30 women for the task, all of whom visited the neonatology unit of the city’s Virgin del Rocio University Hospital. Some of these
women gave birth early (defined as a 30 to 36-week pregnancy), and some gave birth at term (that is, had pregnancies lasting between 37 and 42 weeks). Colostrum samples were collected in the days immediately after their infants were born, and mature milk samples were collected 15 days after.

On analyzing the samples, the investigators found that about a third of the xanthophyll content of colostrum was present as esters—and that colostrum was rich in these esters, whereas mature milk was not. Why this would be appears to hang on the secretion of milk fat globules into milk. If xanthophyll esters are distributed on the surface of milk fat globules of colostrum but not of mature milk, the researchers argue that this indicates the gradual accumulation of these esters in the mammary epithelium, from which the globules’ membranes are derived. Once lactation gets going, however, the lipid constituents of milk fat globules increasingly reflect those molecules that were most recently added to the mammary epithelium. And because the addition of xanthophyll esters requires the completion of various biochemical processes, there simply isn’t the time to restock the mammary epithelium as milk is made.

Why esters of lutein might be functionally relevant in the first few days of life is unclear. Meanwhile, non-esterified lutein is certainly present in mature human milk, and far more so than it is in infant formula. Indeed, the only infant formulas that contain any lutein are thought to be those manufactured using egg yolk as a source of lipid, and their median lutein content per gram of fat has been found to be a quarter of that typically found in human milk [7]. These findings are already leading researchers towards the development of lutein supplements, with initial indications proposing casein proteins from goat’s milk as superior to those from cow’s milk at improving lutein’s solubility and hence its stability in storage [8]. But with those results just months old, the most straightforward way to ensure that an infant is getting enough lutein is for a breastfeeding mother to keep eating her greens.


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Assessing the Evidence Around Perfluoroalkyl Substances

- Chemicals called perfluoroalkyl substances have been used in manufacturing for many decades, and have been detected in the food chain and in drinking water.
- Some research has linked these chemicals to development consequences in children.
- Scientists have reported that the chemicals are passed from mother to fetus via the placenta, and that they appear at low levels in human milk.
- Research has also revealed that perfluoroalkyl substances are present in infant formula at similarly low levels.

For approximately the past decade, scientists have started to wonder about potential hazards that could be posed to human health from chemicals collectively known as perfluoroalkyl substances (PFAS). These chemicals are widespread in the environment globally—they have been used in manufacturing products such as food packaging and textile coatings since the 1950s, and are now detectable in the food chain, and even in dust and dirt. Since these chemicals can accumulate in the body, researchers are studying how they might be passed from mother to infant. This appears to happen to some extent via the placenta and to a lesser extent via human milk. Such findings should not dissuade mothers from breastfeeding, however, because the levels of PFAS in infant formula have sometimes been found to be higher than those of human milk [1].
PFAS comprise many different molecules with similar structures that make them chemically stable. This means that once absorbed into the body they last for a long time, and can therefore accumulate. Examples of the best-studied PFAS include perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS), perfluorohexane sulfonate (PFHxS) and perfluorononanoic acid (PFNA). Manufacturers in the US no longer use most of this particular list, however, newer varieties of PFAS are replacing them over time, says Erin Hines of the US Environmental Protection Agency, and the effects of these newer chemicals are less well studied.

People frequently eat PFAS. Fish and crustaceans generally have higher levels of PFAS than other foodstuffs [2]. But PFAS have been detected in pretty much everything from beef to flour [3]. One study of the PFAS content of vegetables in Europe found traces of all four of the aforementioned chemicals: PFOA was the most abundant; PFOS was detected in spinach from the Czech Republic, Belgium and Norway; PFHxS occurred at low levels in Swedish and Belgian vegetables; and PFNA was found in fruit and vegetables from The Netherlands and Norway [4].

Even drinking water can be a source of PFAS. Scientists have been monitoring the population of the Germany city of Bochum, located on the Ruhr River, ever since it was shown that the waters of the Ruhr were contaminated by PFAS, which were mixed with soil improver and spread on farmland upstream [5]. Bochum’s inhabitants have higher concentrations of the pollutants in their blood plasma than the residents of another city on the Ruhr, called Duisburg, which is located further downstream where the water supply was not so contaminated. A recent study of these blood plasma differences concludes that its finding “opens [up] the opportunity to examine the impacts” of PFAS exposure in the two cities.

How harmful are these chemicals to human health, and what is the evidence that these chemicals pass from mother to child? Hines, who has conducted studies on PFAS in her lab at the EPA, recently reviewed the published research [6]. “My coauthors and I found that elevated prenatal or early life PFAS in children’s blood, a marker of exposure, were associated with the children’s health outcomes of altered immunity, kidney function, elevated cholesterol, and age at menarche,” she explained in an email.

Science’s understanding of how children become exposed to PFAS is still very much evolving. Aside from eating and drinking low levels of PFAS that are in the food chain all over the world, there is some evidence that individuals can be exposed to PFAS in the womb. A study of Danish women and children found that women with few or no children had higher levels of PFAS in their blood than women who had given birth to several children, implying that the chemicals somehow move out of a woman’s body with each additional offspring [3]. This study could not identify the relative contribution of different means of transfer because it collected no data on breastfeeding.

But the evidence that PFAS move from a pregnant woman’s bloodstream into that of her fetus is quite strong. In Duisburg, for example, the blood plasma in the umbilical cords of now-teenagers born between 2000 and 2002 contained PFAS profiles that strongly correlated with those of their mother’s circulating blood plasma at the time of their birth. A similar study in Spain found strong correlations between cord and early-pregnancy maternal blood samples for individual types of PFAS [7]. It proposes using maternal blood to assess prenatal exposure.

The extent to which PFAS pass from mother to infant via human milk, however, seems less straightforwardly understood. Different studies show different outcomes. Hines co-authored a study published in 2009 that did not detect any amount of PFAS substances in the milk of 34 women in North Carolina [8]. Looking back on it, she wonders whether differences in the way laboratories measure these chemicals might explain conflicting results. “Each study or lab has a lowest concentration at which their chemical analysis is able to make a measurement,” she says. This is known as the limit of detection. “The same milk sample analyzed in two labs may have a non-detectable result (no PFAS present) in one lab with a higher limit of detection but may have a measured concentration in another lab that has a lower limit of detection.”

This may explain why a study in Sweden did pick up PFAS in human milk [9]. In this study, researchers looked at samples of milk that had been pooled from multiple women. The pooled samples were collected and frozen each year going back to 1972, which facilitated the search for trends in the PFAS content of human milk over time. These pooled samples revealed rising concentrations of PFOS, PFHxS, and PFOA.
from 1972 until the late 1990s. Over that period, the concentrations of these chemicals increased by about an order of magnitude, before levelling off and then decreasing from 2001 onwards. This pattern roughly fits that of PFAS use by industry.

But how dangerous are the levels found in the Swedish study thought to be? It cites other work that establishes health risk for infants who are exposed to PFAS via mothers’ milk [10]. The combined concentrations of PFOS and PFOA in human milk that might pose a risk is, by this account, 540 pg/mL, a concentration that was never reached in the pooled milk samples collected in Sweden. (The authors of the Swedish study do, however, report a single case of an individual mother's milk exceeding this value.) More recently in France, the PFAS content of 100 individual mothers’ milk was compared with the levels found in their blood serum, and also in their placental blood serum. This kind of individual-level comparison is especially helpful in assessing mother-infant transfer. The levels found in milk were far lower than in cord serum in this study, indicating that PFAS transfer occurs more readily from a mother’s blood to placental blood than it does from her blood to her milk [2].

What should new mothers make of this? When it comes to considering public health advice and individual decisions about whether to breastfeed, the finding that PFAS can appear in human milk does not mean that choosing not to breastfeed will reduce an infant’s intake of PFAS. To assess whether this is the case, human milk’s PFAS content needs to be evaluated next to that of infant formula. One study has done this. It compared formula and milk in Japan and China. In Japan the levels of the PFAS were lower in formula and in China they were lower in human milk [1]. So given all of the many health benefits that accrue from feeding infants human milk over formula, the evidence to date around PFAS does not contradict the message that breast is best.


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Fresh or Frozen: The Facts about Freezing Milk

- Freezing does not significantly alter the nutritional benefits of cow or human milk.
- Cow milk’s freezing point can be an indicator of quality for producers.
- Milk can be safely frozen for future consumption.

The first thing that comes to mind when many people think about freezing milk is ice cream. Ice cream, frozen yogurt, and custards are all sweet treats that are notable for their creamy consistency. Yet milk that has been frozen sometimes seems less appealing once it’s brought back to a liquid state. Though some might not prefer milk that has been previously frozen, the ability to freeze and store milk and dairy products can be a safe and economical way to provide beneficial nutrition that people need. Likewise, the ability to keep human milk frozen for one’s own child helps families around the world every day. A
common concern about freezing milk—whether produced by human or cow—is whether nutrients are lost in the process. So what, exactly, happens when we freeze milk?

From Farms to Freezers

Though most people simply associate “milk” with a commercially produced beverage consumed from cartons and containers, we know that the milk of different animals can vary in interesting ways. The freezing points of milks likewise can vary. Goat milk, for example, freezes at −0.509°C (31.084°F) and buffalo milk at −0.558°C (30.996°F). Cow milk freezes in a range of −0.564 to −0.516°C (30.985 to 31.071°F) with a mean value of −0.540°C (31.028°F) [1]. Variations in environment, management, and breed can all influence the freezing point of animal milk. Even the time of day and season in which the milk is collected, as well as the type of feed and the amount of water the animal consumes, can affect milk’s freezing point, which is also referred to as its melting point [2].

Though we often consider the effects of fat on milk’s consistency, it might be surprising that fat content doesn’t actually affect milk’s freezing point. Osmotic pressure, or salt balance, of a cow’s blood must balance with that of her milk. The greater the amount of salts in the blood, and therefore the milk, the higher the pH. Thus the pH—as well as lactose concentration—of milk may alter its freezing point. Potassium, chloride, sodium, citrates, urea, and other components also have an impact on the freezing point of milk, depending on their molar concentration. During pasteurization, the calcium phosphate complex and the pressure of carbon dioxide both can change, which can alter the freezing point of milk. When milk is cooled to freezing, soluble salts aggregate and transfer to casein micelles [2].

For dairy farmers and producers, the freezing point of milk can be used as an indicator of milk quality, especially adulteration with water. Typically, milk is approximately 87% water and 13% solids, including fat. When this balance is altered, usually by adding or removing water, the freezing point changes. According to the International Dairy Federation, many countries use the freezing point of milk as one of the criteria for ensuring high-quality milk, as it is considered one of the most effective ways to test the “natural” quality of milk and to detect contaminants. Any additives to milk—whether accidentally introduced to cows or deliberately added into collected milk—will alter the freezing point and thus be more easily identified [2]. Most dairy producers will conclude that milk has been watered down if the freezing point is anywhere above −0.250°C (31.55°F).

From Moms to Freezers

Breast milk is often frozen for easy storage and transport while a mother is nursing her baby, and NICUs keep the mothers’ and donors’ milk frozen for babies in hospitals around the world. Thus, there is ample research on the effects of freezing on human milk at different temperatures for various amounts of time. Interestingly, it is harder to pinpoint the freezing point or range for human milk, as the variation of components in the milk expressed by a woman can be significant, and can even differ between her own breasts. One of the most comprehensive studies was published in 1953 and looked specifically at the phenomenon of adulterating human milk “destined for milk banks” with water and/or cow milk. That paper, by R.A. Miller and R.W.B. Ellis, reported the range of freezing temperatures as −0.531 to −0.586°C (31.044 to 30.945°F), with a mean of −0.564°C (30.985°F), meaning it tends to freeze at a temperature slightly lower than cow milk does [3].

Though human milk is stable at room temperature for hours, freezing it promptly ensures its nutritional benefits. When frozen and stored for more than 90 days, however, fat, protein, and calories may decrease, and acidity may increase due to ongoing lipase activity [5]. A small but notable decline in pH and a rise in free fatty acid concentrations may also be attributed to persistent activity of lipolytic enzymes [6].

From Freezers to Families
Frozen milk—both animal and human—holds its nutritional properties well; when returned to a liquid state, its nutritional profile remains mostly unchanged. Enzymes and fat-soluble vitamins are usually unharmed, though sometimes depleted, making the decision to freeze milk a smart move for many families.

According to both the American Academy of Pediatrics and the Human Milk Banking Association of North America, storing human milk at −20°C (−4°F) is ideal and using it within 3–12 months is optimal [4]. A. English and L. Simon, in collaboration with the Academy of Breastfeeding Medicine, note that “frozen human milk should be stored in the back of the freezer to prevent intermittent re-warming due to freezer door opening, and should be kept away from the walls of self-defrosting freezers” [5].

Upon defrosting, the odor of once-frozen human milk may be different from fresh milk due to lipase-mediated triglyceride breakdown, which releases fatty acids that may become oxidized. This lipolysis process has antimicrobial effects preventing the growth of microorganisms in thawed refrigerated milk. According to researchers at the Academy of Breastfeeding Medicine, there is no evidence that infants reject defrosted breast milk due to changes in odor [5].

That said, searching the Internet for information about freezing human or cow milk for future consumption reveals many seemingly conflicting opinions on whether physical changes like odor and texture indicate spoilage. This might result in consumer uncertainty and the loss of a beneficial source of nutrition.

One common issue that arises when cow milk is frozen is its tendency to change consistency or texture. In particular, when frozen milk is brought back to liquid form, fat can separate, resulting in a graininess that some find worrisome or even off-putting. “Milk is a very complex liquid,” notes Bristol University physicist P. Barham [7]. “It consists of many small droplets of fat, each surrounded by a membrane that helps to keep them suspended in a solution of proteins and sugars in water. The delicate balance that keeps the fat droplets suspended can be upset in many ways.” Freezing milk creates ice crystals that can puncture the membranes around fat molecules. If, when defrosting milk, the temperature becomes high enough to melt the fat, “it can escape through the punctured membrane, making small ‘puddles’ of oil.” This can result in the grainy, separated consistency that some consumers don’t like. Shaking or blending defrosted milk can easily remedy this issue.

Most research advises that frozen cow milk is safe to store for 1–3 months. To reduce the likelihood of consistency issues, milk should be frozen quickly and in small batches. Containers of approximately one cup of liquid, with ample room for expansion, should be placed near the wall or back of a freezer. Many consumers prefer to freeze whole containers of one quart or more, and this is safe as well. Defrosting milk in a refrigerator for 1–2 days is ideal.

For many consumers, access to refrigerated milk in a store on a daily or even weekly basis is difficult. Likewise, for parents who want to feed breast milk to their infants, the option to provide freshly expressed human milk is not always available. Thus, the option to freeze milk for future use provides a safe and healthy solution for families around the world.


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SPLASH® milk science update

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