

**UPDATED REBUTTAL 2011 FDA ARTICLE**  
**“Raw Milk Misconceptions and the Danger of Consuming Raw Milk”**  
**Raw milk is SAFE, nutrient-rich, and should be available to consumers**  
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In 2011, the FDA released a position statement describing “misconceptions” about the nutritive value of raw milk and arguing that pasteurization is necessary for safety.

The position paper is part of FDA’s continuing campaign to discourage the consumption of raw milk, which includes legal actions taken against those who wish to produce and provide healthy and safe raw milk and raw milk dairy products for consumers<sup>1</sup>.

The main points claimed by the FDA are:

1. pasteurization does not diminish milk’s nutritive value and;
2. pasteurization ensures the safety of milk and prevents foodborne illness.

We will show, first of all, that raw milk is in fact a nutrient-rich, complete food with many scientifically established health benefits and that commonly used heat treatments do in fact lower the nutrient content of the milk.

Secondly, the claim that raw milk poses a higher health risk and has caused more disease than pasteurized milk is false. In fact, the FDA has exhibited blatant bias against raw milk; as the FDA has not discouraged people from consuming eggs, meat and vegetables, all of which have caused more foodborne illness than raw milk. The FDA even falsely claims that HACCP-approved production methods will not make raw milk safe. We will show that there is no scientific basis for specifically targeting raw milk.

We have revisited each point outlined by the FDA and provided a detailed response to each. For additional information about raw milk, previous statements and analyses, here are additional sources:

<https://www.realmilk.com/key-documents/>  
<https://www.realmilk.com/safety/raw-milk-safety-summary/>

**Point 1: “Raw milk does not cure lactose intolerance”**

In 2007, the Weston A. Price Foundation conducted a survey of milk consumers in the state of Michigan<sup>2</sup>. The survey found that 81 percent of those diagnosed by a physician with lactose intolerance could drink raw milk without any adverse symptoms. We cannot claim that raw milk “cures” lactose intolerance, but from the survey it is clear that most people who have trouble tolerating pasteurized milk can consume raw milk without problem.

**Point 2: “Raw milk does not cure or treat asthma and allergy”**

Many current studies show a negative correlation between raw milk consumption and allergic reactions; in fact, enough recent data exists to craft hypotheses as to how raw milk produces the effects seen in these studies.

In the early 2000s, several studies found an association between a farming lifestyle,

specifically the consumption of farm milk, with a reduction in the development and severity of childhood allergies.<sup>3,4</sup> The PARSIFAL study<sup>3</sup> involving 14,893 children utilized a detailed survey, which controlled for several variables such as dietary restrictions other than milk, socio-demographic background, and the presence of atopic disease in parents. Prevalence of asthma, rhinoconjunctivitis and reactions to multiple allergens (measured by skin prick tests and serum IgE levels) showed an inverse correlation with the consumption of farm milk, independent of other dietary or farming exposure-related variables.

This study demonstrated far more statistical power than the trial cited by the FDA in the 2011 article,<sup>5</sup> which included only five children with previously recorded milk allergies. The 1988 study cited by the FDA by Host and Samuelsson claimed no statistically significant correlation between the consumption of raw milk and reduction allergies.<sup>5</sup> However, the Host and Samuelsson study was too small to generate an appropriate statistical power for this conclusion. Furthermore, the statistically insignificant difference reported in the study did indicate that pasteurized milk could induce an allergic reaction in patients already allergic to milk.

An additional study published in *The Lancet* in 2001 showed an inverse correlation between consumption of farm milk, which is usually raw, with asthma, hay fever and atopic sensitization across 2,618 children.<sup>6</sup>

As noted by the FDA, the PARSIFAL study and others served as the foundation for further studies on the components of “farm” milk, and eventually raw milk specifically, which contribute to the reduction and prevention of allergies. The 2011 GABRIELA study involved 8,334 children, 7606 of which provided additional serum samples for IgE measurements.<sup>7</sup> Improving on the PARSIFAL study, the GABRIELA study analyzed the specific status of the farm milk with regards to heat treatment and pasteurization and found an inverse correlation between *raw* milk and incidence of asthma, atopy and hay fever, independent of other farm exposures. Boiling the milk removed the protective effect of farm milk.

The GABRIELA study also began to investigate the specific components of raw milk that might contribute to this protective effect. After analyzing 800 cow’s milk samples collected from the homes of study participants, it was demonstrated that increased levels of bovine serum albumin (BSA),  $\alpha$ -lactalbumin, and  $\beta$ -lactoglobulin in the consumed milk samples were inversely correlated with asthma.<sup>7</sup> As noted, BSA and  $\beta$ -lactoglobulin are both heat sensitive.

Four other studies--from Crete, Germany, New Zealand, and England--published in the early 2000s, all show a negative correlation between the consumption of raw milk (not simply “farm” milk) and various allergies and asthma, tested by skin prick and blood IgE evaluations.<sup>8-11</sup> Additionally, the PASTURE study<sup>12</sup> included 900 European children and demonstrated an inverse correlation between the consumption of unpasteurized milk before the age of six and the development of asthma. In more recent years, extended analyses of 35 asthmatic and 49 non-asthmatic children from the PASTURE study showed that the higher fat content, in particular omega-3 polyunsaturated fatty acids (PUFAs), was associated with the protective effect of unpasteurized, raw farm milk.<sup>13</sup> (Omega-3 fatty acids are fragile and likely to be adversely affected by heat treatment.)

Multiple studies provide more biological insight into the exact components of raw milk that contribute to the protective effects against allergy and asthma. In the same journal issue as

the PARSIFAL study, an editorial by M R Perkin, further speculated on the biological components of raw milk that have a scientific potential to contribute to the protective effects of raw milk against allergies. Raw milk has a greater diversity of bacteria, which would contain a greater diversity of antigens, thus influencing the maturation of the immune system, either directly or indirectly via influencing the gut flora. The GABRIEA study correlated the protective effects of raw milk with whey proteins, which are denatured by pasteurization.

In a 2019 comprehensive review published in the journal *Nutrients*, the authors outline the potential effects of the immunomodulatory whey proteins lactoferrin, transforming growth factor  $\beta$  (TGF- $\beta$ ) and interleukin 10 (IL-10), present in raw milk and disrupted by pasteurization.<sup>14</sup> TGF- $\beta$  is a cytokine that plays many different roles in the immune system, but very importantly has a key role in the development of the mucosal immune system, likely aiding in the development of protection against asthma and allergy via consumption through raw milk. Additionally, human and bovine TGF- $\beta$  proteins are identical, and TGF- $\beta$  concentrations in cow's milk significantly decline after pasteurization.<sup>15</sup> The consumption of bioactive cytokines such as TGF- $\beta$  and IL-10 through raw milk may also modulate IgA and IgG secretion in the gut, which may support protection from allergic reactions.<sup>14</sup> Lactoferrin is an iron-binding glycoprotein that, in addition to sequestering iron from potentially bad bacteria and interfering with their cell walls acting as an antimicrobial, also prevents the secretion of pro-inflammatory cytokines involved in allergic reactions, such as tumor necrosis factor (TNF)- $\alpha$  and IL-1 $\beta$ .<sup>16</sup>

We still have much to learn regarding the mechanisms and functions of the abundant immunomodulatory components of raw milk that become disrupted upon pasteurization; meanwhile there is enough case-study evidence to demonstrate the protective effects of raw milk against allergies and asthma, despite the animal studies cited by the FDA showing that there were no differences in the ability to sensitize to anaphylactic shock in either guinea pigs or a mouse model.<sup>17, 18</sup> It should be noted that those animal studies examined acute, short-term anaphylaxis, not chronic allergies and asthma. Additionally, the researchers in the guinea pig study first fed the subjects various types of treated or untreated milk and then injected milk intravenously to test for anaphylaxis. Milk is consumed through the GI tract, and not normally injected, so this study does not represent an accurate screen for how milk affects protection against asthma or other general atopy.

As there is no more risk of foodborne illness associated with the consumption of raw milk than from any other farm products (examined in detail in a later section of this report), parents deserve the right to provide their children with protection against allergy and asthma while we continue to learn more valuable information about the specific mechanisms of protection.

### **Point 3: “Raw milk is not more effective in preventing osteoporosis than pasteurized milk”**

The FDA's claim here lies first in their statement that the *bioavailability* of calcium is not significantly affected by pasteurization, as calcium levels in milk are not affected by pasteurization. A study in 1928 published in the *Journal of Biological Chemistry* demonstrated that adults who drank raw milk (designated in the study as “fresh” milk) had better “calcium balance” in their bones compared to those who drank pasteurized milk.<sup>19</sup> Studies from Randleigh Farms in 1940s showed that rats fed raw milk had longer and

denser bones than rats fed pasteurized milk.<sup>20</sup> A 1941 study from Oregon State College showed that guinea pigs fed pasteurized milk exhibited atrophied muscles streaked with calcification and tricalcium deposits under skin, in joints, the heart and other organs, while subjects fed raw milk had no abnormalities or irregular calcium deposits.<sup>21</sup> This study indicates that the calcium in pasteurized milk is not utilized properly, but deposited in the soft tissues rather than the bones.

There are other factors that contribute to calcium bioavailability in milk. It is well known that vitamin D is crucial to the proper use of calcium and phosphorus for proper bone health; vitamin D assimilation is reduced by half after pasteurization, due to the fact that it is bound to heat-sensitive lactoglobulins.<sup>22, 23</sup> Proteins in the whey fraction in milk are heat-sensitive, and the vitamin D receptor and vitamin D binding proteins lie in this fraction.<sup>23</sup> Additionally, the vitamin D binding protein is rich in cysteine amino acid residues, which contain sulfur atoms responsible for forming disulfide bonds that hold the proper structure of the protein, giving even more reason to believe that the availability of vitamin D from milk may be diminished upon pasteurization.

The FDA cites a 1973 study by Rolls and Porter claiming that there is no change in calcium availability or calcium levels upon pasteurization.<sup>24</sup> However, this study demonstrated that the whey proteins (including calcium and vitamin D binding proteins) were denatured by 10 percent during standard pasteurization and 70 percent by ultra-high temperature pasteurization (UHT).<sup>24</sup> UHT is more widely used than HTST pasteurization in the dairy industry today. Rolls and Porter also cite a 1967 study by Roy, which demonstrated that calves given pasteurized milk did not grow as well as those given raw milk.<sup>24, 25</sup> Rolls and Porter also claim UHT pasteurized milk was used “successfully” to feed human infants.<sup>24, 26</sup> Rolls and Porter fail to specify exactly what “successful” means in the context of this cited study, especially with regards to bone health. It is therefore not scientifically sound to conclude that calcium and vitamin D bioavailability is unchanged upon pasteurization.

In the FDA-cited study by Williamson and others,<sup>27</sup> the authors found no difference in calcium absorption in preterm infants between raw and pasteurized milk; but intestinal absorption alone cannot be used to make any claims about subsequent bone health, as the calcium needs to be properly incorporated and deposited in the correct tissues and associated with the proper enzymes to contribute to bone health. Ironically, the Williamson study also showed that the infants gained weight more rapidly on raw milk than on any heat-treated milk and also had increased fat absorption.

The other study for this point cited by the FDA looked only at the mineral content itself in raw and pasteurized milk, failing to consider the other protein components needed for proper bioavailability.<sup>28</sup>

The multi-faceted and superior nutritional value of raw milk is explored further in a later section of this report.

While there may be a lack of study specifically on osteoporosis in humans, there is certainly enough evidence to hypothesize the benefits of raw milk for bone health in both children and adults prone to osteoporosis. Until further study is performed, people deserve the right to choose raw milk for these scientifically potential benefits.

#### **Point 4: “There are no beneficial bacteria in raw milk for gastrointestinal health”**

The FDA first states that probiotic microorganisms must be non-pathogenic, which is true. However, the “pathogenic” organisms cited to occur in raw milk are also causative agents of foodborne illness attributed to pasteurized milk, among other food products, indicating that pasteurization does not provide protection against illness. Examples of these organisms include *E. coli O157:H7*, *Salmonella*, *Yersinia enterocolitica*, *Campylobacter jejuni*, and *Listeria monocytogenes*.

The FDA claim that the probiotic effects of certain microorganisms cannot be transferred from cow’s milk to humans is also incorrect. The World Health Organization even states, in regards to probiotics, it is the specificity of the action, not the source of the microorganism that is important.”<sup>29</sup>

The FDA also claims that the beneficial bifidobacteria found in raw milk are indicative of fecal contamination.<sup>30</sup> However, bifidobacteria are not exclusive to feces, as they are also naturally found in the milk itself, which is considered the source of bifidobacteria in the guts of breastfed infants.<sup>31-34</sup> In other words, studies associating fecal contamination with bifidobacteria are merely circumstantial. Studies of raw milk collected through aseptic techniques from humans has demonstrated the presence of the probiotic organisms lactobacilli and bifidobacterial.<sup>30</sup> There is also recent evidence that the immune system actively transports beneficial bacteria, such as bifidobacteria, from the gut into the mammary gland to be secreted into the milk, in contrast to claims that raw milk is naturally sterile. Bifidus factor is also present in raw milk, a compound that promotes the growth of *Lactobacillus bifidus*, a particularly helpful bacteria in the infant gut as it helps crowd out potentially pathogenic bacteria<sup>35</sup>.

The FDA states, “high bacteria counts in raw milk only indicate poor animal health and poor farm hygiene,” a statement that is only partially true. FDA fails to clarify the fact that bacteria count alone does not account for safety because it does not consider the bacterial species present. Furthermore, if the animal producing the milk is healthy and free of pathogenic infection, then any contamination with pathogenic bacterial species at potentially harmful concentrations is due to contamination during handling and contact with equipment, and therefore has nothing to do with whether the milk is pasteurized or not. Beneficial bacteria come from the gut of the lactating animal, and most pathogenic bacteria linked to foodborne illness come from outside contaminations that pose risks to both raw and pasteurized milk, among other food products.

#### **Point 5: Raw milk is not an immune system-building food and is particularly unsafe for children.**

The first point in this claim, that raw milk is not an immune system-building food is incorrect. The known components of raw milk such as cytokines, and multiple proteins in the whey fraction, have many established immunomodulatory functions.<sup>14, 15</sup> These components can also modify local mucosal immune responses and enforce epithelial barriers in airways and the gut, thus increasing immunity to respiratory infections and decreasing allergies.<sup>15</sup> Additionally, toll-like receptor signaling stimulated by microbiota results in improved respiratory tract immunity.<sup>15</sup> There are multiple immunoglobulins that are functionally transferred from the blood to the mammary gland,<sup>36</sup> and bovine IgG can bind to bacterial and viral pathogens,<sup>15</sup> so we may predict its functionality in humans after

consumption. Additionally, vitamins A and D3 present in raw milk have a known function in the tissue-homing abilities of lymphocytes; these vitamins less bioavailable after pasteurization. Consumption of these vitamins from raw milk may be hypothesized to increase the functionality of lymphocytes against infection. A 1987 study by A Kulczycki, published in *Molecular Immunity*, found that IgG proteins available in raw milk can bind to human Fcγ receptors, indicating their functionality in the human immune system.<sup>37</sup> The FDA cites the Kulczycki paper as proof that heat treatment can actually increase bovine IgG function (that is, increase binding to human Fcγ receptors); however this was performed testing temperatures of 63°C on isolated IgG, which does not accurately depict pasteurization conditions.

In regards to the safety concerns for children, the FDA ignores the numerous foodborne illness outbreaks associated with pasteurized milk (cited in a later section) and those associated with other food products. There is nothing specific about raw milk that makes it more dangerous than other types of dairy, meat, fruit and vegetable products, especially in regards to children.<sup>38</sup> Additionally, some of the outbreaks cited by the FDA do not actually demonstrate that the danger is higher for children than adults. The statement that raw milk is particularly risky for children is less scientific claim than rhetoric designed to instill unnecessary fear.

#### **Point 6: There are no immunoglobulins in raw milk that enhance the human immune system**

As stated in the previous section, immunoglobulins are indeed present in raw cow's milk, and the IgGs isolated from colostrum do have a preventative effect on respiratory infections. If breastfed infants can obtain these IgGs from breast milk, then raw milk-fed infants can obtain these IgGs from cow or goat milk. Raw milk can provide these immune-boosting benefits for toddlers and older children as well.

The FDA claims that during conditions that simulate pasteurization, bovine IgG can aggregate and then bind to human Fcγ receptors.<sup>37</sup> While studies demonstrate that heat treatment of bovine IgG increases the binding affinity to human Fcγ receptors, the heat treatment was 63 °C for 30 minutes, while common pasteurization techniques use higher temperatures (at least 72°C) and different treatment times.<sup>37</sup> This study does not show the effects of IgG binding affinities under actual pasteurization conditions. Furthermore, as noted earlier, these heat-aggregated antibodies could contribute to allergies or have other unknown adverse effects on immunological functions, which cannot be determined in isolated *in vitro* binding tests.<sup>39</sup>

The FDA cited a 1997 study published in the *Journal of Food Science* that showed only minor changes to IgG under HTST pasteurization techniques, but did show more significant reductions at higher temperatures starting at 77 °C. This calls into question the effects of the commonly used UHT pasteurization techniques and their influence on IgG levels and functionality.<sup>40</sup>

The FDA also claims that IgG concentrations in milk are so low as to be negligible. While the IgG concentrations of mature milk are about 0.6 mg/ml, the concentrations in colostrum can reach up to 200 mg/ml. High IgG levels in bovine colostrum are necessary since the calf is unable to transfer IgG across the placenta and therefore depends on the high levels of IgG in colostrum transferred from their gut after consumption. Humans, however, are able to

transfer IgG across the placenta in significant amounts and therefore do not require those high concentrations in milk. While denaturation of IgG may be lower at standard HTST pasteurization, denaturation still occurs, and becomes greater with the higher temperatures used in UHT pasteurization. Thus the statement that the function of immunoglobulins from milk is not important or affected by pasteurization is incorrect.

**Point 7: There are no additional proteases and lipases in raw milk that facilitate digestion**

With regards to proteases, the FDA claims that enzymes from the human gastrointestinal tract destroy any milk-derived proteases, but this is not a scientifically based reason to avoid raw milk. In fact, recent evidence shows that protease-mediated release of functional peptides, or “pre-digestion,” happens within the mammary gland, indicating that enzymes in raw human milk are active before they even enter the gastrointestinal tract.<sup>41</sup>

Additionally, the human milk enzymes plasmin and cathepsin D are still active at a gastric pH found in the stomach.<sup>42</sup> The FDA also notes that proteases from somatic cells become more abundant in milk from cows with mastitis.<sup>43</sup> However, it is unsafe to consume any type of milk, raw or pasteurized, from a mastitic animal, so this point is irrelevant to any argument against the consumption of raw milk.

Milk-derived lipase is important for the utilization of milk fats, as demonstrated by a study showing that infants fed pasteurized breast milk had lower weight gain and developmental growth compared to those who consumed raw milk.<sup>44</sup> With regards to the major lipases in bovine as well as human milk, such as lipoprotein lipase (LPL), the FDA’s claim that there is no role for LPL in digestion is incorrect. LPL is involved in the major steps of triacylglyceride-rich lipoprotein (TRL) hydrolysis, which is crucial for production of fatty acids for energy use or storage.<sup>45</sup> LPL catalyzes the rate-limiting step for TRL catabolism<sup>45</sup> and moreover, triacylglycerides make up to 98 percent of the lipids milk.<sup>46</sup> A review of recent findings of the role of LPL in lipid metabolism revealed that low levels of LPL are associated with metabolic disorders and that LPL is responsible (along with other factors) in clearing TRLs from the vascular endothelial wall, where TRLs initially dock before their metabolism.<sup>45</sup> While the transport of lipids from the intestine to the bloodstream is facilitated by chylomicrons, LPL is a vital part of the process that breaks down those lipids for further use.

The FDA cites a chapter from *Advanced Dairy Chemistry* (2003) which states that LPL has no demonstrated role for milk utilization in offspring, but the authors of that same chapter state that “it is hard to reconcile the data on synthesis and secretion of LPL with the view that its appearance in milk is a mistake, and that the enzyme has no useful purpose in milk.” The authors suggest that it may bind to fat globules in the intestinal lining as it does in the vascular lining and facilitates their digestion, transfers cholesterol and fat-soluble vitamins into the intestinal cells, pre-digests milk fat globules and makes them more accessible for the lipases in the pancreas. This *Advanced Dairy Chemistry* chapter also highlights the fact that LPL is known to generate fatty acids with powerful anti-parasitic activity in humans and therefore may act the same way in cow’s milk.

The known functions of LPL in the vascular lining and its predicted functions in the intestine are all crucial to lipid digestion, and because cow LPL has 92 percent identity with human LPL we can predict a similar function in humans.<sup>47</sup> Furthermore, a 1993 study in the *Journal of Biological Chemistry* demonstrated that bovine LPL was capable of inducing

catabolism of human TRLs,<sup>48</sup> indicating that bovine LPL is functional in humans. Removing almost 97 percent of LPL from milk via pasteurization<sup>49</sup> is not “desirable” as the FDA claims, and their statements that LPL activity in milk will create lipolysis, a rancid off-flavor, and decreased shelf life, is not true. According to the same text and chapter from *Advanced Dairy Chemistry*, only homogenization of raw milk containing LPL will increase LPL activity and undesirable lipid breakdown prior to consumption. When milk is collected and then transported to the dairy on the same day, induced lipolysis by LPL in raw milk is not an issue and therefore is no scientific reason to prevent or prohibit raw milk consumption.

## **Point 8: Raw milk is not nutritionally superior to pasteurized milk**

### *Milk proteins*

The strongest study cited by the FDA on this point is the 2008 paper by Lacoix stating that nitrogen utilization from milk proteins is unchanged with pasteurization. However, this study only showed this result with HTST pasteurization; higher temperatures reduced protein metabolic usage from the milk.<sup>50</sup> Secondly, this study looked at nitrogen utilization as a way of measuring protein availability. While from a metabolic viewpoint, this study may have shown that HTST pasteurization does not affect the digestibility of milk proteins, the functions of native proteins such as enzymes *are* affected. For example, as discussed earlier, LPL is almost completely damaged in pasteurization and immunoglobulins aggregate and create altered binding affinities for their targets.<sup>37,49</sup> The availability of vitamins and minerals related to enzymes is further discussed upon below.

One benefit of the native whey protein fraction is its ability to increase glutathione content in the body. Glutathione is a powerful antioxidant, with many potential therapeutic uses in shown in clinical trials for multiple diseases and conditions.<sup>51</sup> A 1991 study in mice demonstrated that mice fed *undenatured* whey protein had increased glutathione levels in tissues and elevated humoral immune response.<sup>52</sup> The two major whey proteins that best produce glutathione in the body are  $\beta$ -lactoglobulin and serum albumin, both of which are particularly heat sensitive. These proteins contain glutamyl-cysteine bonds, which constitute a large part of glutathione itself.

How do conventional pasteurization practices affect these proteins in milk? With regards to  $\beta$ -lactoglobulin, one study showed that HTST pasteurization reduced  $\beta$ -lactoglobulin levels in the whey protein fraction by 22 percent.<sup>53</sup> A previous study had demonstrated that HTST pasteurization destroyed 30 percent of total whey protein,<sup>54</sup> meaning that HTST-pasteurized milk has up to 45 percent less  $\beta$ -lactoglobulin and therefore a significantly diminished glutathione-producing potential.<sup>55</sup> With regards to serum albumin, heating milk at only 65 °C for 15 seconds destroyed 40 percent of this protein while 85 °C for 30 seconds destroyed 77 percent.<sup>56</sup> The study authors even note that “denaturation of individual whey proteins. . . have been adopted as thermal indicators of processed milk.” The middle section of the quote denoted by the ellipses lists both immunoglobulins and bovine serum albumin as these “indicator proteins,” subject to denaturation during heat treatments.<sup>56</sup> While the level of heat sensitivity varies between different proteins and the individual’s dietary needs, pasteurization results in an absolute nutritive loss in the whey protein fraction, starting at HTST conditions.

### *Milk Vitamins*



The FDA states that pasteurization has little effect on both water and fat-soluble vitamins. However, a 2011 study by MacDonald and others demonstrated that Vitamins B2, B2, C, B12, E and folate (more on folate-binding protein in a later section) were decreased.<sup>57</sup> The studies reviewed in this analysis were inconsistent on vitamin A.

Apologists for pasteurization may acknowledge that heat treatment reduces the levels of water-soluble vitamins in milk, but argue that this is not an issue because the concentrations of these vitamins are already low to begin with and not nutritionally significant. However, for many populations of young children and adults who, for various reasons, depend on milk for these vitamins, this conclusion is false.

In regards to the particularly heat-sensitive vitamin C, despite “low” concentrations in milk, it is widely known that consumption of raw milk by infants and calves prevents vitamin C deficiency. According to a 2011 review in the journal *Pediatrics*, “without doubt, the explosive increase of infantile scurvy during the latter part of 19th century coincided with the advent of usage of heated milks and proprietary foods.”<sup>58</sup>

With regards to vitamin B6 in milk, heating causes varying levels of degradation depending on whether UHT or HTST conditions are used.<sup>24, 59, 60</sup> However, in addition to degradation, heat-treatment causes the formation of a compound called phosphorylpyridoxyllysine.<sup>59</sup> This binding of B6 combining with the amino acid lysine acts against normal vitamin B6 metabolism.

In general, assessing a nutrient’s value based simply on its concentration in a food product is not a practice that is scientifically sound, as it does not take into account efficiency of absorption, presence of co-factors and binding proteins, structural effects of heat treatment on vitamin behavior, synergistic effects of nutrients with each other, and frequency of consumption.

The enzymes present in raw milk are known to facilitate efficient absorption and utilization, so the levels of vitamins in raw milk need not be high. As we have seen, it is not only vitamin levels that are important, but levels of enzymes and binding proteins that make them biologically available. For example, vitamin B12 binding protein is inactivated during pasteurization.<sup>61</sup> Additionally,  $\beta$ -lactoglobulin, a heat-sensitive protein present in milk vulnerable to damage during pasteurization, is known to facilitate vitamin A absorption in the intestine. Vitamin A itself is also heat-sensitive.<sup>61, 62</sup>

The FDA states that many other factors, such as storage conditions, oxidation and light exposure can also affect vitamin stability in milk. Alterations in stability and shelf life hold true for both raw and pasteurized milk. Since raw milk does not pose any more safety problems than pasteurized milk or other animal products and produce (more on this in later sections), and since many nutritional factors are in fact damaged by heat treatment, the status of vitamin content does not constitute a scientific reason to discourage raw milk consumption.

### *Milk Minerals*

As with vitamins, it is not only the levels of minerals in milk that must be considered, but also their binding proteins. In the case of iron, the binding protein and transporter lactoferrin is abundant in raw bovine milk and is important for the cellular usage of iron.

Studies cited by the FDA have shown minor decreases (but still decreases) in lactoferrin function upon standard HTST pasteurization.<sup>63,64</sup> Unfortunately, lactoferrin function after UHT pasteurization has not been analyzed. However, in a 1991 paper published in *Dairy Science*, the authors state that “it has been widely accepted that [lactoferrin] is easily denatured by heat treatment” and cite several studies demonstrating “virtually complete destruction” of lactoferrin in milk upon pasteurization.<sup>65</sup>

With regards to the effects on calcium (linked to vitamin D function as well) see the response to claim three above. Additionally, the FDA cites a paper by Zurera-Cosano and others which stated that pasteurization had no effect on milk mineral content or bioavailability; however this study demonstrated a 15 percent loss of manganese, a 25 percent loss of copper, and a 35 percent loss of iron.<sup>28</sup>

### *Milk Fat*

FDA claims that homogenized milk is more digestible than raw milk. When looking at the available data and biological information, the question of whether or not homogenized milk is more digestible is complex. Even the authors of the review cited by the FDA state that while homogenized milk is more digestible for those adults with intestinal disease, raw (unhomogenized) milk is more digestible for pre-term infants.<sup>66</sup>

The mechanisms by which milk fat globules are digested in humans remain to be fully elucidated. However, a recent study using a simulated *in vitro* digestion model showed that pasteurized, homogenized milk had lower potential digestive availability for fats than raw milk.<sup>67</sup> Since these findings illustrate a difference in the behavior of milk fats after homogenization, it is therefore premature to conclude that homogenization does not effect milk fat digestion and energetic availability in humans.

### **Claim 9: Raw milk does not contain natural antimicrobial components that make it safe**

With regards to the general antimicrobial potential of raw milk, multiple challenge tests have demonstrated that raw milk has anti-microbial action against known pathogens. Multiple studies have shown that *C. Jejuni* and *E. coli O157:H7* inoculated into milk survive significantly longer and are more viable in pasteurized or sterilized milk than in raw milk.<sup>68</sup> These studies demonstrate that the general antimicrobial effect of raw milk is diminished upon heat treatment.

It is then important to examine the particular antimicrobial components of raw milk and the effects of heat treatment on their functionality. The known antimicrobial components of raw milk are lactoferrin, xanthine oxidase, lysozyme, and lactoperoxidase. The two major claims the FDA makes are:

1. These components are not in high enough concentration to be effective;
2. Heat treatment does not affect antimicrobial function.

Each of these components and claims is now examined individually.

### *Lactoferrin*

The FDA first claims that at only about 0.1 g/L of milk, the concentration of lactoferrin in milk is not high enough to exert antimicrobial effects.<sup>69</sup> While the concentrations are indeed low, lactoferrin synergizes with lysozyme, and some of it is broken down during digestion into fragments with one hundred times the antimicrobial potency as the undigested protein.<sup>35</sup> Additionally, while HTST conditions do not seem to have a major effect on the function of lactoferrin, commonly used UHT conditions abolish the ability of lactoferrin to bind bacteria.<sup>70</sup>

It was also demonstrated that the antimicrobial activity of human-derived lactoferrin is more heat-sensitive than bovine lactoferrin, and for many other additional reasons, it is unwise to pasteurize human breast milk as well (although this is a common practice).<sup>63</sup>

In general many of the studies involving lactoferrin response to heat treatments have been carried out on isolated lactoferrin, and there is some variability in methodology with regards to whether or not lactoferrin is already bound to iron or not. Overall it is most physiologically relevant to study the effects of heat treatments on the bactericidal properties of the whole milk itself. Other well-established immune-modulatory functions<sup>14, 71</sup>, in addition to isolated bactericidal properties, have also not been considered in these studies. Thus, it is premature to conclude that the effects of heat treatment on milk-derived lactoferrin function are insignificant.

#### *Lactoperoxidase and Lysozyme*

Lactoperoxidase is an enzyme that works in a system along with thiocyanate and hydrogen peroxide to create a reaction product with antimicrobial activity. The FDA states that in order for lactoperoxidase to be active, thiocyanate and hydrogen peroxide need to be added to the milk. However, the Food and Agriculture Association (a specialized agency of the United Nations) states that thiocyanate and hydrogen peroxide “are naturally present in milk in varying concentrations, depending on the feed given and on the species/breed of animal.”<sup>72</sup> While the antimicrobial response is weak in fresh drawn milk, it lasts up to two hours, enough time post-collection to then properly cool and store milk at temperatures inhibitory to any microbial growth.

Additionally, a study of isolated *C. jejuni* from raw cow’s milk found that inactivation of the lactoperoxidase system immediately resulted in better isolation of the pathogen.<sup>73</sup> The organism was found in only 4.5 percent of the 904 milk samples analyzed.

The premise that the contribution of the lactoperoxidase system to antimicrobial activity of raw milk is always negligible is incorrect, although this action can vary from animal to animal based on factors that do not involve infection. Additionally, studies indicate that adding small amounts of thiocyanate, hydrogen peroxide and lactose oxidase, a novel activator of lactoperoxidase, to fresh milk can help extend its shelf life.<sup>74, 75</sup> While lactoperoxidase activity still exists after HTST pasteurization, temperatures above 80 °C (well below UHT conditions commonly used) almost completely destroy lactoperoxidase activity.<sup>76</sup>

Enzymes such as lysozyme and lactoperoxidase do not exist in a vacuum. Nothing in a native physiological system ever exists in a vacuum, and knowing that there are multiple factors contributing to the antimicrobial efficacy of raw milk calls into question the validity of studies on isolated enzymes. For example, lysozyme does synergize with lactoferrin;<sup>35</sup>

thus the concentrations of a single enzyme should not be the only factor in determining whether it is having an antimicrobial effect in raw milk.

### *Xanthine Oxidase*

The FDA first states that the particular mechanisms of xanthine oxidase's antimicrobial activity are not well characterized and that there is a lack of experimental evidence showing that endogenous xanthine oxidase in raw milk acts against pathogens. However, a 2004 review by Martin et al described experiments with raw (referred to as "fresh") bovine milk, demonstrating that when mixed with a nitrite-containing substrate, raw milk had bacteriostatic effects on *E. coli*.<sup>77, 78</sup> It was previously demonstrated that nitrites are a substrate for the Xanthine Oxidase enzyme.<sup>79</sup> The 2004 review by Martin et al also cites other sources as to other potential endogenous sources of nitrites, which are also present in bovine milk.<sup>78</sup>

Other studies showed that xanthine oxidase had antibacterial activity towards *S. aureus* and *S. enteritidis*, in addition to *E. coli*.<sup>78</sup> While high levels of nitrites are considered dangerous to gut health, xanthine oxidase activity requires low levels for activation and could be considered additionally beneficial due to lowering nitrite levels in the gut microenvironment.<sup>78</sup> Xanthine oxidase may also work in tandem with the lactoperoxidase system by providing hydrogen peroxide. While xanthine oxidase may be heat stable at HTST pasteurization conditions, UHT and sterilization conditions completely inactivate the enzyme, as does homogenization, due to disruption of the fat globules that xanthine oxidase is associated with.<sup>80</sup>

### **Claim 10: Raw milk does not contain nisin for pathogen inhibition**

This statement is not consistent with available molecular evidence. A genetic study of lactic acid bacteria cultures from raw milk with antagonistic activity against one of the most pathogenic gram-positive bacteria, *L. monocytogenes*, identified nisin genes by polymerase chain reactions in these lactic acid bacteria.<sup>81</sup> Thus nisin-producing bacteria do exist in raw milk. While it is true that nisin peptides are not effective against gram-negative bacteria, there are other systems in raw milk that can target gram-negative bacteria like *E. coli* (see previous section). Another study showed that homogenization impairs nisin's bactericidal activity.<sup>82</sup>

### **Claim 11: Folate-binding protein (FBP) is not denatured during pasteurization and folate utilization is not reduced in pasteurized milk.**

With regards to vitamins like folate (and others, see Claim 8) it is not only the concentrations of the vitamins themselves that are important, but their binding proteins essential for nutritive utilization. The FDA states that folate-binding protein (FBP) is not denatured by pasteurization, however a 2012 review on FBP cites studies from 1978 and 1996 that show inconsistency in how much HTST pasteurization affects FBP function. A 1996 study demonstrated a 20 percent decrease in total FBP levels after HTST pasteurization, while the 1978 study demonstrated a nearly 90 percent decrease,<sup>83</sup> and this loss would only increase (or completely destroy) FBP in raw milk after UHT treatment.<sup>83</sup> FBP is known to denature at temperatures between 70-80 °C, and therefore all pasteurization techniques will have a significant effect on FBP levels and function. While folate levels in milk may be low, FBP increases absorption efficiency and may also support

absorption of folate from other dietary sources.<sup>83</sup>

### **Claim 12: Pasteurized milk is safer than raw milk**

This claim is based on the FDA citations of 8 outbreaks from 2010 and 133 outbreaks between 1987 and 2010, causing a total of 2,659 illnesses. FDA fails to provide additional information in order to ascertain whether this claim true.

It is important to note that there were over 60 known outbreaks of foodborne illness due to pasteurized milk between 1966 and 2015,<sup>84-98</sup> Thus, pasteurization does not fully protect against foodborne illness. Additionally, in order to claim that pasteurized milk is safer, one must be able to say that it has caused less illness in the same time frame. However, between 1986-2010 there were 3,028 foodborne illnesses reported due to pasteurized milk or milk products,<sup>87, 92, 95, 97, 98</sup> and if we include a *Salmonella Typhimurium* outbreak in 1985,<sup>99</sup> we could add another 150,000 more illnesses to the count. Even if we reduce the time frame to 1994-2010, the illness count is still 2,926. Due to the fact that raw milk has protective properties against foodborne illness (outlined in a previous section of this article), and that more people consume pasteurized milk than raw milk,<sup>100</sup> pasteurized milk causes more illness per pathogen outbreak than raw milk.

The causative organisms for cases blamed on raw milk and those attributed to pasteurized milk are often the same, meaning that whatever safety problems attributed to raw milk must also be attributed to pasteurized milk. For example, *Listeria monocytogenes*, *Campylobacter jejuni*, *Escherichia coli*, and *Salmonella enteritidis* have been found as causative agents in outbreaks attributed to both raw milk cited by the FDA and those attributed to pasteurized milk. It is clear that pasteurization does not ensure protection against illness from these organisms. With regards to *Listeria monocytogenes*, none of the outbreaks attributed to raw milk between 1993 and 2005 were attributed to this pathogenic organism.<sup>101</sup> According to FDA, there is higher risk of listeria infection from deli meats and pasteurized milk than from raw milk.<sup>102</sup>

### **Point 12: Raw milk causes a greater rate of foodborne outbreaks than pasteurized milk.**

The FDA here analyzes cases of foodborne illness attributed to pasteurized milk, which is not an analysis of the “rates of outbreaks” (outlined in the previous section) and notes that “In most cases, the implicated milk was contaminated post-pasteurization.” This now opens the door to continue the discussion about farming, animal husbandry and product handling methods as points of contamination, and not whether or not the milk was pasteurized.

While the FDA uses this as an argument to blame the raw milk pre-pasteurization, what they are really doing is telling us that, in “most cases” analyzed and cited by the FDA, the pasteurization status has nothing to do with the foodborne outbreak, nor did it prevent the outbreak. Multiple cases analyzed cite cross contamination with other infected animals (such as pigs) or other transported products found to be contaminated (such as eggs).

The FDA also cites a case in which cows infected with listeria were implicated in the illness outbreak from pasteurized milk.<sup>96</sup> Not only does this implicate the health of the animal rather than the pasteurization status of the milk, but this also shows that pasteurization did not protect from listeria infection. Regardless of the status of the milk, milk products from

infected animals should never be distributed. Other implications in the FDA-cited cases on this point include facilities found with sanitary violations or milk that was highly infected pre- or post-pasteurization.

### **Point 13: Raw milk produced under HACCP does not make it safe to drink**

It is true that HACCP procedures do not ensure that any milk product is completely free from pathogens, but this is true whether the milk is pasteurized or not. Pasteurization is not effective at killing every single pathogen, and when examining food products as a whole, there is never any way to completely avoid exposure to pathogens associated with food.

This is why our bodies have carefully designed immune systems to deal with pathogens. However, a HACCP-like system will ensure that levels of pathogens in raw milk are low enough for the body to deal with them, especially in synergy with the naturally protective functions of the raw milk itself, some of which act to create a healthy immune system in the raw milk consumer (outlined in previous sections). In conclusion, there is no scientific basis to restrict the freedom of farmers or consumers to their right to choose raw milk for its many scientifically demonstrated and potential health benefits.

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