

Research Reflection

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Author for correspondence:

Rafael Fagnani, Email: rafaelfagnani@hotmail.com

Why knowledge is the best way to reduce the risks associated with raw milk and raw milk products

Rafael Fagnani¹, Luis Augusto Nero² and Carla Prado Rosolem¹

¹Mestrado em Ciência e Tecnologia de Leite e Derivados, Universidade Pitágoras-Unopar, Londrina PR, Brazil and

²Universidade Federal de Viçosa, Departamento de Veterinária, InsPOA – Laboratório de Inspeção de Produtos de Origem Animal, Viçosa MG, Brazil

Abstract

In an age of flexible conditions about mandatory milk pasteurisation, this opinion-based research reflection supports the view that the knowledge and the awareness of milk-borne infections are key requirements to decrease the risks associated with raw milk. Providing an analysis of the current potential risks related to consumption of raw milk and raw milk products, we discuss the main reasons to continue to be vigilant about milk-borne pathogens and the current scenario in relation to the formal and clandestine sale of raw milk. Finally, we select some highly effective strategies to reduce the risks associated with raw milk in food services. Regardless of whether a country regulation allows or prohibits the trade of raw milk and its products, this is not the time to be negligent.

Introduction

Given that most dairy products are now industrialised, thermally treated and have to undergo sanitary inspection during processing, is it still necessary to be concerned about diseases related to consumption of dairy products? This issue is often discussed amongst food safety researchers and industry professionals, but it is not always possible to reach a consensus (O'Callaghan *et al.*, 2019).

In a multitude of scientific articles (over 900 000 Google Scholar search results typing 'raw milk consumption') it is possible to notice a remarkable convergence of ideas: the knowledge and the awareness of milk-borne infections are key requirements to decrease the risks associated with raw milk. The national regulations, the inspection service and the market surveillance are perennial strategies and cannot be neglected. However, food safety is only maximised when adopting simultaneous knowledge intensive practises. Here, we aim to clarify some relevant points related to dairy-borne diseases, providing information regarding the current scenario of the clandestine sale of raw milk and its products, in order to allow improvements in food safety.

Current relevance of milk-borne pathogens

There are three main reasons why it is still important to be aware about milk-borne pathogens. The first reason is because the sale of raw milk is regulated in some countries and direct sale to consumers is, therefore, possible. Raw milk is a product that has not undergone any thermal processing. Even milk from healthy cows, without any alterations, can still contain pathogenic microorganisms and transmit pathogens. Some of these diseases can be lethal, such as tuberculosis and listeriosis, whilst others may be incurable such as brucellosis (Claeys *et al.*, 2013). In recent times, the consumption of bulk milk sold directly from producers was found to be associated with a higher probability of haemolytic uraemic syndrome (Ntuli *et al.*, 2018). Thus, raw milk can pose a risk to public health.

In view of this concern, the pasteurisation of milk for direct human consumption and for the production of fresh cheese is mandatory in many countries, including Australia and Brazil (Baars, 2019). However, more flexible conditions are found in other countries, like USA, where some states allow the sale of raw milk, while others still prohibit such sales (Mungai *et al.*, 2015). In some countries, such as the UK, the situation can be more permissive and raw milk can be sold directly to consumers. However, strategies in the UK to reduce risks are well established, and raw milk must be from official brucellosis and tuberculosis-free herds (Abernethy *et al.*, 2013). In addition, such milk must carry a health warning and can only be sold by registered milk producers or by milk roundsmen.

Can such permissive behaviour have an impact on consumer health? Prior to the 1950s, about a quarter of all foodborne infections were associated to milk consumption. Following the introduction of regulations recommending milk pasteurisation, milk was attributed with less than 1% of reported outbreaks of foodborne diseases (Mungai *et al.*, 2015). However,

in recent years this figure seems to be increasing as more countries have allowed the legal sale of raw milk. For example, in the USA the average number of outbreaks linked to raw milk each year was four times higher from 2007 to 2012 than from 1993 to 2006. Furthermore, the percentage of outbreaks associated with raw milk increased from 2% (2007–2009) to 5% (2010–2012) (Mungai *et al.*, 2015). The infection risks associated with the consumption of raw milk are clear and undisputed; throughout history, mandatory pasteurisation has been linked with decreased numbers of outbreaks of milk-borne pathogens (Alegbeleye *et al.*, 2018).

The second reason to continue to be vigilant about milk-borne pathogens is that even where governments restrict legal sales, raw milk and its products can be purchased clandestinely, such as in street markets or from roundsmen (Paraffin *et al.*, 2018). Compared to places where the sale of raw milk is regulated, the clandestine market poses more risks to public health because such locations are not checked by official inspection agents. In such locations there is no guarantee of food safety. In addition to the diseases that can be transmitted, these products may also be fraudulent (Tibola *et al.*, 2018). These frauds are economically motivated and may breach the rights of consumers regarding the authentic purchasing of dairy products. Examples of this include adding water to increase volume and chemicals to preserve their shelf life, selling milk as belonging from one species when it is actually produced by another, adding non-dairy fats, and so on (Tibola *et al.*, 2018). Consequently, clandestine dairy products are highly likely to be adulterated.

The third reason to continue to be aware of milk-borne pathogens relates to the consumers themselves. Why do consumers continue to buy these products? Is it due to a lack of information? Because of the flavour? A lack of choice? The price? A mistrust of industrialised products? The most commonly cited motivations behind the consumption of clandestine dairy products are the taste and the purity of such products (Buzby *et al.*, 2013; Raymundo *et al.*, 2018; Waldman and Kerr, 2018). However, the motivations that might drive European are not necessarily the same as for Americans, but are strongly influenced by culture. Socio-cultural aspects, such as regulatory history, cultural norms, socio-economic status, perception of health and risk and even social justice, also contribute to individual and population preferences regarding raw milk consumption (Meunier-Goddik and Waite-Cusic, 2019).

There has been much popular discussion about the risks and benefits derived from the consumption of raw milk, but all current scientific studies and reviews have categorically concluded that there is no evidence that raw milk has any inherent health or nutritional benefits that outweigh the risks associated with its consumption (Macdonald *et al.*, 2011). Thus the idea that raw milk might be a super food is misplaced (Alegbeleye *et al.*, 2018).

It should be stressed that consumers receive information and make purchasing decisions based on non-scientific criteria, without consideration for factors such as safety and risk (Jay-Russell, 2010). In a recent study, about 17% of raw milk samples tested positive for antibiotic residues, and over 21% were found to be adulterated with water, which contradicts the concept that clandestine raw milk is pure and without chemical modifications (Ondieki *et al.*, 2017).

Main threats associated with raw milk and its products

The consumption of raw milk and its products may pose risks to the health of those who consume them, so much so that warning

labels are required on raw milk sold in some countries such as UK and some US states, such as California. However, what are the risks of using raw milk and its products as ingredients in thermally processed food, such as bread, cookies, cakes and other baked goods? If milk and its products are obtained from the clandestine market, then the hazards and risks are those mentioned above. These issues can result in low quality products, low yields, microbiological fermentation failures due to possible antibiotic residues and taste defects (Fleischer *et al.*, 2001; Novés *et al.*, 2015). These taste defects may be of microbiological origin, caused by bacteria that produce proteolytic and lipolytic enzymes, and/or physical factors such as oxidative rancidity caused by exposure to light (Cadwallader and Singh, 2009).

If raw milk and its products are obtained from the formal market, then the problem of adulteration is minimised. However, there will still be microbiological risks. As an example, a monitoring survey of raw milk sold through vending machines in Italy from 2009 to 2011 found that of the 618 samples tested, 1.6% were positive for *Listeria monocytogens*, 1.5% for *Campylobacter* spp., 0.3% for *Salmonella* spp. and 0.2% for *E. coli* O157 (Bianchi *et al.*, 2013). It is important to highlight that all samples came from health and vaccinated herds and the selling vending machines were in accordance with the enactment of an Italian law that allows the sale of unpacked and unpasteurised cows milk on the farm and at markets. More recently (2016), an outbreak with 69 cases of campylobacteriosis was linked with raw milk from vending machines in England (Kenyon *et al.*, 2020). These findings raise the question of whether some national regimes for unpasteurised milk are fit for purpose.

Due to the influence of the food matrix on the viability of bacterial pathogens, the dairy products most commonly involved in milk-borne infections are raw milk, fresh cheeses (without maturation) and fatty products such as cream and butter (Fox *et al.*, 2018). Despite the fact that most cooked foods usually uses temperatures higher than 180 °C there are still three basic threats: staphylococcal enterotoxins, *Brucella* spp. and cross contamination. Figure 1 summarises the main health risks associated with raw and dairy products.

Staphylococcal enterotoxins

The vegetative cells of all pathogenic microorganisms are completely inactivated during pasteurisation. Various times and temperatures can be used to ensure safety, the most common being 72–75 °C for 15–20 s or 62–65 °C for 30 min. Boiling raw milk ensures the safety of the product from this point of view (Tremonte *et al.*, 2014). The remaining problem lies in the presence of staphylococcal enterotoxins, that are resistant to boiling and pasteurisation. They are only inactivated at 120 psi for twenty minutes, and this condition can only be achieved using autoclaves. When ingested, staphylococcal enterotoxins cause staphylococcal gastroenteritis, a rapidly evolving type of food poisoning (from thirty minutes to six hours after the ingestion of contaminated food), as well as clinical symptoms of nausea, vomiting, headaches, abdominal pain and diarrhoea (Artursson *et al.*, 2018; Suzuki, 2019).

Brucella spp.

Cream and whipped cream are widely used in food services, whether for making Chantilly, to cover cakes, in ice cream, for creamy fillings, etc. Cows, goats and sheep that are infected

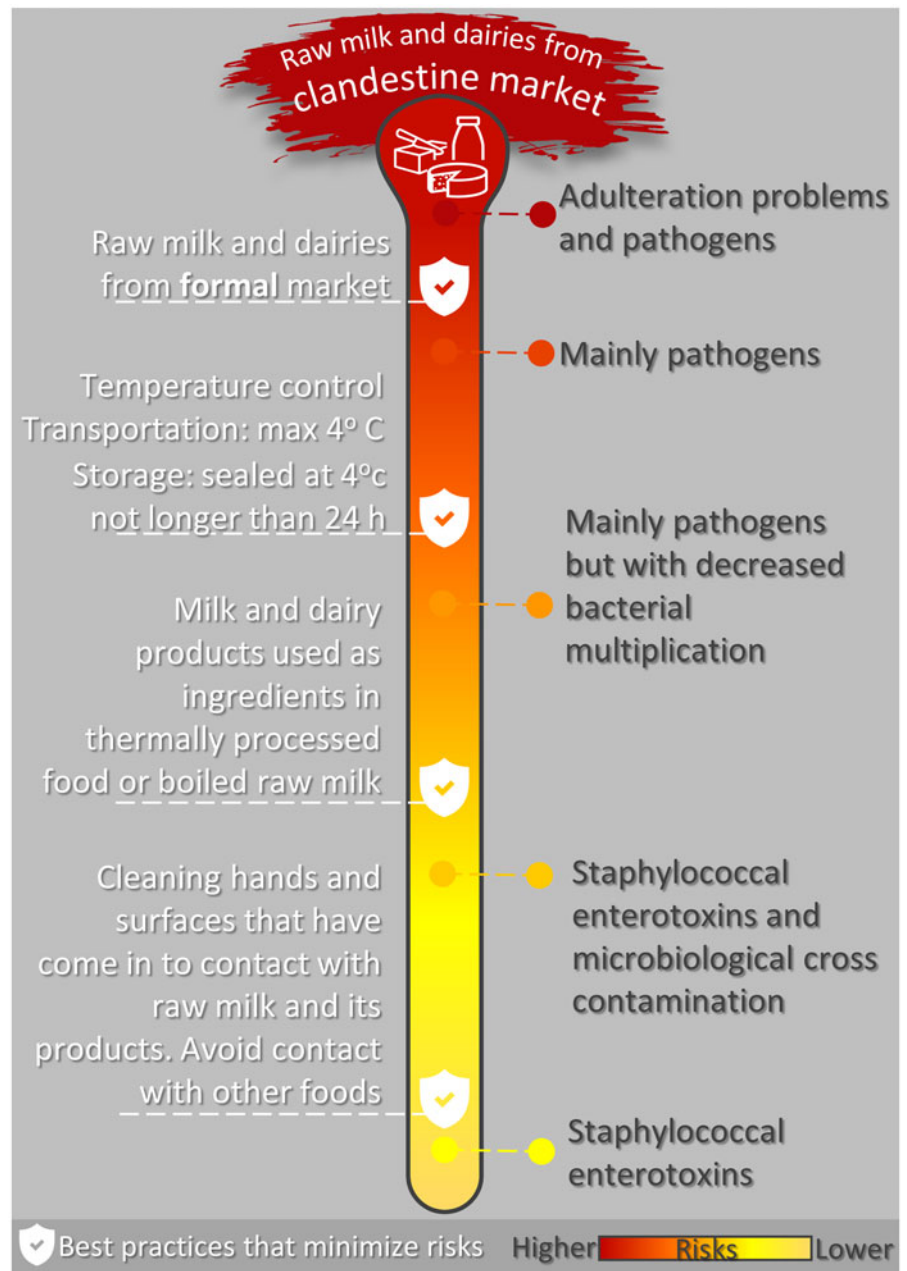


Fig. 1. Main threats associated with raw milk and its products and effective guidance strategies to reduce them.

with brucellosis excrete *Brucella* cells in farmed milk with no visible alterations (LeJeune and Rajala-Schultz, 2009). These microorganisms have an affinity for milk fat globules, and the dairy derivatives that pose the greatest risk are cream and whipped cream. The higher the level of fat, the greater the risk of transmission. This problem is enhanced because the cream is not usually baked with the dough, resulting in the continuing presence of viable cells in these products (Kaden *et al.*, 2018). Brucellosis is an incurable chronic disease that causes arthritis, meningitis, endocarditis, orchitis, fevers and night chills (Dogany and Aygen, 2003).

Cross-contamination

This threat is related to failures in the food safety procedures and may only occur when a pathogenic microorganism is present. In

this case, raw milk and its products can be sources of contamination in food services and industrial kitchens. Some pathogenic cells, such as *L. monocytogenes*, can spread to all surfaces through cross-contamination. The frequency of this microorganism in milk is considerable: of 861 samples of raw milk, almost 7% contained *L. monocytogenes* (Van Kessel *et al.*, 2004). Furthermore, this microorganism has adapted to stainless steel surfaces, where it can set and form biofilms (Herald and Zottola, 1988; Oliveira *et al.*, 2010). Even in industrial plants with excellent levels of cleaning the occurrence of *L. monocytogenes* is 7%; in places where cleaning is deficient the occurrence can reach almost 28% (Walker *et al.*, 1991). Listeriosis is a disease of high mortality but low morbidity: immunosuppressed people are most affected. In addition to causing death, listeriosis also causes miscarriages, arthritis and encephalitis; in its non-invasive form it can result in gastroenteritis.

Another aetiological agent of foodborne diseases linked to dairy products is *Campylobacter jejuni* (Paramithiotis *et al.*, 2017). Over the past decade this pathogenic bacterium has been detected worldwide in raw milk. Recently, almost 12% of raw milk purchased from individual suppliers were positive in Poland (Andrzejewska *et al.*, 2019). In New Zealand, *Campylobacter* is the most common pathogen reported in association with raw milk-related disease outbreaks (Davys *et al.*, 2020). The primary reason is the use of unpasteurised milk for the production of dairy products (Paramithiotis *et al.*, 2017).

Although pasteurisation can effectively eliminate vegetative cells (including *C. jejuni*) (Murphy *et al.*, 2003), it should not be regarded as the only line of defence, especially since the contamination may occur during the subsequent processing steps. One of the consequences of cross-contamination is the growing number of recalls of dairy products, increasing from 4% (in 2015) to 17% in USA (2017) (Paramithiotis *et al.*, 2017).

Reducing the risks associated with raw milk in food services

In order to reduce the risks associated with raw milk and its products, there are five highly effective guidance strategies for food services: (1) Never buy milk and its derivatives from clandestine sources; the latter are not inspected, and in addition to transmitting pathogens these products may be adulterated; (2) When buying raw milk from legally approved sources always boil the raw milk before use or consumption, once even inspected raw products can harbour pathogenic bacteria. (3) Fatty dairy products pose considerable risks: only use industrialised cream, whipped cream and butter; (4) Clean hands and surfaces that have come into contact with raw milk and its products to minimise cross-contamination: hands and surfaces should be cleaned with soap and water and then sanitised; (5) It is essential to strictly control the temperature regarding raw milk and its products; this practice is not only linked to spoilage bacteria, but it can also minimise the presence of pathogenic microorganisms (Leclair *et al.*, 2019). The temperature of transport and refrigeration should never exceed 4 °C. Use recyclable ice and thermal containers during transport. Do not use products stored for more than 24 h, even if refrigerated at 4°C. Products should be sealed when stored, should not come into contact with other foods, and should be consumed as soon as possible. Freezing does not guarantee safety: some microorganisms such as *L. monocytogenes* can survive for more than 365 d in frozen raw milk (Leclair *et al.*, 2019). Figure 1 summarises the main strategies discussed above.

However, knowledge is the best way to reduce the risks associated with raw milk and its products. A recent study concluded that the ability to understand the risks associated with the consumption of unpasteurised dairy products was linked to the health status of the population. We found that consumers who are aware of milk-borne pathogens were twice as likely not to have abdominal pain. For the first time, it was observed that the awareness of milk-borne pathogens provides benefits for consumer health and is a protective factor in relation to abdominal pain (Fagnani *et al.*, 2019).

Other examples also show a positive association between general knowledge and health status. Mosalagae *et al.* (2011) stated that by improving the level of awareness for zoonoses, teaching and training of population, both human health and food safety could be enhanced. In addition, Bell *et al.* (1999) also concluded that educational workshops were a successful food safety intervention to reduce the incidence of *Salmonella* Typhimurium

associated with eating fresh cheese. This leads us to reinforce that knowledge can promote health-seeking behaviour and good health, as reported by Aaby *et al.* (2017).

More recently, a study conducted in Tanzania evaluated how narrative and technical risk and health messages impacted the hygiene practices and the milk quality in a pastoral community (Caudell *et al.*, 2019). The results suggest that the use of narrative messages can promote healthy behaviour even when cultural norms are contrary to best health practices (Caudell *et al.*, 2019). In low income and/or developing countries there is a strong association between educational level and the knowledge of the population on milk borne zoonosis (Mandefero and Yeshibelay, 2018). These regions face challenges to increase the educational level of the whole population, and consequently reduce the incidence of diseases associated with raw milk consumption (Kumar *et al.*, 2017). However, it is common to find people aware of the raw milk consumption risks in developed countries, but still consuming raw milk. Here, the challenge is not only to increase the awareness about milk-borne infections, but to understand why the health risks are ignored by this segment of the population. Then, the strategies to promote knowledge should be in line with the demographic condition. Not only milk-borne diseases but any dietary-related condition are more easily preventable if consumers understand the factors that support their dietary choices.

Regardless of whether a country regulation allows or prohibits the trade of raw milk and its products, knowledge of the risks associated with these products is critical to assure the population health. Consumers should be kept informed and alerted regarding this issue, whether *via* product labels, through advertising campaigns promoted by official inspection and regulatory offices or *via* university outreach programmes. In addition, it is clear that this is not the time to be negligent regarding raw milk and its products because of the health risks that they represent, especially those that are purchased clandestinely.

Future progress

As in other areas, knowledge is the key to promoting health. But how to achieve it? Traditionally, it can be achieved by ongoing and continuous training of food handlers. Each food sector should develop specific didactic and pedagogical techniques providing realistic examples (Gomes *et al.*, 2014). Not least, teaching and training of the population is also essential to strengthen awareness for better food safety. But first, studies about the demographics, perceptions and behavioural attributes of consumers can be helpful in targeting educational efforts and better strategies on consumer education.

In the absence of massive scientific dissemination in this area, it is very likely that distorted information can be spread easily through the population, mainly through the web and social media platforms. However, false information would be ineffective if readers were able to identify it as such. Thus, the exteriorisation of regulations, science and technology out of its own sphere of production is a key requirement for better food safety. The university, organised civil societies, and mainly the government, can bridge the gap between trusted information and society at large through scientific dissemination to ensure a better understanding of food safety (Zhu *et al.*, 2019).

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