

Part I

The Digestion of Particle Suspensions

The food of most animals comprises a mixture of liquids and solids. In microscopic animals this may be directly ingested into the cell. In larger animals such as vertebrates ingested material is processed in the specialised structures and cells of the gastrointestinal tract. The ingested material or digesta generally consists of a mixture of liquid and solid nutritious materials from which nutrients are obtained by solution, digestion and absorption along with unusable detritus which generally persists within the cavity of the digestive system and transits in a solid state. The rate at which digestion and absorption can proceed is limited by a number of physical processes that operate within and between the liquid and solid phases of digesta. The transit of enzymes and soluble nutrients between the surfaces of the digestive organ and the solid or liquid substrate is influenced by the processes of diffusion, advection and mixing. The rate of solution and digestion of solid substrates is limited by their surface area and by the physical nature of the interacting surfaces. The operation of these physical processes is rendered complex as the digesta traverse the physical constraints of the digestive system and as the relative proportion of digestible material declines and that of indigestible residues increase. Hence the physical properties of digesta and the concomitant behaviour of its liquid and solid components may impair or facilitate the bulk mixing of liquid digesta (Anfinsen and Tungland 2005), promote the differential onflow of solid or liquid elements of digesta from a particular segment of the gut (Wolf et al. 2002) and influence the ease with which aggregated masses of particulate solids are deformed and the liquid phase is expelled (Ramkumar and Schulze 2005). Further, the physical characteristics of the solid elements of digesta may impair or facilitate the access of digestive secretions to solid nutrient substrates contained within the particle and the subsequent egress of the soluble products of digestion from the particle (Aguilera 2005).

In the following section we examine those properties of the particulate fraction of digesta that influence the physical processes of their digestion. In this respect we consider 'particles' in their broadest sense as any discreet assembly of material that is not in solution in the aqueous phase. Hence we include aggregates of hydrophobic materials such as globules, emulsions and microemulsions as well as suspensions of solid material including micro and nanoparticles.

Firstly, we examine general aspects of the physical structure and digestion of individual digesta particles, including effects that arise from the heterogeneity of particle composition and from the size of particles. Secondly, we consider the digestion of specific components of heterogeneous particles, specifically carbohydrates, protein and fat. Finally, we examine the physical properties of particle suspensions and how these affect the mass transfer of released nutrients within the gut lumen.