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Food Structure, Its Formation and Breakdown

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The majority of the food we eat has a defined structure. Even an apparently simple liquid such as milk contains protein micelles, stabilised fat droplets and dissolved proteins; all of which contribute to its appearance, taste and texture. Solid produce such as meat, fruit and vegetables contain hierarchical structures developed for the benefit of the plant or animal. In most cases, the craft skills of the butcher and chef are required to transform these architectures into palatable foods. There is a second class of foods, whose structures would not exist without restructuring and assembly technologies. These are the breads, biscuits, cakes and snacks of the patisserie; the sweets chocolates of the confectioner; and more recently the shelf stable soups, sauces, spreads and dressings of the food manufacturer. Interested readers are directed to reference [1].

Despite the common place nature of all these products, the processes of their assembly have been developed by empiricism, and the "engineering handbooks" are recipes, rather than the detailed descriptions of unit operations and design drawings of other manufacturing industries. Furthermore, the recipes describe ingredients and processes which produce something that is pleasant to eat. There is little explanation of why such structures give acceptable texture in the mouth. We do not swallow foods whole, yet the dynamics of structure breakdown and reassembly before swallowing is poorly described and understood. The central role of food microstructure in manufacture and consumption is shown in Figure 1. and examples of microscopic change in both processes will be given.

The food industry faces enormous challenges. Both increasing population and relative wealth means that there is increasing demand for a greater variety and convenience of foods. So much so that the planet cannot produce enough by its traditional supply chains. We will need to produce not just pleasant, but more healthy foods from a greater range of raw materials, whilst reducing waste at all stages. This means we need "Design Rules" in our future engineering handbooks.

For the Assembly Processes in Fig1., there is now a focus of understanding how the processing of food creates product architecture and how ingredients and raw materials interact to form structures. Knowing formulations is not enough. For example, the same ingredients can become a water continuous cream, or an oil continuous spread [2]. Examples will be shown of how architecture and its changes can be understood and manipulated, and the need for microscopic studies across many levels of magnification from the electron microscope to the hand lens.

Studies of the Breakdown Processes in Fig.1 are not new, but require a degree of detailed study of microscopic structure not widely practiced. The perception of texture in the mouth is obviously related to the mechanical processes of structure collapse, and the first approaches focussed on mechanical properties, so rheology became a key discipline for the food texture analyst [3,4]. However, it is obvious to any student of composites, their structure and mechanics, that measurements of bulk rheological properties will not be enough. It is the collapse of the architecture and its microstructure that must be understood. Some examples are, the "toughness" of meat, which relates to the failure of a fibrous composite; the crisp and crunchy texture of cereals involving brittle fracture and failure mechanics; the smoothness of butter and the creaminess of chocolate relating to crystal melting and the formation of emulsions [5].

References:

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Figure 1. The central role of structure in the assembly and quality perception of food.