Temperature and relative humidity influence the ripening descriptors of Camembert-type cheeses throughout ripening

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ABSTRACT

Ripening descriptors are the main factors that determine consumers' preferences of soft cheeses. Six descriptors were defined to represent the sensory changes in Camembert cheeses: *Penicillium camemberti* appearance, cheese odor and rind color, creamy underrind thickness and consistency, and core hardness. To evaluate the effects of the main process parameters on these descriptors, Camembert cheeses were ripened under different temperatures (8, 12, and 16°C) and relative humidity (RH; 88, 92, and 98%). The sensory descriptors were highly dependent on the temperature and RH used throughout ripening in a ripening chamber. All sensory descriptor changes could be explained by microorganism growth, pH, carbon substrate metabolism, and cheese moisture, as well as by microbial enzymatic activities. On d 40, at 8°C and 88% RH, all sensory descriptors scored the worst: the cheese was too dry, its odor and its color were similar to those of the unripe cheese, the underrind was driest, and the core was hardest. At 16°C and 98% RH, the odor was strongly ammonia and the color was dark brown, and the creamy underrind represented the entire thickness of the cheese but was completely runny, descriptors indicative of an over ripened cheese. Statistical analysis showed that the best ripening conditions to achieve an optimum balance between cheese sensory qualities and marketability were 13 ± 1°C and 94 ± 1% RH.
Key words: cheese ripening, ripening descriptors, temperature, relative humidity

INTRODUCTION

Among the environmental parameters that affect the ripening of Camembert-type cheese, temperature, relative humidity (**RH**), and the composition of the gaseous atmosphere in the ripening chamber have the most effect on sensory properties (von Weissenfluh and Puhan,

1987; Choisy et al., 2000; Ramet, 2000). These previous studies highlighted the predominant role of temperature and reported that small increases in temperature can accelerate cheese ripening but can also produce off-flavor components or inconsumable products. This is in agreement with similar studies on Cheddar (Hannon et al., 2005) and Reggianito Argentino cheeses (Sihufe et al., 2010). Bonaïti et al. (2004) showed that temperature and RH influence creamy underrind thickness and the consistency of a smear cheese: at 16°C under 100% RH, the underrind became completely runny after 20 d of ripening. It is recognized that the sensory properties of soft cheeses, such as surface-coating appearance, rind color, and cheese odor, are essential because they determine the choice and preferences of consumers (Dufossé et al., 2005).

To our knowledge, no research on the ripening conditions of Camembert-type cheeses has yet focused on the influence of ripening temperature and RH on ripening properties. Knowledge is lacking on the links between microbiological and physicochemical phenomena and the changes in cheese sensory properties. According to Perrot et al. (2004) and Sicard et al. (2011), cheese-makers often play an important role in this field. In factories, they may use instrumental measurements and empirical sensory perceptions at the same time (Perrot et al., 2004; Picque et al., 2006), and they may interact with automatic systems to assess the sensory properties of the cheeses and to monitor the ripening process. According to Lemoine (2001), the cheese-maker's assessment and reasoning still play a major role in the cheese ripening process, especially concerning sensory property control. Recently, Sicard et al. (2011) showed that it is possible to study the Camembert ripening process by macroscopic evolutions of cheeses evaluated from an expert's point of view. Those authors established a correlation of 76% between the microbiological, physicochemical, and biochemical data and the sensory phases measured according to expert knowledge.

The aim of this study was to evaluate the effects of ripening temperature (θ) and RH on the development of sensory properties in Camembert-type cheeses throughout their ripening (from d 0 to 40) for the same

set of cheese-making runs. The sensory ripening descriptors were studied in association with the microbial and physicochemical evolutions that occur during ripening.

MATERIALS AND METHODS

Camembert Cheese-Making and Ripening

The microorganisms used (*Kluyveromyces marxianus*, *Geotrichum candidum*, *Penicillium camemberti*, and *Brevibacterium aurantiacum*) and the cheese-making process were described previously (Leclercq-Perlat et al., 2012). Surface-mold-ripened soft cheeses (100 cheeses per cheese-making run, each weighing 300 ± 20 g) were manufactured in a sterile environment. The cheeses were aseptically transferred to a previously sterilized ripening chamber. After 24 h at 12°C and $85 \pm 1\%$ RH, they were maintained at 8, 12, or 16°C and 88, 92, or 98% RH, with a periodically renewed atmosphere. To do this, the ripening chamber was sealed on d 0. The concentration of CO_2 increased during ripening and was automatically decreased to 0.1% when it reached 0.5% by injecting humid sterile air (Picque et al., 2006). The cheeses were turned on d 5. On d 13, they were maintained at 12°C and 85% RH for 24 h. On d 14, the cheeses were then wrapped in a reference wrap (CdL, Amcor Flexibles, Barbézieux, France) and ripened at 4°C until d 40. This wrap was described by Picque et al. (2010).

Sensory Analysis Performed on the Cheeses

Sensory analyses were performed on each cheese sample under the same light and temperature (14 ± 1°C) conditions. Sensory evaluation was performed by 5 assessors according to the methodology used by Sicard et al. (2011). Each expert assessed each cheese, taking 5 descriptors generally used by cheese-makers into account, and scored descriptors on a scale from 1 to 5 (Table 1). Six sessions were devoted to training and evaluation before validating the panel's performance (Sicard et al., 2011).To determine the progress of Camembert-type cheese ripening, the appearance of the cheese (*P.*

camemberti coating density and surface covering) was assessed as previously described by Bonaïti et al. (2004) and Sicard et al. (2011). The appearance of *P. camemberti* was assessed in terms of mycelium density and uniformity, varying from 1 (less than 10% of the cheese surface covered by *P. camemberti* mycelium) to 5 (more than 90% of the surface covered by *P. camemberti*). In addition, for each cheese sample, cheese odor, rind color under the *P. camemberti* coating, underrind consistency ($\mathbf{C_{UR}}$), and core hardness ($\mathbf{H_{core}}$) on d 14 and 40 were considered. The greatest difference between 2 panelists for each sensory descriptor was <0.2. The overall cheese odor varied from fresh cheese (score 1) to ammonia (score 5); the typical odor of Camembert corresponded to a score of 3. Cheese color under the *P. camemberti* coating varied from white (score 1) to dark brown (score 5); the typical color (cream) of a Camembert corresponded to a score of 3. Creamy underrind thickness is a key factor that characterizes progress of Camembert ripening (Leclercq-Perlat et al., 2004a, 2006, 2012), but its assessment requires destruction of the cheese. Consequently, cheese-makers use another descriptor, C_{UR}, that characterizes the texture of the ripened part of the cheese, as highlighted by Sicard et al. (2011). The creamy underrind thickness ($\mathbf{T_{UR}}$, mm) was measured using a decimeter with an accuracy of 0.2 mm. The underrind consistency (Picque et al., 2010) varied from dry (score 1) to very runny (score 5). The H_{core}, characterizing the texture of the core part, was estimated by the ease with which the cheese was ground with a mortar and pestle. This hardness varied from very soft (score 1) to very hard (score 5). To simplify the analysis, only 2 characteristic days of ripening were considered: wrapping day (d 14) and the end of ripening (d 40), corresponding to the end of shelf-life for the cheeses.

Experimental Design

The effects of θ and RH on cheese sensory descriptors were examined using a 2-factor, 3-level complete factorial experimental design (3^2) as described by Leclercq-

Table 1. Definition and score of the descriptors used to evaluate the Camembert-type cheese ripening process

Descriptor	Notation	Scale and reference				
		1	2	3	4	5
PC coverage[1]	N_{PC}	<10%	25%	50%	75%	>90%
Overall odor	Odor	Fresh cheese	Musty	Camembert	Camembert ammonia	Ammonia
Rind color	Color	White	Cream	Dark cream	Light brown	Dark brown
Underrind consistency	C_{UR}	Very dry	Dry	Soft	Soft with runny edge	Runny
Core hardness	H_{core}	Very soft	Soft	Medium	Hard	Very hard

[1]PC = *Penicillium camemberti*.