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Running Title: Dairy Food Safety

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Consumption of Raw Milk: A Threat to Public Health

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Abstract

The controversy surrounding the right to sell and consume raw milk has been longstanding for almost a century. Recently, the debate has gained considerable momentum and has intensified. Although raw milk is often contaminated with pathogenic bacteria such as *Escherichia coli* O157:H7, *Salmonella enterica* serotype Typhimurium, *Listeria monocytogenes*, and *Campylobacter jejuni*, advocates still demand the right to sell and consume raw milk. This paper summarizes studies that have proven pasteurization does not alter the nutritional value of milk, effectively kills pathogenic bacteria, and is needed to prevent milkborne outbreaks. Interstate sale of raw milk has been illegal for over three decades. However, intrastate sale depends upon each state to decide its own terms for the legality of raw milk. Today it is legal to sell raw milk for human consumption in at least 25 states. For milkborne illness to decline, the sale of raw milk should become illegal in every state. The basis of this paper is to provide insight into the legal aspects of the raw versus pasteurized milk debate, why it is of such concern, and its implications on public health.

Introduction

The controversy surrounding the right to sell and consume raw milk has been longstanding for almost a century. Recently, the debate has gained considerable momentum. The issues involve an individual's constitutional right to produce and sell a product, and the constitutional right of the general public and society as a whole to be ensured a safe food supply. Six pathogens (*Salmonella*, *Listeria*, *Campylobacter*, *Escherichia coli*, *Toxoplasma*, and Norwalk-like virus) contribute to over 90% of estimated foodborne deaths in the United States. Four of these including *Salmonella*, *Listeria*, *Campylobacter*, *E. coli*, are responsible for many milkborne outbreaks (Mead et al., 1999). Most individuals do not think twice when buying milk- wondering whether or not it was pasteurized and if the pasteurization was successful. It has become a way of life to trust that what is provided at the grocery store is safe and wholesome and will not cause illness. Advocates for raw milk demand to know why milk has been under such legal scrutiny, while trying to rid legal restrictions. The basis of this paper is to provide

insight into the legal aspects of the raw versus pasteurized milk debate, why it is of such concern, and its implications on public health.

What Is In Raw Milk?

The North Carolina Petition for Raw Milk defines raw milk as “natural milk from cows, sheep, and goats having constant access to green pasture, hay, and fibrous plant materials produced without fertilizers, herbicides, and pesticides; from family farms with healthy animals in healthy herds that are not given antibiotics or hormones; and that is not processed i.e. not pasteurized and not homogenized” (www.ncrawmilk.org). The term “healthy” to describe a cow in good condition, however, does not necessarily mean the animal is free of bacteria that are harmful to humans. Bacteria that can contaminate milk include *Escherichia coli* O157:H7, *Campylobacter jejuni*, *Listeria monocytogenes*, *Salmonella enterica* serotype Typhimurium, *Mycoplasma*, *Mycobacterium paratuberculosis*, *Yersinia*, *Brucella*, *Staphylococcus aureus*, *Streptococcus agalactiae*, and many others (Blaser et al., 1979; CDC, 2002; CDC, 2003; CDC, 2007; Oliver et al., 2005; Potter et al., 1984; Rua-Domenech, 2005). General symptoms of foodborne bacterial infection include diarrhea, stomach cramps, fever, headache, exhaustion, and vomiting. However, some foodborne pathogens such as *E. coli* O157:H7 are capable of hemorrhagic colitis, kidney failure, and death (CDC, 2001; CDC, 2007). The bovine intestinal tract harbors many microbes to aid in natural fermentation processes. These microbes are shed in feces and can contaminate cows’ udders and teats when cows lie down in the farm environment. Pathogens can also be transferred from the natural environment such as grass and soil (Oliver et al., 2005; Christiansson et al., 1999). During milking, bacteria from a contaminated udder can easily enter the milk and milking equipment. Bacteria on milking equipment can then contaminate milk from a subsequent “pathogen-free” cow. Each one of these pathogens inherent in milk is potentially harmful to humans, and if the milk is not pasteurized, people can become infected with bacteria in the milk, become ill, and in extreme cases even die.

Pasteurization

Pasteurization is the process by which pathogens are killed to prevent foodborne illness and infection in humans. Pasteurization is a standard process not only for milk, but also for beer, wine, fruit juices, cheese, and egg products. According to the Food and Drug Administration (FDA), pasteurization prevents several diseases such as tuberculosis, diphtheria, polio, salmonellosis, strep throat, scarlet fever, and typhoid fever. There are different methods of pasteurization. According to the International Dairy Foods Association (IDFA, www.idfa.org), milk can be heated to 145°F for 30 min (Vat Pasteurization), to 161°F for 15 sec (“Flash Pasteurization” or “High Temperature Short Time”), to 191°F for 1 sec (“Higher Heat, Shorter Time”), or to 280°F for 2 sec (“Ultra Pasteurization”). These processes are followed by rapid cooling of milk to below 50°F. Vat Pasteurization was the original method of pasteurization and is now used mainly in preparing milk to be processed to cheese, buttermilk, yogurt, and some ice creams. High Temperature Short Time (HTST) pasteurization is the most commonly practiced method in the United States for pasteurization of milk. Using hot water and metal plates, the temperature of milk is increased to at least 161°F for at least 15 sec and is then followed by rapid cooling. Many organic milk producers use the Ultra Pasteurization method, which allows for a longer shelf life. A less common method of pasteurization is termed aseptic processing or Ultra High Temperature (UHT). Commercially sterile equipment (the time and temperature is based upon the equipment used) heats the milk and then fills it aseptically into packaging sealed hermetically. This “shelf stable” milk does not require refrigeration until opening (IDFA, www.idfa.org). Pasteurization also kills bacteria that cause milk to spoil, giving milk a longer shelf life of about 16 days, whereas raw milk has a shelf life of only 3-6 days (Griffiths et al., 1987). Methods for pasteurization are based on parameters necessary to kill *Mycobacterium paratuberculosis* and other milkborne pathogens.

Two Opposing Views

On Health & Disease: One of the biggest proponents of raw milk is the Weston A. Price Foundation. According to their website (www.westonaprice.org), consuming raw milk

increases resistance to tuberculosis, enhances child growth, decreases the chance of tooth decay, and decreases the risk of asthma and other ailments. They also claim that children consuming only pasteurized milk have a greater risk of developing scurvy due to lack of nutritive value in pasteurized milk. On the contrary, research has shown clearly that pasteurization has greatly reduced milkborne diseases, including tuberculosis, diphtheria, and scarlet fever (Vasavada and Smith, 1987). Prior to the use of pasteurization, *Mycobacterium bovis* was reported to cause 6-30% of all tuberculosis cases in the United States (Karlsen et al., 1970; Rua-Domenech, 2005) and it was known that raw milk was a significant source of tuberculosis infections (Rua-Domenech, 2005). In addition, pasteurized milk is fortified with vitamin D, which increases the body's ability to absorb calcium. The addition of vitamin D to pasteurized milk also helped eradicate rickets since calcium, phosphorus, and vitamin D were all provided in a single food (Graham, 1974).

Raw milk proponents also claim many coliform strains of bacteria are beneficial because coliforms inhibit the growth of other bacteria such as *E. coli* O157:H7 and *Salmonella* by producing antimicrobial compounds called colicins. This is referred to as competitive exclusion. Although colicins have been found to inhibit growth of other coliforms, according to a research project by the United States Department of Agriculture (USDA), the ability of each colicin to reduce *E. coli* O157:H7 varied between strains (Callaway et al., 2004; Schamberger et al., 2002). Moreover, *Salmonella enterica* serotype Typhimurium growth rates and cell numbers were not affected by colicin. These antimicrobial proteins could potentially be an effective means to reduce *E. coli* O157:H7 in food-producing animals, but more research needs to be conducted before claiming they are beneficial in humans (Callaway et al., 2004). It should also be noted that these tests were performed in a laboratory setting with optimal growth conditions for bacteria. However, when in an actual animal or human with varying growth conditions, whether or not these colicin-producing bacteria actually grow and inhibit growth of harmful bacteria is still in question. There have also been arguments that inhibins, factors in milk that inhibit bacterial growth, are inactivated by pasteurization. A study by Dold et al. (1938) showed that inhibins from human milk were inactivated at 56°C (HTST pasteurization temperature is 71°C). However, inhibins from cow milk were in fact not inactivated by

heating at 80°C for 7 min, but at 85°C for 7 min (Dold et al., 1938). In order to make a claim, raw milk advocates tend to selectively present data from studies to support their argument.

Another milk constituent in question is the protein lactoferrin which has antimicrobial and iron binding properties. Paulsson et al. (1993) indicated that although its activity is affected by UHT treatment, HTST has no effect on lactoferrin. The study goes on to say that pasteurization is “the method of choice” for ridding of bacteria when this protein is involved since pasteurization does not change the antibacterial or iron binding capacity of lactoferrin.

On Nutrition & Nutrient: According to the Weston A. Price Foundation, pasteurization decreases calcium content in milk while destroying vitamins A, B, and C. However, studies have found that most nutrients in milk are stable under HTST pasteurization conditions. Furthermore, research has shown that vitamin A, vitamin D, riboflavin, pantothenic acid, nicotinic acid, and vitamin B6 changed very little during pasteurization. At the same time, vitamin C had only a 10% loss, while vitamin B-12 and thiamine had a loss of <10% and biotin had no loss (Graham, 1974; Kon, 1972). In regards to casein, a study comparing raw milk to HTST and UHT treated milks demonstrated that HTST pasteurized milk had no change in casein solubility, 0.4% whey protein nitrogen denaturation, and no significant losses in nutritive value, which was also the case with UHT treatment (Douglas et al., 1981).

Various studies have been conducted in regards to xanthine oxidase (an important protein in the liver) activity. One study found no effect of HTST pasteurization on xanthine oxidase activity (Potineni et al., 2005). However, a study by Greenbank and Pallansch (1962) indicated that pasteurization decreased xanthine oxidase by 26%. In the same study, although the enzyme was found to be slightly heat sensitive, it was also reactivated unexplainably during HTST processing (Greenbank and Pallansch, 1962). Another argument made by raw milk advocates is that pasteurized milk can induce arthritis. However, in a study by Verdrengh and Tarkowski (1997), it was shown that

Staphylococcus aureus, a pathogen found frequently in raw milk, can cause septic arthritis.

Milk-induced allergies are another topic of debate. Poulsen et al. (1987) conducted a study in mice showing that homogenized milk increased the likelihood of milk allergy, whereas raw milk did not. Nonhomogenized pasteurized milk did not induce as much of an anaphylactic response as homogenized milk. Although the literature has depicted a less likely chance of becoming allergenic from living on a farm, with consumption of farm milk a factor (Riedler, 2001), the cost and benefits of possibly living without allergies verses taking the chance of succumbing to a possibly life-threatening bacterial illness need to be measured. Overall, substantial differences between nutritional values of pasteurized and unpasteurized milk and the specific benefits of raw milk have not been proven scientifically (Potter et al., 1984).

On Pasteurization's Effective Destruction of Pathogens: According to the Center for Disease Control (1988), *Listeria monocytogenes* can be cultured from about 5% of raw (unpasteurized) milk samples. Because of a Listeriosis outbreak associated with pasteurized milk in Massachusetts in 1983 (Fleming et al., 1985), it has been questioned whether or not pasteurization effectively eliminates *L. monocytogenes*. Many studies have shown that *L. monocytogenes* is in fact inactivated by standard pasteurization practices. Many studies were conducted, one of which involved artificially inoculating milk with the pathogen and testing the effectiveness of various pasteurization procedures in its elimination (Farber et al., 1987). A news article from the Boston Channel reported that after results of studies were investigated, the World Health Organization Working Group on foodborne Listeriosis concluded that "pasteurization is a safe process which reduces the number of *L. monocytogenes* in raw milk to levels that do not pose an appreciable risk to human health."

D'Aoust et al. (1988) compared the effects of HTST on hemorrhagic *E. coli* O157:H7, *Yersinia enterocolitica*, and *Campylobacter* species (*C. fetus*, *C. coli*, *C. jejuni*). The study demonstrated that HTST pasteurization was successful in inactivating all of the

tested pathogens. *Escherichia coli* O157:H7 had no cell counts when the temperature was >64.5°C, and *Y. enterocolitica* and *Campylobacter* species had even higher heat sensitivity and were inactivated at 60°C.

Although some studies have shown survival of *Mycobacterium paratuberculosis* after pasteurization, there have also been studies that prove its destruction through pasteurization (Gao et al., 2002). It has, however, been suggested to ensure *M. paratuberculosis*' complete inactivation, that longer holding times of 25 sec in High Temperature Short Time treatment should be implemented in high-risk areas (Gao et al., 2002). Pasteurization was also effective against *Staphylococcus aureus*, *C. jejuni*, *Salmonella* species, and many other potential pathogens (Lewis, 1999). Foot and Mouth Disease virus was effectively inactivated by UHT pasteurization at 148°C for 3 sec (Douglas et al., 1981).

Federal Standards & Regulations

“There is no article of food in more general use than milk; none whose impurity or unwholesomeness may more quickly, more widely, and more seriously affect the health of those who use it” (Wright and Huck, 2001). This quote summarizes one reason why raw milk is the only food item to have strict legal restrictions. In 1973, the United States FDA proposed a regulation requiring that all milk moving in interstate commerce be pasteurized. Between 1974 and 1982, there was growing evidence of the association of certified raw milk with human disease. Therefore, in 1987 the FDA finished the proposed regulation of mandating pasteurization and banning interstate traffic of raw milk (Headrick et al., 1998; Weisbecker, 2007). The regulation requires interstate commerce or distribution of milk products for human consumption must be pasteurized by either of the following methods: 63°C for 30 min, 72°C for 15 sec, 89°C for 1 sec, 90°C for 0.5 sec, 94°C for 0.1 sec, 96°C for 0.05 sec, or 100°C for 0.01 sec (FDA Sale/Consumption of Raw Milk Position Statement M-I-03-4; FDA Cod of Federal Regulations title 21 vol. 8, revised April 1, 2006). However, the intrastate sale of raw milk and its legality is determined by each state.

The revised 2003 Pasteurized Milk Ordinance states “only Grade “A” pasteurized, Ultra-Pasteurized, or aseptically processed milk and milk products can be sold to the final consumer, restaurants, soda fountains, grocery stores, and similar establishments.” Standards set for Grade “A” raw milk for pasteurization include a bacterial limit of 100,000 colony forming units (CFU)/mL before commingling with other producer milk and should not exceed bacterial counts of 300,000 CFU/mL after commingling and prior to pasteurization. Also, within 4 hours after the first milking, the milk must be cooled to no more than 10°C. Milk must then be cooled to no more than 7°C within 2 hrs after milking. In addition, the somatic cell count of individual producer milk should not exceed 750,000 cells/mL and coliforms should be no more than 50 CFU/mL. Once pasteurized, Grade “A” milk should have no more than 10 CFU/mL for coliforms, bacterial limits of 20,000 CFU/mL, and be cooled to no more than 7°C. Producers’ raw milk for pasteurization is sampled at least 8 times a year, each in a different month, in order to regulate the bacterial and somatic cell count limits. Samples are tested in a milk laboratory approved by the Regulatory Agency (Pasteurized Milk Ordinance, 2003).

Raw Milk Standards

According to the Raw Milk Association of Colorado and Guidelines for Raw Milk Distribution in Colorado, raw milk producers have certain guidelines to follow. Commingled milk must be sampled monthly and tested for coliforms, *Salmonella*, *Listeria*, *Staph. aureus*, *Streptococcus agalactiae*, and *Mycoplasma* species. Bacterial limits are 10,000 CFU/mL for standard plate counts and somatic cell counts should be below 400,000 cells/mL for cows, or 600,000 cells/mL for goats. The coliform limits are 50 CFU/mL. If bacteria or somatic cell counts are above the set limits, distribution of milk should cease immediately until compliance with limits are reached. In addition, consumers can only receive raw milk directly from the dairy and must sign a notarized document that mandates a legal consumer/farmer contract (Raw Milk Colorado, www.rawmilkcolorado.org).

Organic Pastures, a raw milk dairy in California, has different bacterial and somatic cell count limits (personal interview). Standard plate counts should be <50,000 CFU/mL for the tank and <15,000 CFU/mL for the individual bottle. Coliforms should not exceed 10 CFU/mL, as set by the March 2008 legislation, and somatic cell counts should not exceed 650,000 cells/mL. These standards are strikingly different than those for raw milk dairies in Colorado, and whether this might play a role in raw milk associated outbreaks will be discussed later.

Ideal counts for raw milk to be pasteurized (Jayarao et al., 2004) for somatic cells are no more than 200,000 cells/mL, standard plate counts of 5,000 CFU/mL, and no more than 50 CFU/mL of coliforms. If these limits are ideal for raw milk that will be pasteurized, should they not also be the limits for raw milk consumption?

Effects on Public Health

The effects on public health improvement due to pasteurization and milk regulations have been extreme. Milkborne outbreaks were about 25% of all outbreaks from contaminated food in 1938. By 2002, the figure dropped to about 1% (Bren, 2004). Pasteurization, the Pasteurized Milk Ordinance, and the requirement that milk in interstate commerce must be pasteurized have led to a decrease in many infectious diseases and have rid many vectors of foodborne disease (CDC, 1999). Pasteurization and milk hygiene contributed to decreased infant mortality (CDC, 1999). Milk pasteurization has also contributed to greatly reducing tuberculosis in humans and cattle (Cosivi et al., 1998). Between 1880 and 1907, 500 milkborne disease outbreaks were reported (CDC, 1999), while between 1997 and 2006, the number of raw milkborne associated outbreaks reported was 50. Still, however, *Salmonella* accounts for 31%, *Listeria* accounts for 28%, *Campylobacter* accounts for 5% and *E. coli* accounts for 3% of total estimated food-related deaths (Mead et al., 1999). These percentages could be drastically reduced by mandating pasteurization of raw milk in every state.

States' Legalities

According to a study reviewed by the National Environmental Health Association Position Regarding Sale of Distribution of Raw Milk (www.neha.org) reported to the CDC, outbreaks due to consumption of raw milk from 1972-1992 correlated directly with states in which the sale of raw milk was legal. Eighty-seven percent of outbreaks associated with raw milk consumption occurred in states allowing the sale of raw milk. More specifically, 40 of the 46 outbreaks that were milk-related occurred in 28 states that permitted intrastate sale of raw milk (Headrick et al., 1998).

More recently, however, trends comparing states in which the sale of raw milk is legal and states in which the sale of raw milk is illegal have been less clear. There could be different explanations for these discrepancies. The many outbreaks in states where raw milk is illegal could be due to illegally selling raw milk or through cow-share programs. Cow-share programs are crafty ways of circumventing the state law. A raw milk producer can sell ownership rights of his cows to consumers, who can then obtain milk from the cow since they own part of the cow. Some states, however, do allow cow-share programs. There are correlations, though, between legal cow-share programs and raw milk associated outbreaks. For example, between 1997-2004 there were 3 raw milk associated outbreaks in Wisconsin, during which time cow-share programs were considered legal. In 2005, Wisconsin banned cow-sharing programs, and there has only been one raw milk-associated outbreak in the state since the ban was initiated, and this involved contaminated cheese (CDC, Outbreaks Surveillance Data 1996-2006). During the same time period of 1997-2004, Arizona did not have any raw milk associated outbreaks nor did they allow cow-sharing programs. Since the state legalized cow-shares in 2005, an outbreak has already been reported (CDC Outbreak Surveillance Data 1996-2006).

States in Which Raw Milk is Illegal

In 1948, Michigan was the first state to make it mandatory to pasteurize milk, and today there are 4 illegal cow-share programs in the state (Weisbecker, 2007). Michigan also has some of the more strict milk laws, including producers can not even sell raw milk directly

on the farm. However, even though the 4 cow-share programs are not approved, there has not been an attempt to shut them down. In Tennessee, the sale and simply giving away of raw milk are illegal. Although raw milk sales are legal for only the consumption by pets and there are a few illegal cow-share programs in the state, Tennessee's strict restrictions on raw milk has kept the state from having any outbreaks originating in its territory. In Wisconsin, it is legal to sell raw milk only directly to consumers on the farm, and advertising is not permitted. Cow-shares are illegal in the state, but employees or shippers of milk can legally buy the milk since they are considered shareholders. Between 1997 and 2006, Wisconsin has had at least 4 reported outbreaks associated with raw milk consumption, whereas Michigan has had only 2 and Tennessee has had none.

States in Which Raw Milk is Legal

California is the largest producer of certified raw milk in the United States. The American Association of Medical Milk Commissions, which is a private trade organization, sets the standards for certified raw milk. Sales of raw milk and raw milk products are legal in stores and on the farm, but milk must be produced along the standards of the Milk and Milk Products Act of 1947 and only Grade A milk require warning labels, and dairy producers need market milk permits. The results of a study concluded that raw milk drinkers in California tend to be younger than 40 years of age, more than likely of Hispanic origin, and have less than a high school education. The most important reason for drinking raw milk was taste, followed by health (Headrick et al., 1997). Raw milk was obtained from retail stores followed by a farm or ranch. The California Department of Health Services issued about 50 public health advisories due to multiple *Salmonella* contaminations of raw milk supplies. Finally in 1991, warning labels on raw milk and raw milk products were mandated (Headrick et al., 1997). In March 2008, the legal sale of raw milk in California was eliminated with new restrictions by the governor to have a maximum coliform count of ≤ 10 CFU/mL.

New York laws permit the sale of raw milk on the farm and the producer must obtain a license from the State Department of Agriculture and Markets. There must be a sign at the entrance to the farm indicating health hazards of raw milk. Additionally, the state routinely inspects retail raw milk for pathogens. Although in 2003 the state shut down

raw milk sales due to increased levels of *Staph. aureus*, between 1997 and 2006 there have been at least 6 reported raw milk associated outbreaks in New York.

Pennsylvania permits the sale of raw milk on the farm and in retail stores under the Pennsylvania Milk Sanitation Law (P.S. Sec. 645). Those selling raw milk for retail must have a permit, as well as their own packaging, labeling, and bottling machines. According to the Kansas State University Food Safety Report and Update of Outbreaks (Kansas State Extension Food Safety), between 1981 and 2007, there have been 6 raw milk-associated outbreaks in Pennsylvania.

By 2003, only 15 states prohibited the sale of raw milk, while 35 permitted its sale in some form, including for pets (Karlsen and Carr, 1970). In February 2007, 27 states allowed the sale of raw milk for human consumption (CDC, 2007). Some outbreaks involving the states mentioned are discussed in the following section.

Pathogenic Organisms & Outbreaks

Escherichia coli O157:H7

Escherichia coli causes diarrhea, nausea, abdominal cramps, and fever, while enterohemorrhagic *E. coli* O157:H7 can cause hemorrhagic colitis (CDC, 2007). *Escherichia coli* O157:H7 can cause hemolytic uremic syndrome (HUS), which leads to kidney failure and ultimately death. *Escherichia coli* causes 73,000 illnesses, 2,000 hospitalizations, and 61 deaths per year in the United States, 8% of which lead to HUS and 4% of those that do cause death (CDC, 2001; CDC, 2007). In 2005, residents in Washington and Oregon became infected with *E. coli* O157:H7 after consuming raw milk through a cow-share program (CDC, 2007). Symptoms of the infections included diarrhea, bloody diarrhea, and abdominal cramps. Five of those infected were hospitalized and 4 resulted in HUS, all between 1 and 13 years old. It was reported that the risk of illness increased with the amount of consumed milk per day (CDC, 2007). In addition to the risk of becoming infected with *E. coli* from drinking unpasteurized milk, there is evidence of person-to-person transmission of *E. coli* (Emund et al., 2007). Some studies have reported that many cases, about 72%, of *E. coli* infections are in fact

asymptomatic, and that person-to-person (secondary) transmission rate is between 4 and 16% (Emund, 2007; Ludwig, 2002; Parry and Salmon, 1998). This is significant because once infected, even though one might be asymptomatic, the pathogen can still be shed in the person's feces, and if proper hygiene is not followed, transmitted to other people.

Listeria monocytogenes

Listeria monocytogenes can cause premature birth, miscarriages, meningitis, septicemia, and gastrointestinal symptoms (CDC, 2001). Symptoms of Listeriosis include fever, headache, stiffness, nausea, abdominal pain, diarrhea, and miscarriages. Therefore, this pathogen is extremely important in regards to pregnant women. During 2000-2001, 12 adults from North Carolina became infected with *L. monocytogenes*. The source was cheese made from contaminated raw milk of a local dairy. Ten of those affected were pregnant women, which resulted in 5 stillbirths, 3 premature deliveries, and 2 infected newborns (Bren, 2004). From 1982-1983 there was an outbreak among rural Iowa children associated with drinking raw milk in which 53 persons became ill. In January of 2008, 3 people died from *Listeria* bacteria in Massachusetts, and 5 others had symptoms. One of those infected miscarried (Associated Press, Jan. 8, 2008). The three who died were 78, 75, and 87 years old, while another elderly man and woman survived, but the woman was pregnant and miscarried (Associated Press, Jan. 8, 2008). This outbreak, however, was due to consumption of milk that was contaminated after pasteurization, an incidence that is rare but occasionally happens nonetheless. This incidence further demonstrates the need for adequate pasteurization, since pasteurized milk can easily become contaminated if it accidentally comes into contact with pathogens from raw milk.

Campylobacter jejuni

In Wisconsin in 2001, 75 people became ill with *C. jejuni*. All but 5 of the patients had consumed unpasteurized milk and symptoms included diarrhea, abdominal cramps, nausea, bloody diarrhea, and fever. The dairy from which the persons obtained milk had a cow-leasing program, since it is illegal to sell raw milk in Wisconsin. It should be noted the dairy sold Grade "A" raw milk (CDC, 2002). The survival of *C. jejuni* in unpasteurized milk stored at refrigeration temperature was studied and one strain survived up to 21 days. It was determined that the presence and persistence of *C. jejuni* in

Grade “A” raw milk further affirms the need for pasteurization (Doyle and Roman, 1982). In addition to secondary transmission of *E. coli*, person-to-person transmission of *C. jejuni* has also been detected (Blaser and Reller, 1981), which means even greater public health risks since non-consumers can be affected. There were 20 *Campylobacter* outbreaks in 11 states between 1981 and 1990, involving 458 infections. Each person infected claimed to have consumed raw milk (Wood et al., 1992). In Utah in 2003, consumption of raw milk occurred at a high school athletic dinner, even though raw milk sales in Utah are illegal. Symptoms of those affected were diarrhea, abdominal pain, vomiting, nausea, body aches, headache, and chills. Thirteen of the 15 people who drank the milk became ill (Peterson, 2003). *Campylobacter jejuni* survives for weeks in milk kept at 4°C, so pasteurization is the only way to completely eliminate the risk of Campylobacteriosis. This became apparent through a study after an outbreak in Arizona in 1981. The outbreak involved nearly 200 cases of *C. jejuni* enteritis and households with members who consumed raw milk had significantly more diarrheal illness than households in which raw milk was not consumed by any member (Taylor et al., 1982).

It is important to note that not all cases of infection or illness are reported to the CDC and it is impossible to receive data from every individual affected. Only 9 of 15 different outbreaks of *Campylobacter* between 1981 and 1988 were reported to the *Campylobacter* national surveillance system at the CDC (Wood et al., 1992). Additionally, during many of the outbreaks, when cows were tested for the pathogen, the pathogen was not detected. Therefore, even though dairies might test for pathogens, the tests might not always be positive even though pathogens have contaminated the milk.

***Salmonella* Typhimurium**

Salmonella is associated with about 1.4 million foodborne illnesses per year, 16,000 hospitalizations, and 580 deaths (Mead et al., 1999). During 2002-2003, infections due to *Salmonella enterica* serotype Typhimurium in two children required them to be hospitalized, while 60 other consumers in Illinois, Indiana, Ohio, and Tennessee fell ill from drinking raw milk from an Ohio farm. Sixty-two people became ill; 40 were customers, 6 lived in the same household as someone who consumed raw milk, and 16 were dairy workers. Signs of illness included diarrhea, fever, chills, cramps, bloody

diarrhea, nausea, vomiting, headache, and body aches. The sale of raw milk is legal in Ohio and at the time, the dairy was the only one in Ohio selling raw milk legally. However, its license for selling raw milk was revoked after the outbreak. Today no businesses in Ohio sell raw milk legally (CDC, 2003).

Another outbreak involved unpasteurized milk in Pennsylvania in 2007, where raw milk sales are legal; 29 cases were reported. Although the dairy stopped selling milk, and after inspections maintained two consecutive negative cultures from milk samples, when they were allowed to sell milk again weeks later, *Salmonella enterica* serotype Typhimurium again caused illness in three other people, who used raw milk from the dairy to make and consume cheese from a local Hispanic grocery store. Two of the 29 were hospitalized (CDC, 2007).

Although there are many cases of outbreaks associated with direct raw milk consumption, there have been a few reported outbreaks associated with consuming pasteurized milk. However, in each of these cases, the milk was either not adequately pasteurized or contaminated after pasteurization. Between 1960 and 2000, there have been 12 outbreaks associated with pasteurized milk, 7 from contamination after pasteurization. One such case occurred in Pennsylvania and New Jersey involving *Salmonella enterica* serotype Typhimurium in 2000. This particular outbreak involved multidrug resistant strains that were resistant to ampicillin, kanamycin, streptomycin, sulfamethoxazole, and tetracycline. Antimicrobial drugs are used to treat persons with Salmonellosis and can be life saving. Antimicrobial resistance limits treatment options and might lead to more deaths.

Conclusions

Scientific studies present substantial and sufficient data that pasteurization does not significantly change the human nutritional value of milk. Multiple studies also prove that pasteurization effectively kills pathogenic bacteria in raw milk. With the rise of multi drug resistant strains of bacteria, the need for effective pasteurization to kill bacteria in

milk is ever more pressing. Historical data has shown clearly that pasteurization has decreased the spread of potential milkborne diseases, such as tuberculosis. Finally, the chance that consuming raw milk might help prevent allergies should be weighed by the more likely chance that one will acquire pathogenic bacteria that could be life-threatening.

The debate between the importance of public health verses the personal right to hold to a “true belief” is circumstantial. Merely believing that raw milk is beneficial to health does not void the lack of scientific data to support such a belief. Once studies are conducted to prove actual health benefits of consuming raw milk instead of pasteurized milk, then the argument might prove more effective. The data are unequivocal; states in which the sale of raw milk is illegal have fewer milkborne outbreaks of disease, while states in which the sale of raw milk is legal continue to have battles between raw milk producers and their consumers becoming ill. In order to drastically reduce the number of raw milk associated outbreaks per year, states should not only deem it illegal to sell and consume raw milk, but should also ban cow-share programs. Once these measures are put into place and consumers fully realize the benefits and need of a pasteurized milk supply, milkborne, and thus foodborne outbreaks swiftly decline.

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