International Journal of Food Microbiology 177 (2014) 136–154

Contents lists available at ScienceDirect

International Journal of Food Microbiology

journal homepage: www.elsevier.com/locate/ijfoodmicro

Review

Traditional cheeses: Rich and diverse microbiota with associated benefits

Marie-Christine Montel [a,*], Solange Buchin [b], Adrien Mallet [c,d], Céline Delbes-Paus [a], Dominique A. Vuitton [d,e], Nathalie Desmasures [c,d], Françoise Berthier [b]

[a] INRA, Unité Recherches Fromagères, 20 Côte de Reyne, F-15000 Aurillac, France
[b] INRA, UR342 Technologie et Analyses Laitières, F-39801 Poligny, France
[c] Normandie Univ, France
[d] UNICAEN, ABTE, F-14032 Caen, France
[e] EA3181/Université de Franche-Comté, 25030, Besançon, France

ARTICLE INFO

Article history:
Received 9 August 2013
Received in revised form 17 February 2014
Accepted 22 February 2014
Available online 3 March 2014

Keywords:
Traditional cheeses
Raw milk
Microbiota
Diversity
Sensory benefits
Health benefits

ABSTRACT

The risks and benefits of traditional cheeses, mainly raw milk cheeses, are rarely set out objectively, whence the recurrent confused debate over their pros and cons. This review starts by emphasizing the particularities of the microbiota in traditional cheeses. It then describes the sensory, hygiene, and possible health benefits associated with traditional cheeses. The microbial diversity underlying the benefits of raw milk cheese depends on both the milk microbiota and on traditional practices, including inoculation practices. Traditional know-how from farming to cheese processing helps to maintain both the richness of the microbiota in individual cheeses and the diversity between cheeses throughout processing. All in all more than 400 species of lactic acid bacteria, Gram and catalase-positive bacteria, Gram-negative bacteria, yeasts and moulds have been detected in raw milk. This biodiversity decreases in cheese cores, where a small number of lactic acid bacteria species are numerically dominant, but persists on the cheese surfaces, which harbour numerous species of bacteria, yeasts and moulds. Diversity between cheeses is due particularly to wide variations in the dynamics of the same species in different cheeses. Flavour is more intense and rich in raw milk cheeses than in processed ones. This is mainly because an abundant native microbiota can express in raw milk cheeses, which is not the case in cheeses made from pasteurized or microfiltered milk. Compared to commercial strains, indigenous lactic acid bacteria isolated from milk/cheese, and surface bacteria and yeasts isolated from traditional brines, were associated with more complex volatile profiles and higher scores for some sensorial attributes. The ability of traditional cheeses to combat pathogens is related more to native antipathogenic strains or microbial consortia than to natural non-microbial inhibitor(s) from milk. Quite different native microbiota can protect against *Listeria monocytogenes* in cheeses (in both core and surface) and on the wooden surfaces of traditional equipment. The inhibition seems to be associated with their qualitative and quantitative composition rather than with their degree of diversity. The inhibitory mechanisms are not well elucidated. Both cross-sectional and cohort studies have evidenced a strong association of raw-milk consumption with protection against allergic/atopic diseases; further studies are needed to determine whether such association extends to traditional raw-milk cheese consumption. In the future, the use of meta-omics methods should help to decipher how traditional cheese ecosystems form and function, opening the way to new methods of risk–benefit management from farm to ripened cheese.

Published by Elsevier B.V.

Contents

* Corresponding author. Tel.: +33 471456411; fax: +33 471456413.
E-mail address: Marie-Christine.Montel@clermont.inra.fr (M.-C. Montel).

http://dx.doi.org/10.1016/j.ijfoodmicro.2014.02.019
0168-1605/Published by Elsevier B.V.

1. Introduction

Guerrero et al. (2009), analysing European consumers' perceptions, defined a traditional food product as "a product frequently consumed or associated with specific celebrations and/or seasons, normally transmitted from one generation to another, made accurately in a specific way according to the gastronomic heritage, with little or no processing/manipulation, distinguished and known because of its sensorial properties and associated with a certain local area, region or country". Raw milk PDO cheeses (an estimated 70% of all traditional cheeses in France) fit this definition perfectly as each one is produced in a specifically defined geographical area using specific know-how and skills and with little or no prior processing of the milk. To some extent, however, the "traditional cheese" label can also be applied to cheeses made on-farm or at small dairies using thermized or pasteurized milk inoculated with various starter combinations and allowing the growth and expression of ripening microbiota. Makers of traditional cheeses adapt their manufacturing practices to the characteristics of the vat milk day by day. Moreover, traditional cheeses are recognized for their diverse and distinctive sensory properties.

Few of the risks and benefits claimed for traditional cheeses have been objectively and clearly set out, owing to the scattered data and large number of cheese varieties. All the focus has been on the recurrent debate over the pros and cons of raw milk cheeses. Anthropologists and sociologists, especially in the USA, have examined it from the standpoints of microbiopolitics (Paxson, 2008; Mendelson, 2011) and consumer fears (West, 2008). Microbiologists debate how best to handle microorganisms. Defenders of pasteurization advocate managing the pathogen risk by applying heat to reduce the microbial load on equipment and in milk and inputs, and standardising production by inoculating a few selected strains into milk. The raw milk sector also focuses its battles against pathogenic bacteria on the process upstream of the vat milk (review Claeys et al., 2013) and then in the cheese (Brooks et al., 2012). Herd certification programs, adapted Hazard Analysis Critical Control Point (HACCP) systems and systematic microbiological quality control throughout the supply chain (EFSA, 2010; European regulation EC853/2004) have been developed to guarantee the safety of unpasteurized cheeses, including raw milk cheeses. In industrialized countries, successful management of the pathogen risk is reflected in the relative small number of food-borne outbreaks due to dairy products (1–5%), including unpasteurized cheeses (De Buyser et al., 2001; Kousta et al., 2010; EFSA European Food Safety Authority, 2011, 2012). *Salmonella* outbreaks have been scarce since 2000; only fifteen outbreaks have been reported in the last two decades (De Buyser et al., 2005; Jourdan-Da Silva and Le Hello, 2012). Outbreaks of shigatoxin-producing *Escherichia coli* (O157:H7, 026:H11) have been linked to raw milk and to cheeses made with both pasteurized and unpasteurized milk, due to defective pasteurization and/or post processing contamination (Farrock et al., 2013).

Listeriosis connected with the cheese consumption is very rare (Maijala et al., 2001; Goulet et al., 2006; Antal et al., 2007; EFSA, 2010) even though it has become the emblematic example of severe illness transmitted by raw milk products. Contamination by *Listeria monocytogenes* is not specific to raw milk cheeses; cheeses made from pasteurized milk can be contaminated (Rudolf and Scherer, 2001; EFSA, 2012; Pini and Gilbert, 1988) due to improper pasteurization or post-pasteurization contamination (De Buyser et al., 2001; Donnelly, 2001).

Defenders of traditional cheeses recommend maintaining high taxonomic diversity in indigenous cheese microbial communities and diverse cheese-making practices. Their arguments rely on the fact that a high diversity of microbial activities, combined with particular cheese manufacturing methods, is the key for allowing traditional cheeses to develop their particular characteristics, including low pathogen risk and diversification of gustatory characteristics. The raw milk microbiota is an important part of the microbiota of many traditional cheeses. This review first considers the sources of this microbiota and the particular practices that further enrich microbiota in the cheese. It then reports on the taxonomic composition and dynamics of cheese microbiota, which have been extensively documented for raw milk cheeses over the last decade, encouraged by the arrival of accurate molecular taxonomic methods. The main objective of this review is to assess the sensory, hygiene and potential health benefits of traditional cheeses. It does not set out to analyse the risks.