Biochemistry of Cheese Ripening

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1 Introduction

As discussed in Chapter 1, cheese manufacture essentially involves concentrating the fat and casein of milk 6–12-fold by coagulating the casein, enzymatically or isoelectrically, and inducing syneresis of the coagulum which can be controlled by various combinations of time, temperature, pH, agitation and pressure. At the end of the manufacturing phase, all the rennet (enzymatically)-coagulated cheeses are essentially very similar, consisting of a matrix of calcium paracaseinate in which various proportions of lipids are dispersed and with moisture contents typically in the range 35–50%. Depending on the cooking temperature used during manufacture and the moisture content, fresh rennet cheeses are more or less ‘rubbery’ and are essentially flavourless. Although they may be consumed in this state, this is not usually done. Instead, they are matured (ripened) for periods ranging from about three weeks (e.g. Mozzarella) to two or more years, depending on the moisture content of the cheese and the intensity of flavour desired.

The basic composition and structure of cheese are determined by the curd manufacturing operations but it is during ripening that the individuality and unique characteristics of each cheese variety develop, as influenced by the composition of the curd and other factors, e.g. the microflora established during manufacture. Some bacterial growth does occur in cheese during ripening, especially of the non-starter lactic acid bacteria, and of moulds in the case of the mould-ripened varieties. Although the actual growth of these microorganisms does contribute to cheese ripening, perhaps very significantly in some varieties, cheese ripening is essentially an enzymatic process.

The ripening of the principal cheese varieties is reviewed in separate chapters in Volume 2. The objective of this chapter is to overview the general aspects of the biochemistry of cheese ripening, which are more or less common to all varieties, and the agents responsible for ripening.
2 Ripening Agents

Four, and possibly five, agents are involved in the ripening of cheese: (1) rennet or rennet substitute (i.e. chymosin, pepsin or microbial proteinases); (2) indigenous milk enzymes, which are particularly important in raw milk cheeses; (3) starter bacteria and their enzymes, which are released after the cells have died and lysed; (4) enzymes from secondary starters (e.g. propionic acid bacteria, Brevibacterium linens, yeasts and moulds, such as Penicillium roqueforti and P. candidum) are of major importance in some varieties; (5) non-starter bacteria, i.e. organisms that either survive pasteurization of the cheesemilk or gain access to the pasteurized milk or curd during manufacture; after death, these cells lyse and release enzymes. The contribution of enzymes from non-starter bacteria to cheese quality is controversial; there is a commonly held view that in the case of Cheddar and Dutch cheeses, species of Lactobacillus, Pediococcus and Micrococcus probably have negative effects on cheese quality, although they almost certainly contribute to the intensity of cheese flavour.

There has been interest for about 30 years in devising model systems that would permit quantitation of the contribution of each of these five agents to cheese ripening and to the secondary reactions. The techniques developed eliminate one or more of the above agents, thereby enabling its role to be assessed, directly or indirectly.

Non-starter bacteria may be eliminated by using an aseptic bucket milking technique, developed by Perry & McGillivray; the teat cups and clusters were chemically sterilized and the bucket steam-sterilized. Cows were screened for the bacteriological quality of their milk and animals with counts <100 cfu. ml⁻¹ selected; prior to milking, their udders were cleaned with a quaternary ammonium solution. An essentially similar approach was used by O'Keeffe et al. who obtained milk with a total bacterial count of <500 cfu. ml⁻¹. Kleter & de Vries included a cooling coil between the cluster and bucket and succeeded in achieving counts averaging 46 cfu. ml⁻¹. This approach was also adopted by Visser. Reiter et al. withdrew milk aseptically by means of a teat cannula, but the quantities obtained (1 litre) were sufficient to produce cheeses of only about 100 g.

Having collected low-count milk, a heating step is usually employed to reduce bacterial counts further. Perry & McGillivray used batch pasteurization (68°C × 5 min) in a steam-jacketed cheese vat. Chapman et al., who did not use an aseptic milking technique, used HTST pasteurization (71·6°C × 17 s) to produce low-count milk. Reiter et al., Visser and Kleter also used HTST pasteurization. Turner et al. investigated the thermal destruction of various strains of bacteria with reference to the production of milk for aseptic cheesemaking. It was noted that a reduction of 10⁸ was required to produce cheese with non-starter counts of <100 cfu per 10 kg cheese from milk with an initial count of 10³ cfu. ml⁻¹. It was concluded that a heat treatment of 83°C × 15 s or 72°C × 58 s would be necessary to ensure this death rate but a heat treatment of 72°C × 15 s would be sufficient for milk with an initial non-starter count of 10 cfu. ml⁻¹. An LTLT