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Viewpoint

World wide traditional cheeses: Banned for business?

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Abstract – Traditional cheeses are characterized by strong links to their territory of origin and are testimonial of the history and the culture of the community that produces them. Every traditional cheese originates from a complex system which results in unique organoleptic characteristics. The development of these unique characteristics is linked to several biodiverse factors: the environment, the climate, the natural pasture, the breed of the animals, the use of raw milk and its natural microflora, the cheesemaking technology with the unique role of human beings rather than automated technology, historical tools as well as the natural aging conditions. In many countries traditional products are almost banned, even in Europe, despite Article 8 of the Directive 92/46 of the EEC, which grants derogations for the manufacture of cheese with a period of aging or ripening of at least 60 days. Issues relating to "food safety" are frequently given as a "false" argument to explain the banning of traditional products. Reviews of food safety outbreaks have demonstrated that raw-milk cheeses do not pose any greater risk than industrial cheeses made from pasteurized milk. Improper pasteurization, post-processing contamination, storage and cross-contamination are the main contributing factors that are responsible for these outbreaks. Traditional cheeses cannot be identified simply by the use of "raw milk"; there are a "multiplicity of practices" that have the potential to make safe products. The challenge for the research community is to demonstrate the role and the importance of those practices to deliver the maximum safety benefits to the consumer. Eliminating the production of traditional cheeses would make it much easier to market industrial products. However, consumers would lose the opportunity to compare the natural aroma, the health benefits, the cultural background as well as the biodiversity of traditional products.

traditional cheese / food safety / health property / biodiversity / raw milk

摘要 – 全世界传统干酪的贸易禁令。传统干酪与其生产地域、历史、文化内涵息息相关的。 每种传统干酪特有的感官特性与其形成的多种生物因素有关，如环境、气候、自然放牧、动物的种类、生鲜乳及其自然的微生物菌落、特定人群采用的手工加工技术、原始的加工工具以及自然成熟的条件等因素。 在许多国家传统干酪是禁止生产，甚至在欧洲也是如此，尽管欧共体 92/46 指南中条款 8 中不包括成熟期在 60 d 以上的干酪。 传统干酪被禁止的原因主要是食品安全问题。 大量的研究文献证明由生鲜乳生产的干酪与巴氏杀菌乳干酪一样不存在食品安全的危险。 不适当的巴氏杀菌、后处理过程中污染、贮藏和交叉污染是病原菌爆发的主要原因。 传统干酪不能简单的定义为由生鲜乳制成的干酪，实际上所采用的“多重性加工技术”能够保证干酪产品的安全性。 科研人员通过大量实验证明这些加工过程可以最大程度地保障消费者的食用安全性。 取消传统干酪也许会扩大工业化生产

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干酪的市场需求，但对消费者来讲将没有机会去品尝美味、有益健康、赋予文化内涵和丰富多彩的干酪。

传统干酪 / 食品安全 / 有益健康 / 生物多样性 / 原料奶

Résumé – Les fromages traditionnels dans le monde : bannis des affaires. Les fromages traditionnels sont caractérisés par un lien fort avec leur terroir d'origine et attestent de l'histoire et de la culture de la communauté qui les produit. Chaque fromage traditionnel provient de systèmes complexes qui lui donnent des caractéristiques organoleptiques spécifiques. Ces caractéristiques sont liées à divers facteurs de biodiversité, comme l'environnement, le climat, la prairie naturelle, la race des animaux, l'utilisation de lait cru et de sa microflore naturelle, la technologie fromagère s'appuyant sur le savoir-faire unique des hommes et non pas sur une technologie automatisée, les outils historiques et enfin les conditions naturelles d'affinage. Dans de nombreux pays, les produits traditionnels sont presque interdits, même en Europe, malgré l'article 8 de la Directive 92/46 de la CEE qui accorde des dérogations pour les fromages affinés plus de 60 jours. La « sécurité alimentaire » est fréquemment utilisée comme prétexte pour interdire les produits traditionnels. Les travaux de synthèse concernant les toxi-infections alimentaires collectives ont démontré que les fromages au lait cru n'apportent pas plus de risques que les fromages industriels fabriqués à partir de lait pasteurisé. Les principaux facteurs impliqués dans les toxi-infections alimentaires sont une pasteurisation incorrecte, une recontamination après traitement, les conditions de stockage et des contaminations croisées. Les fromages traditionnels ne peuvent pas être simplement définis d'après l'utilisation de lait cru pour leur fabrication ; une multitude de pratiques ont un potentiel pour faire de ces fromages des produits sûrs. Le défi pour les chercheurs est de démontrer le rôle et l'importance de ces pratiques pour apporter le maximum de bénéfices sécurité au consommateur. Éliminer les fromages traditionnels faciliterait la commercialisation des produits industriels. En revanche, les consommateurs perdraient l'opportunité de comparer la saveur, les propriétés santé, le contexte culturel et la biodiversité des produits.

fromage traditionnel / sécurité alimentaire / propriété santé / biodiversité / lait cru

1. INTRODUCTION

In recent decades raw-milk cheeses have been categorized as "risky" foods. In many developed countries, traditional products are almost banned, even in Europe, despite the exceptional derogation of Directive 92/46 Article 8 of the EEC [14]. Article 8 of the Directive grants derogations for the manufacture of cheese with a period of aging or ripening of at least 60 days, laying down the health rules for the production and placing on the market of raw-milk, heat-treated and milk-based products. Member states may grant individual derogations from milk-based products requirements (including milk quality control, preparation in processing establishments, wrapping, packaging and labeling), provided that milk used in the manufacture of such products is obtained from cows which do not show symptoms of tuberculosis or brucellosis or any other infectious diseases communicable to human beings and which are in a good general state of health.

We believe that most of the time, even in the scientific community, there is a lack of understanding of what "traditional cheeses" are, how they are produced, whether they are microbiologically risky foods, what they represent and why many governments have tried to ban them. This paper attempts to give some answers to these questions based on the review of scientific publications and on CoRFiLaC's research activity during the last two decades.

CoRFiLaC is a dairy research center based in Ragusa, Italy. CoRFiLaC's main activity is the study of traditional Sicilian dairy products with a chain approach that aims "from the farm to the fork" (i.e. from animal nutrition to consumers' behavior) to evaluate the peculiarity of each traditional cheese under study.

2. TRADITIONAL CHEESES: THE REAL VALUE

To emphasize the importance of world wide traditional cheeses does not mean a lack of support for industrial products. There is need to educate consumers, the press and opinion leaders to distinguish the difference. These products represent two different worlds. Industrial cheeses have reached considerably good quality, but the meaning of the term "quality" must be interpreted in a different way when we talk about traditional or industrial cheeses. The industrial ones deliver nutritious food (i.e. protein and calcium) and offer convenience at an economical price to the majority of consumers. These products are standardized, deliver consistent quality every day and most of the time are fresh cheeses with mild flavors. The industrial cheeses are usually produced on a large scale by big companies at any place in the world, and producers are able to obtain almost the same final product. Instead, the traditional cheeses are *niche products* that are usually handmade and produced at the farm or village level. These products have a strong linkage to the territory of origin (i.e. orography, landscape, rural architecture and human resources) and therefore are testimonial of the history, of the culture and of the lifestyle of those communities that produce them. Traditional products are neither nostalgia nor simply food, but a unique expression of the symbiotic interaction between human resources, the culture of rural communities and nature. Traditional cheeses are characterized by intense and different flavors, with reasonably high variability even within the cheese variety. These products could either be consumed after few days (e.g. buffalo mozzarella cheese) or aged even for years (e.g. Parmigiano Reggiano and Beaufort). Every traditional cheese originates from complex systems that draw on the peculiar bio-organoleptic characteristics tied to several "biodiversity factors", such as: the environment; the macro- and micro-climate; the natural pasture; the breed of the animals (often native or heritage breeds); the use of raw milk and its natural microflora; the use of natural coagulants; the use of natural ingredients (e.g. saffron, sugar, flour and spice); the cheesemaking technology with the unique role of the cheesemaker and not a computerized machine; the historical tools; and natural aging conditions including the ancestral practice of sun-drying.

Every traditional production system is characterized by the sequence of countless biological and natural processes, each one marked by its natural rhythms. The cheesemaker has to understand, support and coordinate the delicate harmony of the sequence of actions and timing of the cheesemaking and aging process in order to produce the most exciting form of milk, the "cheese".

Every biodiversity factor involved in the production system of a specific traditional cheese will represent the specificity of the territory and the cheesemaking culture that has been handed down from generations. These factors will synergically influence the quality of the final products. Considering that traditional cheeses are obtained with full respect of nature, their quality must be evaluated not just in terms of nutrient (i.e. protein, fat, etc.) but for their health properties, aroma and sensory profiles and for the social impact in the communities and for the role they play as protectors of the environment.

From the economic point of view, we must also consider that milk price, for different reasons, in many countries is dropping down, and small size farms will soon be out of business. Making traditional cheeses with low investment on new equipments appears to be one good and effective solution to continue to be on the market. Furthermore, producing high-quality traditional cheeses may give the opportunity to gain higher value for milk that is used for making traditional cheeses compared to the price of milk that is sold to the industries to produce fluid milk or standard cheeses. The farm organization will be completely different, but we strongly believe that it is a great opportunity for the small farmers to compete successfully on the market.

At the present time, thousands of traditional cheeses are produced world wide, and these products have fed billions of people for centuries, but very little scientific work has been done for investigating these kinds of cheeses. Grant for studying these niche products has been difficult to obtain. However recently, the European Commission has financed an integrated project to improve the quality and safety of Traditional European Food (TRUEFOOD) by introducing innovation into traditional food industry. Governments and public institutions should support these studies because the actual importance of these cheeses goes beyond their commercial value, and is much higher for the social and environmental protection roles. The challenge for researchers is to demonstrate that traditionally produced cheeses are "different" and characterize them for their health and aromatic properties, for their food safety qualities and further establish criteria for territory markers (geographic indications and geographic protections).

3. TRADITIONAL CHEESES IN THE GLOBAL CONTEXT

The era of globalization has almost accelerated the demise of small-scale food production systems. Stiglitz affirms that globalization is mainly an economic phenomenon [58]. The market fundamentalists and the multinational companies play a crucial role in any world wide decision, they believe on the business for business, without due respect to the social, cultural and historical origins of traditional foods.

The multinational companies work following the rules of the market which is finalized to the profit, without any obligations for the states, for the parliaments and for the general interest of the communities. The actual world wide condition is that "territories are without power and are depending on the power of multinational company without territory" [30].

The multinational companies work under globalization by standardizing products, erasing the influence of territorial peculiarity (e.g. pasteurizing the milk and delocalizing the production), introducing high technology and low labor cost, cutting the costs thanks to the delocalization, producing large quantities and mass qualities and positioning the products on the market as "low quality – low price". It is easy to understand that small-scale, handmade production systems cannot compete in the market for price: the only chance for them is to compete for high-quality certified products that is consequence of the scientific characterization and control.

Globalization has destroyed the "local" production system. In the last decade, the new generation of anthropologists, sociologists and economists began to argue on the real meaning of globalization and to encourage doubts on the free market fundamentalism and on the paradigm "the economic development for the economic development" which considers only the profit margin achieved by the owner of the capital [30]. Consequently, it is time to understand that "the development finalized to the development" will depauperate the planet. The planet space is limited, the expected area is 51 billion hectares (ha), with "bioproductive" space accounting for 12 billion ha, equivalent to 1.8 ha per planet inhabitant [6]. A citizen of the USA utilizes 9.6 ha, a Canadian 7.2 ha, a European 4.5 ha on average, a French citizen 5.26 ha and an Italian 3.8 ha. Most of African citizens use up 0.2 ha of bioproductive space and further they produce food for the animals of developed countries [4]. The super economic growth will destroy the planet, the environment, because the waste produced is much higher than what the planet can support. In the era of globalization, it is urgent to consider new strategies for development, where the economic value must no longer be at the center of the system and must become just a simple means to improve the life quality and not achieve the only final objective [9].

It is absolutely necessary to reconsider the social and cultural aspects of the communities of developed and developing countries and hence of the planet, and to define an overall strategy to save the environment.

The importance of the real economy, and not the financial bubble, deriving from natural agriculture must come back to save the planet and to give dignity to millions of rural farmers. For the developed countries, it will be impossible to stop the processes of globalization, but it is possible to reconsider the strategy and the fundamental approach by switching from business to the social principles as Stiglitz suggests using the positive opportunities that the globalization undoubtedly offers [59]. As well, it will be crucial to give back reasonable space to the "localism", to open a direct connection between producers and consumers, to use local seasonal products (recently denominated "km 0") and to appreciate the culture of the communities that from generations handed down their specialty products.

The defense of world wide traditional cheeses has been based on the above considerations, their recognition representing much more of their intrinsic economic value, even if it were crucial. To give economic opportunities to rural farmers producing traditional cheeses in less favored environments will help save it, and more importantly it will give cultural and social recognition to communities that are under the risk of disappearance with unbelievable consequences on social justice and on global peace.

4. CONSUMERS' EXPECTATIONS

The defense of world wide traditional cheeses has also been encouraged by the results of several studies on consumer purchasing behavior. A CoRFiLaC survey based on 933 Sicilian consumer interviews (Fig. 1) suggests that the first seven criteria on cheese purchase intention are: food safety, use of natural ingredients, health properties of the products, local products, protected denomination of origin (PDO), artisanal production and typical flavor [46].

Similar results were found in a California focus group response to sociopolitical questions about specialty cheese purchases, method of production and product benefits [49].

In France, the Sofres survey (http://www.fromages-de-terroirs.com/marche-fromage1.php3?id_article=652, 2005) "les Français et le fromage" on 3000 people interviews in metropolitan area indicates that adults over 36 years old (representing the 36% of the sample) base their cheese preference on the following criteria: quality, PDO certification, sustainability and naturalness. Whereas younger people look for functional products giving importance to price and accessibility.

West affirms that "the expanding market for raw milk cheeses in recent years has been associated with consumer desires for greater traceability in the food system and produce accountability. The corollary of this is that raw-milk cheese makers survive only on good reputation" [66].

The true traceability that CoRFiLaC proposes to define cultural traceability (available at http://www.corfilac.it) is possible especially for these traditional products. For each cheese it will be possible to keep track of each biodiversity factor that is involved in the production system (i.e. animal breed, animal nutrition, milk treatment, cheesemaking and aging technology) and to follow the human influences on the process (i.e. family story, recipes that the tradition suggests, etc.). These are conditions unthinkable for mass productions, for which connections no longer exist among farmers, territories and final products due mainly to mass milk collection and application of high standardized technology (e.g. pasteurization and membrane technologies).

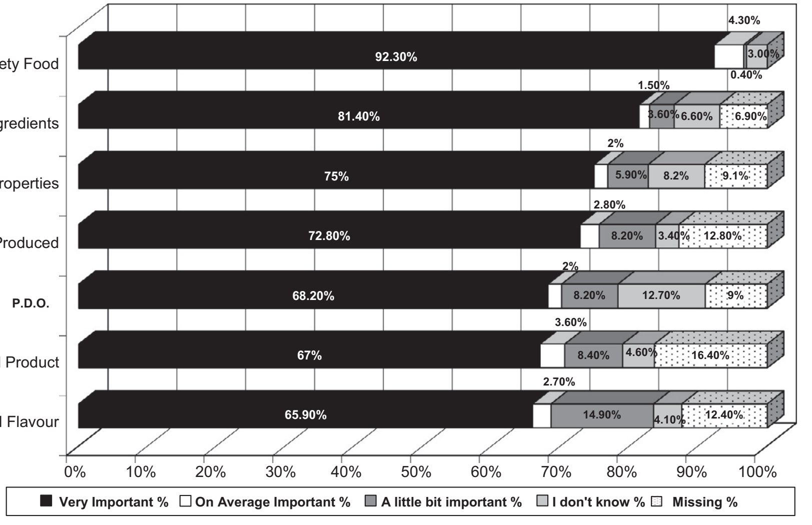

Figure 1. The first seven consumers' criteria in cheese selection of 933 Sicilian consumers (CoRFiLaC, data).

5. BIODIVERSITY FACTORS ON TRADITIONAL CHEESEMAKING

To report a well-documented scientific review of the above-mentioned list of biodiversity factors would need a specific paper; therefore, we are going to present only the results from few relevant studies.

5.1. The importance of traditional tools

The importance of traditional tools such as the "tina wooden vat", to support EU decisions Directive 92/46 EEC [14], 852/2004 [50] and 853/2004 [51], has been studied. Member states may grant individual or general derogations insofar as certain requirements of this directive are likely to affect the manufacture of milk-based products with traditional characteristics, that should cause the leveling off of typical flavors, aromas and smells, conferred by natural dairy microflora which should fail.

The presence of a bacterial biofilm was found on the surface of "tina wooden vat" that is used in the Ragusano PDO cheesemaking process, where no starter cultures are allowed to be used [33]. In fact, the bacterial ecosystem of the tina biofilm quickly and efficiently releases lactic acid bacteria into the raw milk, thereby making the acidification process faster. Thus, tina's use is crucial especially for raw milks with low initial counts of lactic acid bacteria. The amount of yeasts, molds and enterococci was extremely variable from one tina biofilm to another, confirming the farm specificity regarding the microbial profile and consequently the strong linkage with the territory. It was further demonstrated that *Salmonella*, *Listeria monocytogenes* and *E. coli* O157:H7 were totally absent in the 15 tinas studied, which represented 37% of the active tinas in the Hyblean region. These results strongly reinforced the idea of the safety of wooden vat system [35]. The main factors that prevent pathogens from adhering to or surviving in these biofilms are: the acidic conditions measured at the surface of the biofilm (pH < 5) and the competition among the nutrients, as well as the cooking temperature above 40 °C. Further studies are necessary to evaluate the influence of the native microbial ecosystem of the tina biofilm delivered on the raw milk, on the aroma and the flavor of the final product.

5.2. The influence of native pasture on the aroma and sensory profile of the product

The linkage with the territory has been demonstrated in a study concerning the influence of native plants in Sicilian pastures on the aroma compounds that are present in Ragusano cheese [8]. Cheeses that are obtained from milk produced by cows fed with native pasture plants presented more odor-active compounds. In 4-month-old cheese made from milk of pasture-fed cows, 27 odor-active compounds were identified, whereas only 13 such compounds were detected in cheese made from milk of cows fed with total mixed ration (TMR). The pasture cheeses were much richer in odor-active aldehyde, ester and terpenoid compounds compared to cheeses from milk produced by cows fed with only TMR. A total of eight unique aroma-active compounds (i.e. not reported in other cheeses evaluated by gas chromatography-olfactometry) were detected in the Ragusano cheese that was made from milk by cows fed with native Sicilian pasture plants. Furthermore, sensory analysis by trained panelists confirmed the difference between the two experimental treatments [7]. This research demonstrated clearly that some unique odor-active compounds found in pasture plants can be transferred to the cheese and identified by human beings.

5.3. Health properties of milk components

In the last two decades, scientists have increased their interest in studying health properties in foods and also focused their research in milk components with anticancer potential [34, 43–45]. Whey products (i.e. whey protein concentrate, lactoferrin, α-lactalbumin and β-lactoglobulin), peptides, nucleotide, conjugated linoleic acid (CLA) and antioxidants may positively affect many aspects of human health, including antiatherogenic action, enhancement of immunology function, reduction of body fat and anticancer activities.

Cheeses are, further, a rich source of bioactive peptides that are produced during secondary proteolysis through the action of proteinases and peptidases. The bioactive tripeptides valyl-prolyl-proline (VPP) and isoleucyl-prolyl-proline belong to the most potent angiotensin-converting enzyme inhibitory effect with a positive action on human health as antihypertensive [63].

The lipid fraction of dairy products has often been treated as a health concern because of the relatively high content of saturated and trans-fatty acids that adversely influence plasma cholesterol. However, studies have shown that whole milk was more effective in protecting against cardiovascular disease (CVD) than skimmed milk [57]. This may imply that milk fat contains components that may positively influence risk factors for CVD. Among them, the CLA, eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), fat-soluble antioxidants, such as α-tocopherol, β-carotene and retinol, could be envisaged as main players.

5.3.1. The importance of feeding animal fresh pasture on health properties

It has been shown that grazing cows resulted in CLA concentrations 5.7 times higher in milk compared with milk from cows fed with diets containing preserved forage and grain at 50:50 ratio [13]. Grass-based diets, especially pasture, also lead to higher milk β-carotene concentrations than diets rich in concentrates or corn silage.

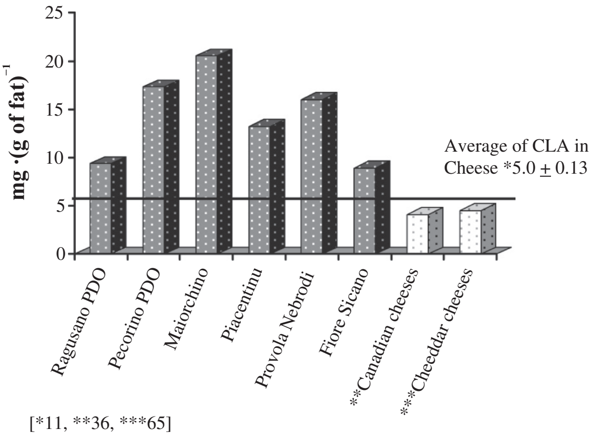

Figure 2. CLA content in the traditional Sicilian cheeses (CoRFiLaC, data) obtained from raw milk produced by grazing animals (▩) compared to USA Cheddar and Canadian cheeses (⬚).

Degradation of carotenoids and retinol is accelerated by increasing temperature and is catalyzed by mineral ions; therefore, pasteurization of milk will be detrimental for these components.

The α-tocopherol concentration in fresh pasture is 4 to 5 times higher than that found in a typical TMR according to National Research Council values [41]. Nevertheless, pasture is unique in terms of increase of polyunsaturated fatty acids and fat-soluble antioxidants. Furthermore, cows fed with fresh pasture produced milk with increased amounts of CLA [26].

In agreement with the above-mentioned research, it was found that CLA, vaccenic acid, EPA and DHA significantly ($P < 0.05$) increased in plasma and in milk as a function of the proportion of pasture in the diet [29]. Such changes in fatty acid composition were accompanied by a concomitant increase in the concentrations of α-tocopherol and β-carotene both in plasma and milk. No change in the retinol content was found in the plasma and milk samples. The increase in EPA, DHA and CLA, β-carotene and α-tocopherol in plasma may have a beneficial impact not only for milk and meat quality, but also for animal and human health.

The level of CLA also increases in the cheeses when they are obtained from raw milk produced by a grazing animal (Fig. 2).

6. FOOD SECURITY ISSUE

6.1. Mandatory pasteurization

In many developed countries homemade traditional products are almost banned under the "false" reason of protecting the consumers in the name of "food safety".

In 1998, a trade group representing American industrial cheesemakers began actively lobbying the Food and Drug Administration (FDA) [62] to require that all cheeses produced and marketed in the US be pasteurized [21, 28]. Big cheesemakers also lobbied the EU to ban raw-milk cheese production and sales [31].

Pasteurization ostensibly allows the industrial producers to eliminate the external risk factors and to focus on factors under their control. In addition, pasteurized milk also affords predictability and controllability in the production process, allowing industrial cheesemakers to reduce wastage, to maximize output and to insure price competitiveness. These fears, and related values, explain why industrial producers work with pasteurized milk, but not why they seek to make pasteurized milk mandatory for all cheesemakers [66].

Furthermore, we need to consider that very few raw-milk cheesemakers (small and/or one-man cheese factories) could afford the purchase of pasteurization equipment even if they wished to acquire it [28, 31]. Offsetting such investment costs would require the expansion of volume, effectively transforming them into industrial producers [31].

Mandatory pasteurization would eliminate the highly distinctive aromas, textures, colors and flavors that raw-milk cheeses afford, all made possible by the biodiversity factors [66].

Under the false objective of food safety, the multinational industries and/or companies try to overlap the traditional productions with the excuse of protecting the consumers.

David Grotenstein asserted: "We know for a fact that the streets of Europe would be littered with bodies and [European] hospitals would be filled to capacity if there were a problem with unpasteurized products", cited by Soref [56]. It seems to be just business, forgetting the real meaning of traditional cheeses that represent: culture, history, lifestyle, sustainable agriculture and respect of the environment. In few words: "banned for business". In 1998, the US FDA initiated the "Domestic and Imported Cheese Compliance Program" with the objectives of inspecting domestic cheese firms during 1998–June 2004 and examining the samples of domestic and imported cheeses for microbiological contamination [62]. The targeted pathogens were: *L. monocytogenes*, *Salmonella*, *E. coli* (and if 104 or above: enterotoxigenic *E. coli*, enterohemorrhagic *E. coli* (0157:H7)) and *Staphylococcus aureus*. The FDA tested a total of 17 324 domestic and imported cheese samples and conducted 1619 total inspections during the period January 1, 2004 to December 31, 2006. The results revealed that only 3 out of 3360 (0.09%) samples tested were positive for *E. coli* 0157:H7; only 52 out of 2181 cheese samples (2.4%) were positive for *L. monocytogenes*; only 1.3% (45 out of 3520) samples tested were positive for *Salmonella*; and out of 3449 cheese samples tested, 239 (6.9%) were positive for *S. aureus*. Contamination rates were similar for domestic and imported cheeses, ranging from 5.5% to 7.4% (Dr. Catherine Donnelly, University of Vermont, personal communication). Donnelly concluded that: "The results reaffirm the microbiological safety of domestic and imported cheese. These data highlight the low incidence of foodborne pathogens in cheeses, in general, and suggest that current regulations (pasteurization/60 days rule) are working to protect public health. Increased regulatory focus should be given to Mexican-style soft cheeses, particularly those produced in Mexico/Central America" [15].

6.2. Outbreak linked to dairy products

Many researchers have reviewed published outbreaks associated with dairy products, and results indicate that raw-milk cheeses are no more riskier than industrial cheeses made from pasteurized milk. Improper pasteurization, post-process recontamination, storage and cross contamination are the main conditions responsible for outbreaks.

A review of raw-milk cheese safety from the epidemiological literature (1948–1988) revealed that: six outbreaks of illness were related to US produced cheeses; post-pasteurization contamination was cited as the most frequent cause of outbreaks; only one outbreak in US and Canada involved the use of raw milk; and no outbreaks were linked to hard Italian cheese varieties (Parmesan, Romano and Provolone) [25].

Another review on all cheese-associated outbreaks reported to Centers for Disease Control and Prevention (CDC) with onsets during 1973–1992 concluded that in 132 cheese-associated outbreaks just 11 could be attributed to contamination at the farm level, during manufacturing or processing. No outbreaks reported to the CDC during 1973–1992 were associated with raw-milk cheese aged for 60 days [2].

A study in 1976 reported 339 clinically confirmed cases from a cheese-related outbreak and 28 000–36 000 additional suspected cases due to seven lots of Cheddar cheese manufactured "from pasteurized milk" that was contaminated with *Salmonella heidelberg* [17]. The authors' indications were: the cheeses had been aged for < 60 days, and the pH was relatively high (5.6), which may have influenced the survival of the pathogens. Improper pasteurization was cited as cause of this outbreak. Furthermore, poor manufacturing practices coupled with inadequate control programs at the cheese plant were cited as causative factors.

Genigeorgis et al. [20] stated that: "Cross-contamination of certain cheeses with *L. monocytogenes* originating from raw foods (i.e. meat, poultry, fish and vegetables) after opening of packages, may lead to significant growth of the pathogen during refrigerated storage. Cross-contaminated in plants, supermarkets, restaurants, or home due to on inappropriate handling".

In the Canadian province of Quebec, a *Listeria* outbreak in late August 2008 through beginning 2009 was traced to unpasteurized cheese [5]. One death over 39 cases was confirmed. Several tons of cheese were recalled and monthly inspections were instituted to help producers take proper precautions. Several cheese producers and retailers accused the government of "excessively" reacting, driving artisanal cheese producers out of business [5]. Quebec's government had imposed severe rules regarding microbiologic requirements, although the reason and source of implicated products were not totally clear. Consequently, many traditional cheeses cannot be commercialized anymore, although they are perfectly safe according to European standards.

A large outbreak of *Shigella sonnei* gastroenteritis was associated with the consumption of fresh pasteurized milk cheese. Research suggested that an infected food handler at the cheese factory might have been the source of contamination and that the processing method might have allowed cross-contamination to occur [19].

Several authors affirmed that outbreaks of milk-borne diseases have occurred despite pasteurization, caused either by improper pasteurization or by recontamination [2, 12, 23].

6.3. The 60 days aging role

Relevant studies for the US FDA showed that Cheddar cheese produced from pasteurized milk inoculated with the following pathogens can survive for up to: 434 days for healthy *Listeria monocytogenes*, inoculated to contain 5×10^2 cells·mL^{-1} [55]; 270 days (with an average of 195 days for all the experimental condition) for mixed species of *Salmonella* (*S. typhimurium*, *S. senftenberg* 775W, *S.* New brunswick 1608 and *S.* Newport) inoculated with 3–5 × 10^2 cells·mL^{-1} [22]; and 158 days for *E. coli* O157:H7 inoculated with 1×10^3 cells·mL^{-1} [52]. These studies put in the question the adequacy of the 60-day holding period at ≥ 1.7 °C [37].

Most studies on pathogenic organisms' survival in cheese have been based on the inoculation of pathogenic organisms into pasteurized milk prior to the cheesemaking process and on the measurement of the survival during and after cheesemaking. Inoculation of pathogenic organisms into pasteurized milk appears to be the weakness of these studies. Given the fact that the inhibitory factors in raw milk on pathogen survival may have yielded different results if raw milk were used for cheesemaking [48]. The authors showed that the growth of *S. aureus*, *Salmonella enteritidis* and *L. monocytogenes* was slower in raw milk held at 37 °C for 72 h, than in pasteurized milk held for the same time at 37 °C.

The inhibitory effects of raw milk on the survival of these three pathogens in milk are of great importance for cheesemaking from raw milk. The authors hypothesized that the inhibitory effect of raw milk in their study was due to activation of the lactoperoxidase system by hydrogen peroxide producing bacteria naturally present in raw milk that were growing at 37 °C.

Thus, pasteurization may inactivate the lactoperoxidase in cheese and make it easier for pathogens to grow in cheese during and after cheesemaking, if they are present in the milk or cheese due to post-pasteurization contamination. This fact is probably one of the major points that researchers have ignored. The "pasteurization dilemma" has also been debated in other studies [15]. Furthermore, according to Patrick Rance: "Pasteurizing milk doesn't kill all the Listeria bacteria. Some of them are merely stunned. And because other kinds of bacteria have been killed by pasteurization, the *Listeria* bugs have a free run to breed", cited by Jeffrey [24]. Competition between the raw-milk microorganisms and pathogens, even if inoculated, will end up in completely different results compared to pathogens inoculated in pasteurized milk.

In France, in a study on Saint-Nectaire cheese made from raw milk inoculated with two strains of *Listeria monocytogenes* (5–10 $CFU \cdot 25\ mL^{-1}$) it was demonstrated that there was no growth of the pathogen in cheeses with pH < 5.2 and lactate content around 14 $mg \cdot g^{-1}$ [38].

In Switzerland, approximately 80% of cheeses made are manufactured from raw milk. Eight pathogens including *Salmonella* spp., *L. monocytogenes* and *E. coli* were inoculated to raw milk (104–106 $CFU \cdot mL^{-1}$) and no detection of pathogens was found beyond 1 day in the hard cheeses [3].

Similar results were obtained on Parmigiano Reggiano cheese made from raw milk voluntarily inoculated with pathogenic bacteria. After inoculation, the number of pathogenic germs in milk was between 13×10^4 $CFU \cdot mL^{-1}$ (in curdling with *S. aureus*) and 55×10^4 $CFU \cdot mL^{-1}$ (in curdling with *S. typhimurium*). In this study pathogenic bacteria became undetectable after 24 h from manufacture [42].

Pellegrino and Resmini worked on the cheesemaking conditions and compositive characteristics supporting the safety of the raw-milk cheese Italian grana [47]. They confirmed undetectable pathogens after 24 h following in-vat curd cooking 52–55 °C for 60–75 min. More importantly, the subsequent holding of molded cheese at temperatures up to 56 + 2 °C heat developed the growth of lactic acid bacteria, for 10 h at least in the presence of a pH value close to 5, conditions having an effect comparable to that of pasteurization. Absorption of a high amount of NaCl in brining resulted in high osmotic pressure in the peripheral part of cheese, the only one which is still alkaline phosphatase positive. After molding, prolonged ripening brings a further decrease of water activity (a_w) on the rind of the cheese up to a final value which inhibits the growth of pathogens, including those deriving from post-contamination.

Information on Ragusano cheesemaking and aging technology was used for a specific experimental design (data unpublished) to identify critical points, in the cheesemaking and aging process, where the time and level of pH, the temperature (Fig. 3) and a_w (Fig. 4) may influence the survival conditions of pathogens at 60, 90 and 120 days of aging. The parameters applied were: cooking the curd at 43 °C for 2 h at pH 6; stretching conditions at 49 °C for 30 min at pH 5.1 and salting the cheeses in saturated brine for 2 or 3 days per kg of cheese [32]. The targeted pathogens were: coliforms spp., *E. coli*, *S. aureus*, *Streptococcus agalactiae*, *Salmonella*, *L. monocytogenes* and *Pseudomonas aeruginosa*. Despite their presence in the raw milk samples, none of these pathogens were detected at 60, 90 and 120 days of aging.

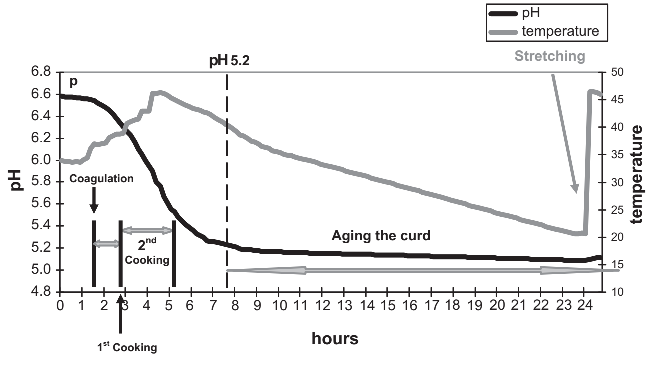

Figure 3. Mean pH and temperature of Ragusano cheese during cheese-making process (CoRFiLaC, data).

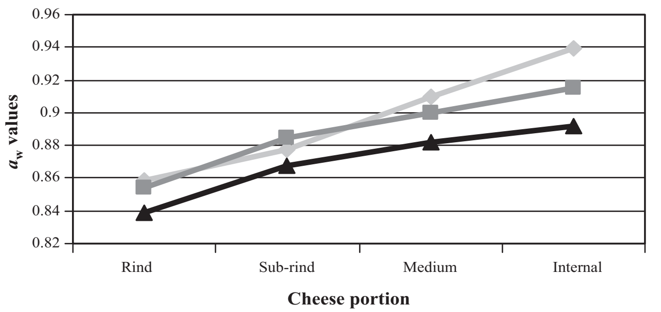

Figure 4. Mean values of a_w in Ragusano PDO after 60 days (light grey diamond line), 90 days (grey square line) and 120 days (black triangle line) of aging (CoRFiLaC, data).

We consider these results the synergic actions of the different multiplicity of practices mentioned above. At 60 days of aging, the effect of the a_w in combination with low pH 5 was crucial. The lowest a_w values, on average 0.85, were observed close to the rind of the cheese (Fig. 4). These considerations are in agreement with other studies where "The repair of heat-injured *L. monocytogenes* occurred under a wide range of pH values and several levels of high a_w ($a_w > 0.93$). Therefore, an environmentally inhospitable condition using a combination of a low level of a_w, low pH, and other hurdles must be considered to effectively prevent the repair and growth of the pathogen" [10].

6.4. Equivalence of pasteurization

We might then ask: Why have there not been more safety problems with aged raw-milk cheeses?

This apparent enigma indicates that there may be a significant gap in our knowledge about the influence of the characteristics of raw milk, the cheesemaking process and the chemical composition of cheeses on pathogenic bacteria. A multiplicity of practices beyond pasteurization or heat treatment significantly contribute to the microbiological safety of cheese [25].

From the above consideration we propose that "Raw milk vs. Pasteurized milk" is a false problem or at the least it is not "The Problem".

The real issue to determine the "food safety" is to take into account the overall traditional systems and not just the use or not of raw milk. Finally the FDA recently have also introduced the concept of "equivalence of pasteurization", to consider other factors that could make the cheese safe.

Many factors are influencing microbial activity during raw-milk cheesemaking and aging process generating synergic effects for microbial inhospitality, injury of microbial cell and generation of bacteriostatic and/or bactericidal actions. The main factors in synthesis are: time and level of pH and acidity, temperature, oxygen, redox potential through the overall process, antimicrobial activity from fresh raw milk (content and activity of key enzymes including lactoperoxidase, lysozyme, lactoferrin, xantinoxidase and the level of sulfhydryl groups and carbon dioxide) [18]; competition for nutrients due to the elevated number of different microorganisms in raw milk; microbial production of bacteriocin in situ or bacteriocin-like substances [1, 16, 20, 25]; speed of curd acidification (fast curd acidification to reach pH 5–5.5 is unfavorable to pathogenic microorganisms); time and level of the temperature of the curd at cooking, molding and stretching stages; cheese composition throughout the overall process (a_w and osmotic pressure, moisture and ingredients' concentration (salt, sugar and spice)), free fatty acid and monoglycerides [60, 64], casein fragment α and β casein-derived peptides released in water-soluble extract [53].

7. TRADITIONAL CHEESES IN THE DEVELOPING COUNTRIES

In developing countries, agriculture is still the biggest production system often covering more than 60% of the employment and even in the presence of a very low availability of technology, these countries continue to produce food in the centuries-old traditional way. Everybody hopes that people living in these countries could have a reasonable and sustainable development to improve their quality of life without losing their identity. But at the same time they can offer an incredible opportunity to understand their culture in cheesemaking. These countries produce safe food, even if almost zero technology is available. Few examples may help to understand our interest in their culture. In Benin, the ethnic group Peuhl produces the Wagashi cheese. They use the latex of *Calotropis procera* to coagulate the milk and produce a cheese with very low proteolytic activity that allows them to boil the cheese over and over again, every 2 days, for about 1 month since it has been produced. This simple practice of prolonged heat treatment makes the cheese safe. Alternatively, cheese can be sun-dried to extend shelf life. A similar technique is used in Morocco for the Lakila cheese, in Burkina Faso for the Gapal cheese, in Mali for the Gashi cheese and in Niger for the Takumart cheese. In India cheesemakers add about 40% of sugar in the Penda cheese. It is also common to use spices in cheese production (honey, garlic, thyme and cumin) for their antimicrobial properties and in specific for their ability to slow down degradation processes, allowing a better food conservation and a natural reinforcement of the immune system.

8. FOOD SAFETY: AN ETHICAL ISSUE

Nestle stated: "Safety is relative; it is not an inherent biological characteristic of food. A food may be safe for some people but not others, safe at one level of intake, but not another, or safe at one point in time but not later. Instead, we can define a safe food as one that does not exceed an acceptable level of risk. Decisions about acceptability involve perceptions, opinions, and values, as well as science. When such decisions have implications for commercial or other self-interested motives, food safety enters the realm of politics" [40].

"To decide what is an acceptable level of risk of death or sickness require an ethical judgment, so too does the very question of what counts as a risk at all! There is an indefinite set of risks associated with any human activity; we take some seriously and ignore others" [54].

In the newspaper USA TODAY (March 17, 2005), Mitchell published that in five years the ranks of those who are 100 or more pounds overweight had grown by 2.6 million people in the USA [39]. At that time 16% of kids in the US are overweight and another 15% are at risk of becoming too heavy. They could live 2–5 years less due to the overweight.

In the US, National Vital Statistics Report [27] stated that the incidence of death for foodborne disease did not appear in the first 15 causes of death, where the last one was 0.7%. Data were not aggregated for foodborne disease and presumably they account even lower percentages.

Rollin continues to affirm "The public must be made to understand that there are no risk-free environments and that to live is to take risks. Furthermore, people need to understand that it is unseemly for a free people to expect to be totally protected from all risks by the government. These reflections lead us to a plausible ethical principle concerning responsibility for food safety" [54]. And what about Genetic Modified Organisms (GMO) or the use of bovine somatotropin in dairy production systems? Consumers are taking the risk; they should at least have a choice in doing so, and thus labeling seems to be a moral necessity. Then, consumers must morally be free to choose or to reject the products and this in turn militates at least in favor of labeling food as "GMO" [54].

What is the real meaning of "food safety"? In many developing countries where billions of people (more than 50% of world wide population) live, it means "to hope that they can get food every day".

Most recent data indicate that about 11 million children die from preventable diseases [61]. In the world 1 child out of 12 dies before the fifth birthday. Malnutrition contributes for more than 50% of the total causes of the child mortality. This means that 21 children die every minute.

Food safety for consumers of developed countries is an important conquest but should not be used for business objectives. Actually, food safety is a complicated "Ethic Issue" that should become not only the main objective of any political decision but also the scientific community should work hard to underline this evidence.

We cannot stop globalization; we cannot stop development; we cannot stop business; and we cannot stop competition. But, we can decide the priorities of our values. We can try to move from the business actions dictated by globalization to the world wide social and cultural interrelationships. Business represents a part of the system and should be used to support the interests of poor people and not of multinational companies of oligarchic countries.

9. CONCLUSIONS

World wide traditional cheeses should not be considered just "food" but testimonial of the history, of the culture and of the lifestyle of the producer communities that make them. World wide traditional cheeses have strong linkage to the territory of origin and are unique expression of the symbiotic interaction of human resource, culture of the communities and the nature.

Traditional cheeses are not riskier than industrial cheeses made from pasteurized milk. Improper pasteurization, post-process recontamination, storage and cross-contamination are the main conditions responsible for outbreaks. In any production system raw-milk screening, good manufacturing practices and post-production control system able to avoid environment contamination of cheeses may be the most effective strategy to improve and control products safety.

A debate over raw milk vs. pasteurized milk for cheesemaking is not the issue. Overall production systems must guarantee cheese safety.

To give dignity to rural populations and to protect traditional cheeses will contribute to save the environment. But, more importantly it will give cultural and social recognition to communities that are going to disappear with an unbelievable consequence on social justice and on planet peace.

It is the time to develop and coordinate an international scientific network through a "World Wide Traditional Cheeses Association" in order to protect traditional cheeses and to work together to demonstrate scientifically: the characteristics of traditional cheese and cheesemaking technology; the importance of traditional tools; the health properties of traditional cheeses; the aromatic and sensorial profiles of traditional cheeses (importance of biodiversity factors); the effectiveness of food safety of cheeses produced with traditional systems.

Public institutes of research, even universities, must certify the quality of world wide traditional cheeses and contribute to educate farmers, consumers and researchers to the real meaning of these cultural products.

Food safety is an "Ethical Issue" and not just a business decision.

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