Assessment of structure and component mobility within Mozzarella cheese

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Abstract

The objective of this study was to identify mechanisms responsible for component mobility relating to structural change within Mozzarella cheese. The use of new techniques alongside well established methods allowed insights to be gained beyond the current understanding of the dynamics within Mozzarella. A number of processing and storage trials were conducted utilising a range of techniques to gain a multi-scale indication of changes in component mobility and structural reorganisation.

Dielectric spectroscopy was explored as a method to characterise both ion and water mobility. Initially a model system was utilised as a means of evaluating the technique prior to being applied to Mozzarella. The model system allowed the composition of the cheese to be systematically controlled, especially the calcium. However, subsequent trials (in real Mozzarella cheese systems) indicated that water movement within the cheese during both maturation and heating confound the dielectric response, indicating the method is not ideally suited to measuring a dynamic Mozzarella system.

Nuclear magnetic resonance was used to probe changes in component mobility within Mozzarella. Initially well-established relaxation methods were used to monitor the decrease in free water within Mozzarella following manufacture. However, after raising the question of the effect of temperature on free water in cheese, relaxation and diffusion measurements were employed as tools to gain an understanding of the dynamics of water movement within the porous cheese structure. This work was extended further by using these techniques to follow a newly manufactured Mozzarella through a storage trial. The relaxation and diffusion measurements were taken at a range of temperatures at each point of the trial. Phosphorus NMR was explored as a novel approach to monitor changes in the arrangement of calcium and phosphorus (as phosphate) within Mozzarella during storage. This in combination with additional techniques characterising structural changes allowed potential mechanisms for the solubilisation of CCP to be discussed.

Collectively these techniques found that Mozzarella undergoes a number of structural changes during storage. Two primary drivers for change were identified from which the other processes cascaded: changing strength in hydrophobic interactions and proteolytic breakdown. Initially the development of the cheese structure was driven primarily by a relaxation in protein matrix (caused by weakening hydrophobic interactions), resulting in the moisture equilibration processes through the associated impact on colloidal calcium phosphate solubility and thus protein-protein interactions. Further structural changes occurred as a result of the proteolytic breakdown of the casein and a possible relaxation in the protein structure. These proteolytic mechanisms dominated maturation behaviour after the moisture equilibration processes were substantially completed (typically >20 days).

This thesis revealed new information relating to the movement of components within Mozzarella, particularly at elevated temperatures. These insights will aid in building a more detailed understanding of the dynamics within Mozzarella. It also highlighted several techniques that show promise as potential tools for assessing the structural changes within Mozzarella cheese.

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Contents

Symbol / Abbreviation	Meaning
ε*	Complex permittivity
ε_0	Permittivity of free space
ε'	Dielectric constant
ε”	Dielectric loss factor
G’	Storage modulus
G”	Loss modulus
Tanδ	Loss tangent
η*	Complex viscosity
ω_0	Larmor frequency
ɣ	Gyromagnetic ratio
B_0	Magnetic field
I	Proton intensity
A	Proton intensity of casein associated water
B	Proton intensity proportional to free water
T	time
T_1	Longitudinal (spin-lattice) relaxation
T_2	Transverse (spin-spin) relaxation
NMR	Nuclear Magnetic Resonance
MRM	Magnetic resonance microscopy
D_0	Free diffusion
A	Tortuosity
T	Time
$(\frac{S}{V_p})$	Surface to volume ratio
Θ	Time constant (Pade fitting parameter)
D(t)	Diffusion as a function of time
MAS ^{31}P NMR	Magic angle spinning phosphorous (31) nuclear magnetic resonance
CLSM	Confocal laser scanning microscope
TPA	Texture profile analysis
SEM	Scanning electron microscopy
Δ	Observation times
Δ	Pulse duration