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FOOD STRUCTURE

Review

Structure and function of food products: A review☆

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ABSTRACT

A proper understanding of the behavior of food products requires knowledge of its structure, i.e., the spatial arrangement of the various structural elements and their interactions. The structure can properly be studied by visual observation techniques. In products such as fat spreads, creams, dressings, cheese, bread, milk, yoghurt, whipped cream, and ice cream, different structural elements can be distinguished. A number of those elements are discussed, viz., water droplets, oil droplets, gas cells, particles, fat crystals and strands. In addition examples of interactions between structural elements are presented, viz., oil droplets/matrix, protein/protein, protein carbohydrate, and fat crystal/fat crystal interactions. Finally, it is indicated how these elements cooperate in the formation of structure and contribute to function and macroscopic behavior of food products. Particular attention is given to fat spreads, processed cheese, protein gelation, and examples of the mutual interaction of milk proteins and of carbohydrates with milk proteins. It is expected that a proper understanding of the relation between structure and function will help us to design new ways of structuring in our continuing efforts to manufacture high quality, healthy and tasty food products.

Contents

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1. Introduction

Most food products are composed of rather a limited variety of structural elements, such as droplets, air cells, granules, crystals, strands, micelles and interfaces. A proper understanding of the behavior of a food product requires knowledge of its structure, i.e., the spatial arrangement of the structural elements and their interactions. Interaction forces determine the consistency and the physical stability of food products.

The spatial arrangement of structural elements can be studied by visual observation techniques, such as light- and electron microscopy (EM). Also, the result of the interaction between the various components in a system can be studied in this manner. Visual observation techniques are therefore an important aid in the analysis of food structure.

A variety of techniques are available for the determination of functional properties. Rheological measurements give in sight in to mechanical properties and consistency. Consumer panels, and rheological characterizations are used to measure sensory properties. The stability of a foam can be followed by visual inspection.

It is the aim of this review to illustrate how various structural elements cooperate in the formation of structure and contribute to functional properties and macroscopic behavior of food products. To this end, a number of structural elements, as observed by micro-structural techniques, will be described as well as examples of their interaction. Finally, a number of food systems will be discussed.

2. Structural elements

2.1. Water droplets

Water droplets are important structural elements in emulsion type food products such as margarine, butter and low-fat spreads. The droplets are stabilized by soluble emulsifiers, such as monoacylglycerols and lecithins (Madsen, 1987) and/or by solid particles, such as fat crystals (Lucassen-Reynders and van den Tempel, 1963).

An example of water droplets stabilized by a soluble emulsifier in a water-in-oil emulsion, observed by freeze fracture EM is given in Fig. 1. The emulsifier used is DK-F10, which is a mixture of di-, tri-, and polyesters of hydrogenated tallow fatty acids with sucrose (van Voorst Vader & Groeneweg, 1989).

Thin-sectioning EM of a water droplet in a margarine reveals the presence of emulsifier at the interface between oil and water (Fig. 2).

Freeze-fracture EM of an 80% fat spread shows (Fig. 3) that fracture occurs either over the surface of the water droplets or through the droplet. Fat crystals on the surface of the droplets are clearly perceptible, indicating stabilization by fat crystals. Similar observations have been reported (Precht & Buchheim, 1980b).

Water droplets can also be properly observed by light microscopical techniques. Fig. 4 reveals the structure for a 25% fat spread. In this case, the droplets are

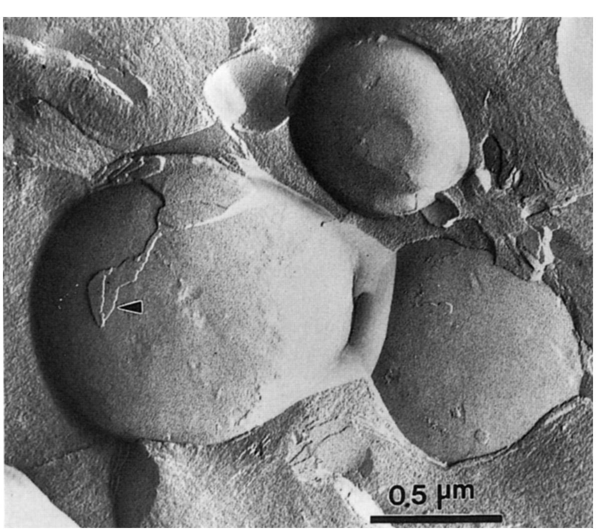

Fig. 1 – Water droplets in a water in oil emulsion stabilized by DKF 10, observed by freeze-fracture EM. Arrow points to multilayered shells.

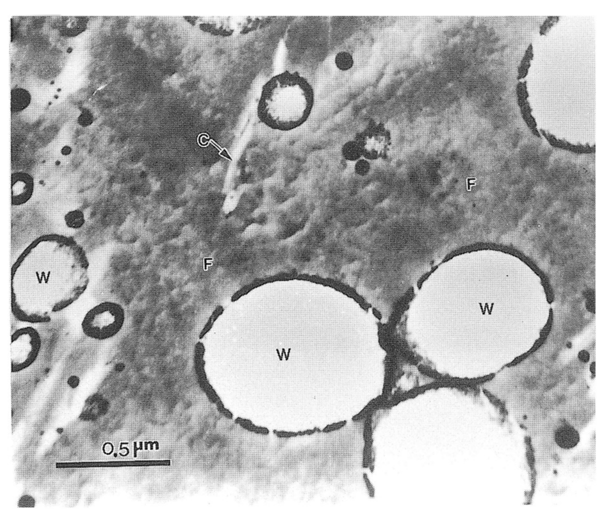

Fig. 2 – Water droplets (W) in a margarine, observed by thin-sectioning EM. Linear structures (C), indicative of fat crystals, can be observed in the continuous fat matrix (F). Dark structures at the W/F interface indicate emulsifier.