

Dynamic Measurement of Carbon Dioxide Diffusion of Cheese and Eye Formation

Walter Bisig*, Ueli von Ah, Dominik Guggisberg, Marie-Therese Fröhlich-Wyder, Daniel Wechsler
 walter.bisig@alp.admin.ch

Introduction

Eye formation is product defining for many hard and semi-hard cheeses. The specific amount of desired eye formation reaches from “blind” e.g. in Gruyère to the big eyes in Swiss-type cheese. CO₂-formation, CO₂-solubility in cheese, cheese texture, eye nuclei and CO₂ diffusion are important factors for eye formation. CO₂ is formed in different metabolic pathways by LAB and NSLAB in cheese during ripening from lactate, citrate and amino acids. In this study, the influence of a possibly increased CO₂-formation with the addition of citrate on eye formation and CO₂ diffusion as well as the influence of eye nuclei are investigated.

Material and Methods

Tilsit-type semi-hard cheeses from pasteurised milk were produced on two different days in duplicate. Facultative heterofermentative (FAC-HET) strain *Lactobacillus casei* sp. *casei* FAM 18121 was added as an adjunct culture to increase CO₂ formation from citrate in all three samples. Citrate content was increased in samples 2 and 3 with the addition of 101 g tri-sodium-citrate-dihydrate into 70 L of milk. Eye formation nuclei were added in sample 3. Citrate and FAC-HET were analysed at days 1, 30 and 127. Gas diffusion over the entire ripening period of 127 days at 14-15°C was continuously measured with a newly developed system in collaboration with Abiotec Ltd. In a tightly sealed stainless steel container with the enclosed cheese, gas diffusion was measured by a highly sensitive pressure sensor and calculated into volume based on the ideal gas law $p \cdot V = n \cdot R \cdot T$. Eye volume at the end of ripening was determined by X-ray and X-ray computed tomography.

Results and Discussion

At day 127, added *Lb. casei* had used the citrate in milk (7.2, 10.7 and 10.4

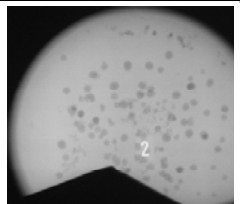
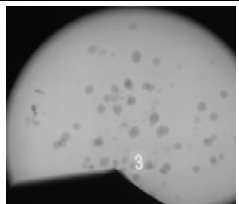
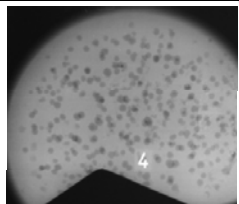
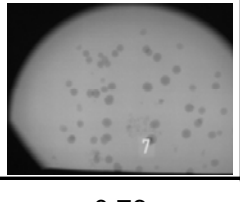
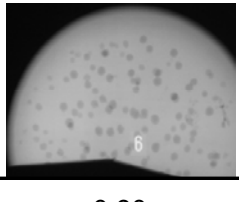
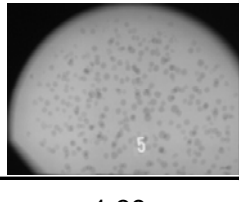
Adjunct Culture	Lactobacillus casei sp casei FAM 18121		
Citrate	Normal of milk	140 % of milk	140 % of milk
Eye nuclei	no addition	no addition	addition
Day 1			
Repetition			
Eye volume (%)	0.76	0.90	1.39

Figure 1: Variants of cheese with pictures of conventional X-ray and eye volume analysed by X-ray computed tomography.

mmol/kg respectively at day 1) completely in all three samples. Numbers of FAC-HET increased from $1.2 \cdot 10^7$ at d1 to $1 \cdot 10^8$ cfu/g at d30 and decreased to 10^3 - 10^4 cfu/g afterwards. Starting at d40, the addition of citrate increased the amount of diffused gas by 31% to 2853 mL measured at day 127 (Figure 2). Eye volume increased only little from 0.76% of cheese volume to 0.90% (Figure 1). In the eyes,

only 1% of CO₂ was found. 61% dissolved in the cheese body and 38% diffused out. Addition of eye nuclei increased eye volume significantly to 1.39% and improved eye quality.

The conclusion is that higher citrate content in milk increases CO₂ formation in the presence of *Lb. casei*. Additionally, eye nuclei are necessary to increase eye volume.

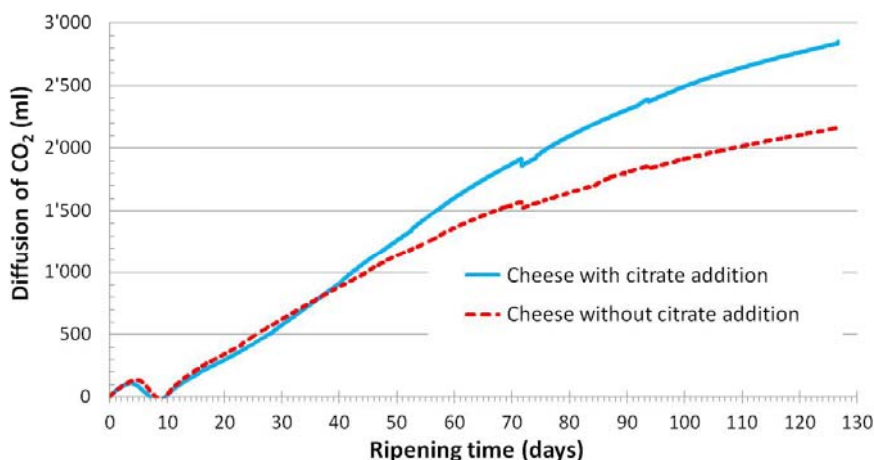


Figure 2: Dynamic gas diffusion out of semi-hard cheeses with *Lb. casei* FAM 18121 without and with the addition of 40% citrate in milk, measured with the gas volume monitor Niesler from Abiotec Ltd.