International Journal of Food Microbiology 234 (2016) 71–75

Contents lists available at ScienceDirect

International Journal of Food Microbiology

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

Sensory quality of Camembert-type cheese: Relationship between starter cultures and ripening molds

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ARTICLE INFO

Article history:
Received 15 March 2016
Received in revised form 17 June 2016
Accepted 21 June 2016
Available online 23 June 2016

Keywords:
Camembert
Dairy technology
Starter-culture
Mold ripening
Quantitative descriptive analysis

ABSTRACT

Starter cultures and ripening molds used in the manufacture of moldy cheese aimed at obtaining characteristic flavors and textures considerably differ among dairy industries. Thus, the study of variables inherent to the process and their influence on sensory patterns in cheese can improve the standardization and control of the production process. The aim of this work was to study the influence of three different variables on the sensory quality of Camembert-type cheese: type of lactic bacteria, type of ripener molds and inoculation method. Batches of Camembert-type cheese were produced using O or DL-type mesophilic starter culture, ripened with *Penicillium camemberti* or *Penicillium candidum* and mold inoculation was made directly into the milk or by spraying. All batches were sensorially evaluated using Quantitative Descriptive Analysis (QDA) with panelists trained for various attributes. Among the combinations analyzed, those resulting in more typical Camembert-type cheese were those using O-type mesophilic starter culture and *P. candidum* maturation mold directly applied into the milk or sprayed and those using DL-type mesophilic starter and *P. camemberti* ripener mold applied by surface spraying. These results demonstrate, therefore, that the combination of different ripener molds, inoculation methods and starter cultures directly influences the sensory quality of Camembert-type cheese, modifying significantly its texture, appearance, aroma and taste.

1. Introduction

Cheeses ripened by molds are divided into two broad categories: those ripened with surface mold (for example, Camembert and Brie) and blue vein cheeses (Roquefort and Gorgonzola). Although these two cheese types have in common mold growth during maturation, the methods used for their manufacturing and attainment of characteristic flavors and textures differ considerably from each other (Fox et al., 2000).

Moldy fine soft cheeses are characterized by the presence of a white crust formed by the growth of *Penicillium* sp. on their surface, which gives them unique aroma and flavor characteristics. These cheeses have more complex ripening patterns when compared with those of other simpler microflora varieties (Spinnler and Gripon, 2004). Among these cheeses, "Camembert de Normandie Protected Designation Origin (PDO)" stands out, whose manufacturing process serves as pattern for Camembert-type cheeses produced worldwide. Created in 1791, this cheese is made with raw cow milk, according to the AOC rules proposed in 1983 (Harbutt, 2009). In France, its home country, it is by definition a soft mass cheese, with surface mold, weighting about 250 g, 2.5 cm in height and 11 cm in diameter (Codex Alimentarius, 1973).

Fungal maturation in Camembert-type cheese occurs mainly by *Penicillium camemberti* or *Penicillium candidum*, directly inoculated into the milk or on the cheese surface after brining (Fox et al., 2000). Commercially, *P. camemberti* is also called *P. album*, being therefore the same mold; at the beginning of maturation, it is white in color, acquiring grayish tone over time. It is commonly used in traditional manufacturing of Camembert and Brie cheeses in France, where *P. candidum* is also used, being considered a mutant species (Furtado, 2003).

The application of molds in Camembert-type cheese gives it pronounced flavor and aroma and characteristic texture due to the intense lipolytic and proteolytic action that occurred during maturation. Thus, the magnitude of the ripening is proportional to storage period. In Camembert, the product is suitable for consumption by around three weeks of maturation, with partial proteolysis at this stage; total proteolysis

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http://dx.doi.org/10.1016/j.ijfoodmicro.2016.06.025
0168-1605/

usually occurs five weeks of maturation, resulting in more pronounced flavor and more creamy texture. After 45 days, there is accentuation of flavor and aroma, which can be more ammoniacal from the 50th day, and these processes are accompanied by increased pH and decreased mold layer over the peel (Macej et al., 2001).

The lipolysis (or hydrolysis) of triglycerides present in the fat always takes place under favorable conditions, being quite accelerated in the presence of lipases. The mold used in Camembert maturation have a developed lipolytic system, producing active extracellular lipases in the pH range of 3.5–11.5, ideally around 8.5. These lipases release free fatty acids by attacking the ester bond of triglycerides and releasing fatty acids that give flavor and aroma to cheese (D'Arce, 2006; Mcsweeney, 2004). The type of mold strain used in the maturation of Camembert-type cheese directly affects the aroma and flavor of cheese, since lipolysis due to the enzymatic activity generates various types of fatty acids that are differently perceived by the consumer (Fox et al., 2000).

In addition to mold strain, the type of lactic bacteria can also influence the sensory characteristics of the final product. Lactic bacteria marketed by the industry for the production of cheeses are divided into two basic groups: mesophilic and thermophilic. The first grow well at 30–32 °C, with maximum temperature of 40–42 °C, and are composed of two types of bacteria: *Lactococcus lactis* subsp. *cremoris* and *Lactococcus lactis* subsp. *lactis*. Its use is intended for the production of closed cheese without eyes due to the absence of gas formation. In this case, bacteria is called O-type. For the production of eyes, DL-type bacteria must be chosen, which besides the bacteria mentioned above, also presents *Lactococcus lactis* subsp. *lactis* biovar *diacetylactis* and *Leuconostoc mesenteroides* subsp. *cremoris*, which produce carbon dioxide during mass fermentation. Lactic acid bacteria called thermophiles are composed of cultures with optimum growth between 43 and 53 °C, represented by the *Streptococcus thermophilus*, *Lactobacillus delbruckii* subsp. *bulgaricus* and *Lactobacillus helveticus* species – which cause rapid acidity in the curd (Munk and Ferreira, 2008).

This study aimed to evaluate the influence of different combinations between types of ingredients (starter cultures and molds) and mold inoculation methods on the perception of its sensory characteristics. In this way, this work could contribute to improve the Camembert-type cheese production in different regions of the world, respecting its standards of identity and the sensory characteristics of the final product.

2. Materials and methods

2.1. Cheesemaking

Manufacturing followed method described by Furtado (1991) and Munk and Ferreira (2008), with modifications. During the process, three different variables were analyzed: species of maturation molds (*P. camemberti* and *P. candidum*), mesophilic lactic bacteria (O-type or DL-type) and method used for inoculation of the maturation mold (into the milk or by surface spraying). Only formulation with DL-type bacteria did not used direct inoculation, since the production of resulting gas from the growth of *Lactococcus diacetylactis* and *Leuconostoc cremoris* can cause the formation of eyes, providing an undesired mold growth in these structures. All formulations were processed under the same conditions, with subsequent maturation for 30 days.

Bovine milk was pasteurized by slow pasteurization (65 °C for 30 min.) and cooled in the manufacturing tank at 32 °C. In the next step, DL-type (CHN 22, Christian Hansen®, Denmark) and O-type (R 704, Christian Hansen®, Denmark) lactic acid cultures were added for pre-maturation (0.03 g/L) (acidification up to 20°D), followed by rennet (Estrella Christian Hansen®, Brazil) (0.8 mL/L milk), calcium chloride (Dinamica®, Brazil) (0.4 mL/L milk), and, finally, *P. camemberti* inocula (ZX27, Mad Millie®, New Zealand) or *P. candidum* (PC TT0033, Christian Hansen®, Denmark) (0.001 g/L). For treatment with direct inoculation, molds were inoculated at that time. The curd waited until whey acidity reached 2/3 the initial milk acidity; followed by cutting with transverse and horizontal lyre (2 cm edge) with curd standing for 5 min. The curd was mixed slowly for 30 min with regular rest periods of 5 min. For cheese molding, the curd was arranged in 11 cm × 11 cm cylindrical forms followed by three turns, after 30, 60 and 75 min of molding. Cheeses were incubated in proper mold for 24 h at 25 °C until acidity reached around 80°D. Subsequently, cheeses were unmolded and salt was added for 60 min in brine (20% w/v) and kept for 2 h in a chamber at 15 °C for drying. For treatments with inoculation by spraying, surface spraying of the mold was performed by manual spray (0.01 g lyophilized mold in 100 mL of sterilized drinking water). Cheeses were submitted to a second drying step at 15–18 °C for 24 h. Maturation occurred in refrigerator at 12 °C with relative air humidity kept at 80–85% obtained using an internal humidifier. After 10 days of ripening, cheeses were wrapped in aluminum foil and stored at 10 °C until the 30th day of manufacture.

At the end of the manufacturing process, six different treatments were obtained: O-Cand-M = O-lactic bacteria and *P. candidum* as maturation mold applied to the milk; O-Came-M = O-type lactic bacteria and *P. camemberti* as maturation mold applied to the milk; O-Cand-S = O-type lactic bacteria and *P. candidum* as maturation mold applied by surface spraying; O-Came-S = O-type lactic bacteria and *P. camemberti* as maturation mold applied by surface spraying; DL-Came-S = DL-type lactic bacteria and *P. camemberti* as maturation mold applied by surface spraying; DL-Cand-S = DL-type lactic bacteria and *P. candidum* as maturation mold applied by surface spraying (Fig. 1). Therefore, 6 treatments were performed using 6 cheeses per treatment, totalizing 36 sampling units. To verify the relative ripening among the samples studied through pH increasing, one of the cheeses produced and not ripened was considered as a control sample (C).

2.2. Quantitative descriptive analysis (QDA)

This step was approved by the Research Ethics Committee under protocol number CAAE 43378015.4.0000.5395.154/2009 (Ethics Committee in Research with Human Beings – ESALQ/USP). The Quantitative Descriptive Analysis (QDA) was applied according to Moskowitz (1983); Stone and Sidel (1998); Meilgaard et al. (1999) and Ellendersen and Wosiacki (2010). Nine members were selected to define the descriptive terminology for the sensory attributes of Camembert-type cheese in three training sessions. The panelists were trained in sensory analysis of commercial Camembert cheese in different ripening stages (10, 25 and 60 days of ripening) to present to them the sensorial attributes of this kind of cheese. The descriptions identified were gathered in order to group the similar terms that best described Camembert-type cheese samples as Creamy (Cre), Brightness (Bri) and Ripened (Rip) as attributes for appearance; Aroma characteristic (Aro) as attribute for aroma; Bitter taste (Bit), Salty taste (Salt), Characteristic taste (Tas) and Sour taste (Sour) as attributes for taste; Homogeneous (Hom), Gummy (Gum), Soft (Soft) and Elastic (Ela) as attributes for texture. The discrepant terms were eliminated. Thus, the reference material was established and the intensity scores were determined for each attribute, which were used in the Sensory Analysis stage.

The sensorial evaluation of the samples was performed in three sessions with 6 refrigerated samples (10 g) kept at room temperature (25 °C) for 15 min in random order, numbered with three digits in a random manner in order to eliminate errors due to residual taste in individual booths under white light. The tasters were instructed to describe the sensations perceived regarding appearance, aroma, taste and texture of the samples using a 10-point intensity scale ranging from less intense to more intense for most attributes.

2.3. Physicochemical analysis

Physicochemical analyses were performed on the cheeses used in the Sensorial Analysis (30 days of ripening). pH was measured at