J. Dairy Sci. 101:1–18
https://doi.org/10.3168/jds.2017-13386
© American Dairy Science Association®, 2018.

Invited review: Structure-function relationships in cheese[1]

Prabin Lamichhane,*† Alan L. Kelly,† and Jeremiah J. Sheehan*[2]
*Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork, Ireland P61 C996
†School of Food and Nutritional Sciences, University College Cork, Cork, Ireland T12 YN60

ABSTRACT

The quality and commercial value of cheese are primarily determined by its physico-chemical properties (e.g., melt, stretch, flow, and color), specific sensory attributes (e.g., flavor, texture, and mouthfeel), usage characteristics (e.g., convenience), and nutritional properties (e.g., nutrient profile, bioavailability, and digestibility). Many of these functionalities are determined by cheese structure, requiring an appropriate understanding of the relationships between structure and functionality to design bespoke functionalities. This review provides an overview of a broad range of functional properties of cheese and how they are influenced by the structural organization of cheese components and their interactions, as well as how they are influenced by environmental factors (e.g., pH and temperature).
Key words: cheese, structure, function, interaction

INTRODUCTION

Overall, the global consumption of cheese is increasing continuously and is projected to increase by ~13.5% between 2016 and 2025 (OECD/FAO, 2016). Simultaneously, consumers/end-users have increasingly been demanding enhanced physico-chemical properties, sensory and nutritional quality, and optimal usage characteristics of cheese, all at a reasonable cost. This is primarily driven by factors such as growing consumer awareness of the role of diet in health and well-being, the potential to use structure to influence flavor release and sensory experience, and the extensive use of cheese as an ingredient in food retail applications. Such expanding consumer demands have triggered the focus of food researchers and cheese producers toward the improvement in the quality of existing products or the design of new innovative products.

It is now well recognized that many of the desirable properties of cheese are largely determined by its structure. For example, structure plays an important role in determining the mechanical, rheological, and cooking properties of heated and unheated cheese (Lucey et al., 2003; Guinee, 2016), eye formation in several types of hard (e.g., Swiss type or Emmental) and semi-hard (e.g., Maasdam type) cheese (Daly et al., 2010), and texture perception (Rogers et al., 2009). More recently, it has also been reported that food structure plays a key role in flavor release (Taylor, 2002) and in the digestion and the absorption of nutrients (Parada and Aguilera, 2007; Singh et al., 2015). Apart from containing basic nutrients, the nutritional value of food can also be enhanced by introducing health-promoting and bioactive compounds, such as polyphenols and peptides. In this context, the cheese matrix can potentially be used as a delivery vehicle for bioactives and probiotics (Sharp et al., 2008; Rashidinejad et al., 2016). Thus, a better understanding of the complex interrelationship between structure and functionality (i.e., the so-called structure-function relationship) is necessary to design of cheese types with specific functionalities. However, the full extent of the relationships between structure and functionality of cheese is not fully understood. The aim of this review is to provide an appropriate knowledge of how cheese structure may be manipulated to control and predict the functional properties of cheese.

CHEESE COMPONENTS AND STRUCTURE

Caseins, the main structural component of cheese, are present in the form of a network in the cheese matrix in which fat globules, water, minerals, bacteria, and dissolved solutes such as lactose, lactic acid, soluble salts, and peptides are all interspersed. The spatial arrangements of these components and their interactions determines the structure of cheese, which is influenced by relative volume fractions of each component and their properties (e.g., residual charge on the casein, composition of membrane materials of fat globules, and state of minerals, water, and fat), cheese manufacturing procedures, maturation conditions, and environmental

Received June 22, 2017.
Accepted August 15, 2017.
[1]Presented as part of the Teagasc-Moorepark/University College Cork Cheese Symposium at the ADSA Annual Meeting, Pittsburgh, Pennsylvania, June 2017.
[2]Corresponding author: Diarmuid.Sheehan@teagasc.ie

conditions (e.g., pH, temperature, and solvent quality/ionic strength), among other factors.

Like other food types, cheese encompasses a hierarchical structure, with scales that span from the molecular to the macroscale (Figure 1). At a macroscopic level, cheese is the assembly of curd particles (resulting from cutting of the gel in the case of brine-salted cheeses), or curd chips or pieces (resulting from milling of curds and dry salting, such as in Cheddar and Stilton cheese manufacture; Guinee, 2016). Eyes, slits/cracks, visible crystals, and mechanical openness are also macrostructural features of cheese. At the microscopic level, cheese is composed of microstructural components, such as the casein network, fat globules, and water droplets. At further higher levels of magnification (nano or molecular scale), microstructural components of cheese are formed from molecules and atoms. Structures at the macro, micro, nano, and molecular levels of organization all have an important role in various properties of cheese. Various techniques to study cheese structure, such as microscopy, rheology, magnetic resonance, and dynamic light scattering, have been reviewed extensively (e.g., Everett and Auty, 2008; El-Bakry and Sheehan, 2014).

From a materials science perspective, cheese can be viewed as a 2-phase composite material (also called "filled gels" or "gelled emulsions") containing fat globules as a filler in a protein gel matrix (Barden et al., 2015). Several researchers used this approach to study the role of milk fat and protein network on the mechanical and rheological properties of cheese (Rogers et al., 2010; Barden et al., 2015; Thionnet et al., 2017).

MOLECULAR INTERACTIONS WITHIN THE CHEESE MATRIX

Various molecular forces and interactions that act between the cheese components are considered important as they can influence the functionality of cheese. For example, it is suggested that the localized balance of the attractive and repulsive forces between casein controls the melting of heated cheese (Lucey et al., 2003). Moreover, the nature and extent of interactions of flavor compounds and nutrients with the food matrix can influence their release patterns in the mouth during mastication and in the gut during digestion, and this can in turn affect the sensorial and nutritional properties of food (Parada and Aguilera, 2007; Gierczynski et al., 2011). For such reasons, knowledge of molecular interactions and forces that act between cheese components is vital.

Some studies have characterized the interactive forces in milk gels and cheese curd using different dissociating agents such as urea, SDS, and EDTA (Lefebvre-Cases et al., 1998; Gagnaire et al., 2002; Zamora et al., 2012). These dissociating agents are known to disrupt specific types of bond or interaction; for example, hydrophobic interactions and hydrogen bonds can be disrupted by SDS or urea, respectively, whereas ionic bonds involving calcium salts are broken by the chelating effects of EDTA (Zamora et al., 2012). Lefebvre-Cases et al. (1998) characterized the interactive forces in rennet- and acid-induced milk gels using different dissociating agents, and the results of their study suggested that hydrophobic interactions and calcium bonds were the most important forces for the stabilization of the structure of rennet milk gels. The contribution of hydrogen bonds seemed comparatively less important for the stability of rennet gel structure than the aforementioned forces. In acid-induced milk gels, hydrophobic and electrostatic interactions and hydrogen bonds have been shown to be important forces, whereas the contribution of calcium bonds have been found to be less important, most probably due to solubilization of colloidal calcium at low pH (Lefebvre-Cases et al., 1998). Calcium bonding, electrostatic interactions, and hydrogen bonds (to a lesser degree) contribute to the formation and stability of the *para*-casein matrix (after pressing) in Emmental cheese (Gagnaire et al., 2002). The major interaction

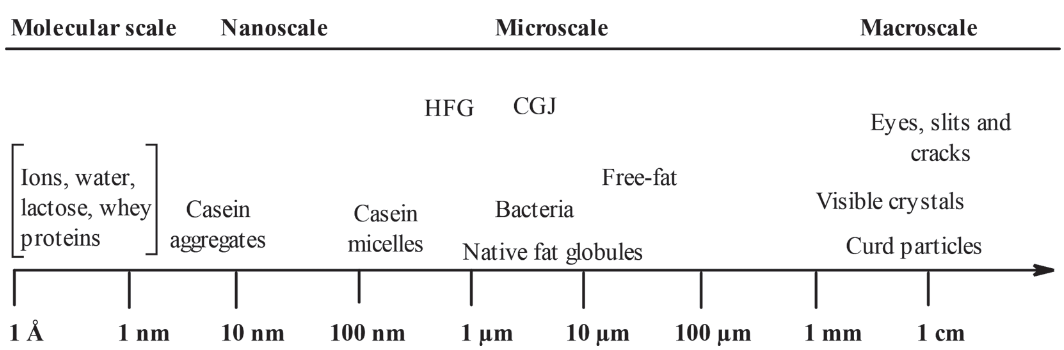

Figure 1. Characteristic length scales in cheese. HFG = homogenized fat globules, CGJ = curd granule junction.

Download English Version:

https://daneshyari.com/en/article/8501515

Download Persian Version:

https://daneshyari.com/article/8501515

Daneshyari.com