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Raw Milk Consumption and Health

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SUMMARY
Contrary to the safe practices of milk pasteurization or sterilization, which effectively reduce foodborne outbreaks incidence associated with raw milk and dairy products use, outbreaks caused by such products continue to occur. Despite this fact, a worldwide movement advocating for the rights of raw milk and cheese selling and consumption, due to their specific nutritive characteristics, has strengthened significantly in recent years. Traditional agricultural manufacturers from Serbia still sell products related to thermally unprocessed milk, such as cottage cheese and raw cream. In AP Vojvodina during the period of 1981-2010 a total of 179 foodborne outbreaks were reported, where the incriminated cause of the outbreak were milk or diary. In 126 (70.39%) outbreaks, totaling 2276 sick individuals and one casualty, it was confirmed that the incriminated food was from the group of dairy products. In 48 instances (26.82%), bacteriological tests confirmed that milk and dairy products were excluded as the outbreak causes, while in another 5 (2.79%) outbreaks, microbiological analysis of food failed to confirm any relation to the actual epidemiological instances. In some cases, bacteriological testing of incriminated foods was not possible. In the cases of outbreaks associated with the consumption of milk and dairy products, traditional raw milk products were cited as being used. Consumption of unpasteurized milk and cheese represents public health threat. National and international rules ensuring use of safe products for human consumption have to set rules of trade of thermally processed milk and products on the market.
Keywords: raw milk; pasteurization; food safety; health

INTRODUCTION

High quality of milk and dairy products is very well known. They are an integral part of a balanced diet, providing energy, essential nutrients and protective substances necessary for individual's adequate growth, development and good health. Human milk is an ideal food for newborns and infants aged up to 6 months and beyond, and with the introduction of food from other groups it forms the basis of the child's nutrition. Besides human, milk from other mammals, technologically adapted to nutritional and other needs of humans is a part of regular diet. Milk and dairy products significantly contribute to intake of calcium, phosphorus, riboflavin, vitamin B_{12}, potassium, vitamin A, zinc, magnesium and proteins [1]. Introduction of milk and dairy products contributes to the prevention of certain chronic diseases, such as obesity, high blood pressure and type 2 diabetes [2]. As an excellent sources of calcium, milk and dairy products contribute to the proper development of bones, to dental health, as well as to the prevention of osteoporosis and oral health in advanced age [2, 3].

Despite nutritive and health benefits associated with consumption of milk and dairy products, there is a potential public health risk associated with consummation of raw milk and products made from unpasteurized milk. They could be a source of pathogenic microorganisms which could cause damage to human health or become epicenters of foodborne diseases [4]. Special risk of developing these diseases is evident among immunocompromised patients, children and pregnant women [5, 6].

MILK AND DAIRY PRODUCTS – SAFETY RELATED ISSUES

Milk is rich with nutrients, has neutral pH, liquid consistency, and is an excellent medium for bacterial growth, which depends mainly on the temperature and presence of competitive microorganisms and their metabolic products [7]. In raw milk, in addition to bacteria that live as saprophytes on the surface of animal skin or in their mammary glands, pathogenic microorganisms (*Salmonella spp, Listeria monocytogenes, Escherichia coli O157: H7, Campylobacter jejuni, Staphylococcus aureus, Yersinia enterocolitica, Mycobacterium tuberculosis, Coxiella burnettii*) could be found [8]. Despite stringent sanitary measures, mere milking procedures, collection, storage, transport, preservation and other processes can potentially lead to unintentional contamination of milk by pathogenic environmental microorganisms, infected persons or chronic germ carriers [9, 10].

Dairy products are derived exclusively from milk; some additives are allowed, just to make the production possible and if they are not intended to partially or completely replace any dairy component [11]. European regulations, similar to domestic national legislation, under

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the category of raw milk imply the product of mammary glands of properly fed farm animals. According to the definition, raw milk is not treated at temperatures higher than 40°C or by any other procedure having equivalent effect. Further, dairy products made from raw milk are considered to be processed products made from raw milk, or those obtained by further processing of such products [12, 13].

The quality and safety of milk and dairy products are more precisely regulated by the international and national regulations and standards, which define nutritional, physical, chemical, physicochemical and sensory properties, composition of milk and dairy products, as well as microbiological safety criteria. High quality milk contains a small number of somatic cells and a small total number of bacteria; it does not have pathogenic microorganisms or residues of antibiotics [4]. According to the regulations that aim to ensure the safety and suitability of milk (cow, sheep, goat and buffalo's) for human consumption, only heat treated milk (pasteurized or sterilized) is allowed to be put on the market, while raw milk has to meet sanitary provisions regulated by the Regulation (EU) No 605/2010 [14]. Current microbiological criteria for raw cow's milk are defined by specific hygiene rules for food of animal origin covered by the Regulation (EC) No 853/2004, as well as by the national regulations governing this area. Total plate count at 30°C and somatic plate count per milliliter must be less than 100,000 and less than 400,000, respectively [12, 13, 15]. According to the Regulation 178/2002 and national Food Law, raw milk intended for human consumption must be free of pathogenic microorganisms [16, 17]. Despite a significant improvement of hygienic conditions in milk production in the European Union and the reduction of total plate count per milliliter (less than 20 000 cfu/ml), there is no absolute certainty in the absence of pathogenic microorganisms in raw milk. Most frequently reported foodborne infections related to raw milk consumption are caused by *Campylobacter spp., Salmonella spp*. and *E. coli O157: H7* and pathogenic *E. coli non-O157:H7* [7]. Bacteria can originate even from clinically healthy animals, or milk contamination could be caused by environmental factors [4].

According to the Statistical Office of the Republic of Serbia, out of total amount of cow milk produced in 2012 (1418 hl in RS and 352 hl in Vojvodina), only one half (52%) was collected and delivered by approved dairy plants, following their standards, while the other half was used on the farms [18]. On the other hand, cow milk produced in EU countries was mostly (91%) delivered to a dairy plants or to collection centers [19]. There is no accurate data available on the quantity of raw milk and dairy consumed in the European countries or in the Republic of Serbia.

PASTEURIZATION

Pasteurization should destroy pathogenic bacteria, yeast, mold, and most of the living microorganisms that can be found in raw milk, generally resulting in improved milk safety. Pasteurization causes inactivation of enzymes responsible for milk spoilage and reduces the number of "spoilage bacteria" thus increasing the usability and shelf-life of products [20, 21]. Rapid cooling and aseptic packaging also contribute to the safe management of final products and extends the usability of milk and products made from thermally treated milk [21]. Procedures ensuring compliance with the microbiological criteria for milk safety are shown in Table 1. They mainly involve the use of certain higher temperatures during specific time period, but modern procedures also include other physical processes.

Thermal treatment of milk can alter sensory, as well as its nutritional properties due to the number of chemical, biochemical and physical reactions occurring during heat-

Table 1. Procedures for ensuring microbiological safety of milk

Procedure	Temperature	Time	Duration and characteristics of the process
Thermization	57-68°C	15-20 s	Pretreatment extends shelf life, but does not inactivate all vegetative forms of microorganisms
HTST pasteurization	71-74°C	15-40 s	Up to 28 days at 4 °C. Destroys all vegetative forms of m.o., but does not destroy already formed resistant toxins and spores of *C. botulinum* or *B. cereus*
ESL Ultra pasteurization	135-150°C	1-2 s	45-80 days at 4°C
Sterilization	110-120°C	10-20 min	6-12 months
Direct UHT pasteurization	135-140°C	6-10 s	6-12 months Destroys all vegetative and sporulent pathogens and their toxins
Indirect UHT pasteurization	140-150°C	2-4 s	6-12 months Destroys all vegetative and sporulent pathogens and their toxins
ISI	150–200°C	0.1 s	Destroys all vegetative and sporulent pathogens and their toxins
Microfiltration	Application of membrane filter for suspended particles using microfilters with pore size between 0.1 and 10 µm. Effective in eliminating bacterial spores, particularly in combination with the application of pressure		
PEF	Alternative to conventional heat treatment for fluid and semifluid food. Limited effectiveness for sporulent forms of microorganisms and for enzyme inactivation		
Ionizing radiation	Non-thermal treatment, use of ionizing radiation is not accepted as a method in production of organic milk and dairy products		
Processing under high pressure	Non-thermal effect; food is exposed to a pressure of 3,500 to 7,000 kg/cm^2. *E. coli* and *L. monocytogenes* are most resistant microorganisms to pressure at room temperature; no change of enzymatic activity.		
Sonication	"Bombing" of milk by ultrasonic waves with frequencies higher than 20 kHz, which heats up milk and destroys microorganisms at significantly lower temperatures, without protein denaturation		

HTST – high temperature, short time; ESL – extended shelf-life; UHT – ultra-heat treated; ISI – innovative steam injection; PEF – pulsed electric field

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ing: destruction of microorganisms, enzyme inactivation, protein denaturation, loss of nutrients, or creation of new components [22].

Influence of milk pasteurization on public health can be illustrated by the number of diseases transmitted by food and water throughout history. Prior to pasteurization era at the end of the 19th century, diseases related to the consumption of thermally unprocessed milk and dairy products were relatively common [23]. According to the Food and Drug Administration (US FDA), one fourth of all water and foodborne disease outbreaks in the United States before 1938 were associated with milk, while at the present time, the percentage of such outbreaks is reduced to less than 1% [24]. In other developed countries this percentage ranges between 1% and 5% [25]. Pasteurization and heat treatment of milk, as an important public health measures, are encouraged by a number of international organizations: World Health Organization [26], Codex Alimentarius Commission (9), US FDA [27], European Centre for Disease Prevention and Control [28], Center for Disease Control and Prevention of the United States [29] as well as other professional, legal, educational and public health authorities, emphasizing public health risks coming from unpasteurized milk and dairy products consummation.

ORGANIC PRODUCTS

Simultaneous increase of organic milk production and dairying has been noticed together with the growing interest in natural and organic food. Republic of Serbia has been recognized as a country with natural predispositions for organic agriculture development, organic farming and production of organic milk and dairy products [30, 31]. Similarly to conventional production, in the cases of organic milk and dairy production, all regulatory standards and measures ensuring microbiological safety of products have to be met [32, 33].

In addition to increased demands for organically produced milk, there is a growing number of consumers, both in rural and urban areas, who choose to use raw, thermally unprocessed milk for the reasons of full flavor and specific nutritional and health characteristics [4].

PROPONENTS OF RAW MILK CONSUMPTION

Raw milk advocates, proponents and enthusiasts [4] fight for the right of selling and consumption of raw, unpasteurized milk and its products, despite the facts and best practices of heat treatment of milk that have led to a significant reduction in the frequency of outbreaks of diseases associated with unpasteurized milk consumption. Currently, in many countries a ban exists on selling of packed raw milk to consumers (Scotland, Canada, individual states within the United States of America, Australia). To be able to obtain raw milk, consumers have been using very inventive means, such as: direct purchase from framers, cow-share or leasing programs or procurement of raw milk as food for pets, etc [4].

Proponents of raw milk use point out many nutritional and health benefits of consuming unpasteurized milk, based more or less on scientific evidences (Table 2). They

Table 2. Overview of benefits and risks associated with the consumption of raw vs. thermally treated milk (adapted from [7])

Characteristics	Raw milk	Thermally treated milk
Microbiological risk	Increased risk, especially when it comes to *Campylobacter jejuni, C. coli.*, *Salmonella*, *E. coli O157:H7* and pathogenic *E. coli non-O157:H7*	Reduced risk; the effects of certain types of thermal treatment are given in Table 1
Nutritional properties of raw milk	Important source of calcium, phosphorus, essential amino acids (especially lysine), vitamins B2 and B12	Negligible effect of temperature on these nutritional elements, with the exception of vitamin B2
Antimicrobial enzymes	Low enzymatic activity at a temperature of storage in cooling devices	At low temperatures most enzymatic systems retain activity, while at higher temperatures it is stopped. In sterile conditions further activity of the antimicrobial enzymes is not needed
The beneficial impact of milk enzymes	No scientific evidence of this impact	Inactivation of most enzymes by thermal procedures as well as in the digestive tract
Lactic acid bacteria	Limited growth at temperatures of storage environment	Inactivation by all thermal processes; following pasteurization germination of spores is possible, which can lead to contamination of the final product
Probiotic bacteria and influence on gastrointestinal tract	Limited growth of probiotic bacteria	Destruction of probiotic bacteria in thermal processes
Lactose disintegration	Lactose content in raw and thermally treated milk is similar. Lactose production at environmental temperature of storage spaces is insignificant	Degradation of small portion of lactose at ultra high temperatures, with the formation of lactulose which has nutritional value
Allergies to milk and lactose intolerance	Presence of allergenic components and lactose in raw milk	Presence of allergenic components and lactose in raw milk
Effect on immunity	Documented outbreaks associated with raw milk; non-significant scientific evidence in favor of increased immunity due to consumption of raw milk	Significantly fewer outbreaks associated with the consumption of thermally treated milk
Diabetes, osteoporosis, arthritis, asthma	Scientific data are limited and controversial	Irrelevant
Sensory characteristics: flavor, color	Whole milk is of standard taste, and generally has lower fat content compared to raw milk. Raw milk has "fuller" taste in comparison to other milk types	Changes in taste and color (brownish color) with the application of high temperature

state that pasteurization destroys some of nutrients present in raw milk and microorganisms beneficial to humans, together with destruction of pathogenic microorganisms. They claim that raw milk can prevent and even treat certain diseases and conditions, such as allergies, lactose intolerance, and even some forms of cancer. These claims have led to extensive professional and scientific debate and analysis of scientific evidences pro vs. cons of raw milk consumption [4, 21, 34, 35].

While scientific evidences pasteurized milk safety are well argumented, health and nutritional benefits, as well as the quality and comparative composition of raw and conventionally treated milk are still the subject of numerous studies, many of which have been conducted in our country [36, 37, 38].

Conducted meta-analysis using the studies of pasteurization effects on vitamins from milk, as well as the connection of raw milk consumption vs. health effects, indicates that pasteurization effect on milk vitamins is minimal, primarily due to the fact that the vitamins in milk are naturally present in very low concentrations [21]. Milk is a significant source of vitamin B2 only. Results of six studies have shown a certain positive protective effects in the cases of some allergies development, which should be looked into further. Additionally, published studies have not found a positive association between raw milk consumption and cancer treatment, nor lactose intolerance [21].

LEGAL STATUS

Although placing milk on the markets in most EU countries implies that it is thermally treated, the Regulation No 605/2010 specifies conditions for the introduction of raw milk and dairy products intended for human consumption on the market, as long as required sanitary standards are met. This regulation has been introduced due to significant influence of the countries members (mostly from the Mediterranean region) which have a long tradition of production and use of raw milk and cheeses produced from untreated milk. In France, raw milk products are considered the standard of high quality products [39]. In Germany, farmers are issued licenses for trade of packed raw milk; packages have to be clearly labeled, having basic information for customers, while unpackaged products must carry a warning that the milk is raw and treatment by heating is required. While in Scotland selling of raw milk is not allowed, in England, Wales and Northern Ireland a large number of farmers deliver raw milk and products made from it directly to consumers, with a warning that the product has not been thermally treated and may contain harmful microorganisms. Selling of such milk in retail stores, use for catering, at hotels, hospitals and schools is not allowed [40]. In the rural countries of Middle East, Asia and Africa, ban on unpasteurised milk selling either does not exist, or has not been applied. In the U.S.A., 28 of states do not prohibit selling of raw milk, while both in Canada and the U.S.A. selling of cheeses made of raw milk and matured over 61 days is allowed [41]. In Serbia, raw milk and cheeses made from unpasteurized milk are sold in informal markets (directly from small producers or re-sold at the markets). Similarly, traditional farmers in AP Vojvodina still offer products of thermally unprocessed milk (cottage cheese and raw cream) at the markets.

OUTBREAKS ASSOCIATED WITH MILK CONSUMPTION

Despite safe practices of milk pasteurization or sterilization (effective in reducing the incidence of foodborne outbreaks associated with the consumption of raw milk and dairy products) outbreaks connected to their use still occur [42].

Recently, the U.S. Center for Disease Control and Prevention has reported results of analysis of registered foodborne disease outbreaks associated with milk and dairy products during a thirteen-year period (1993-2006). According to this study, in all 50 states the rate of outbreaks caused by unpasteurized milk and products was substantially greater compared to outbreaks linked to pasteurized milk. The study also showed that the outbreaks associated with raw milk and products had led to much more severe diseases and disproportionally affected younger individuals vs. outbreaks which involved pasteurized milk and dairy products. The study revealed that 13% of patients in raw milk associated outbreaks were hospitalized with severe disease course, compared to 1% of patients in outbreaks linked to pasteurized milk and dairy products (often caused by relatively mild infections with *Noroviruses* or *Staphylococcus aureus*). Those states, where it is legal to sell raw milk and products, had more than duple outbreak rates compared to the states where such selling practice is not legal. There is a small number of outbreaks, as well as less severe clinical forms of diseases in the states where a ban on selling unpasteurized products is in place [29].

In Vojvodina, during the 1981-2010 period, out of the total of 179 reported foodborne outbreaks in which the incriminated food belonged to milk or diary food group, in 126 (70.39%) outbreaks, totaling 2276 patients and one fatal outcome, it was confirmed that the incriminated food belonged to that food group of products. In 48 (26.82%) outbreaks, bacteriological analysis revealed that other kinds of food led to an outbreak, and in another 5 (2.79%) outbreaks microbiological analysis did not provide evidence supporting causal relationship between controlled food and outbreaks themselves. In some cases, bacteriological testing of incriminated foods was not possible. According to the available data, in the cases of outbreaks associated with the consumption of milk and dairy products, traditional products made of raw, thermally unprocessed milk were most often mentioned as food used [43, 44].

CONCLUSION

The consumption of raw milk is a realistic and unnecessary health threat, due to possible presence of patho-

genic bacteria that may have a significant impact on human health. Treating raw milk by heat, to ensure product safety, is necessary to overcome potential health and nutritional benefits of raw milk consumption. Therefore, from a perspective of public health, the heat treatment of raw milk, especially when it comes to vulnerable population groups, such as children, pregnant women, or people with chronic diseases or suppressed immune system, and in cases where large groups of customers depend on one source of food (hospitals, schools and pre-school institutions, catering, etc.) is absolutely recommended. At this point, despite significant changes in the sensory properties of milk, heat treatment of raw milk and dairy products remains most commonly used and most effective way to increase microbiological safety of milk without important changes of health and nutritional value of its product. Request that raw milk appears on the market, per se represents a significant additional liability for both producers and regulators.

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Употреба сировог млека и здравље

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КРАТАК САДРЖАЈ

И поред тога што су пастеризација и стерилизација млека сигуран и ефикасан поступак који је довео до смањења учесталости алиментарних епидемија повезаних с употребом сировог млека и млечних производа, епидемије изазване овим производима се и даље дешавају. Насупрот томе, током последњих година у свету је оснажен покрет који се бори за право конзумирања термички необрађеног млека и сира, и то због специфичних нутритивних особина сировог млека. Традиционални пољопривредни произвођачи у нашој земљи и даље у промет стављају производе од термички необрађеног млека („швапски" сир и милерам). У Војводини је у периоду 1981–2010. године, од 179 пријављених алиментарних епидемија у којима су инкриминисане намирнице биле млеко или млечни производи, у 126 (70,39%) епидемија с укупно 2.276 оболелих особа и једним смртним исходом потврђено да је инкриминисана намирница припадала групи млека и млечних производа. У случају 48 (26,82%) епидемија, бактериолошком анализом је утврђено да су друге врсте намирница довеле до епидемије, а у још пет (2,79%) епидемија бактериолошком анализом није потврђено да су контролисане намирнице довеле до настанка епидемије. У појединим епидемијама није било могуће микробиолошки испитати инкриминисане намирнице. Према расположивим подацима, у епидемијама које се повезују с коришћењем млека и млечних производа, као употребљене намирнице најчешће се помињу традиционални производи од термички необрађеног млека. Конзумирање непастеризованог млека и сира реална је здравствена претња становништву. Међународни и национални прописи чији је циљ да осигурају сигурност и прикладност производа за исхрану људи прописују стављање у промет термички обрађеног млека и млечних производа.

Кључне речи: сирово млеко; пастеризација; безбедност хране; здравље

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