9 Formation of off-flavours due to microbiological and enzymic action
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9.1 Introduction

Off-flavours that arise in foods because of microbiological or enzymic activity fall into three main categories. These are described in the following sections.

9.1.1 Off-flavours preformed in the food

Off-flavours may be preformed in the food from normal biochemical metabolism or as stress metabolites. These types of off-flavour are dependent, to a large extent, on agronomic factors such as varietal differences, feeding or fertilizer regimes, level of water used, spacing, etc.

9.1.2 Off-flavours formed as a result of cellular disruption

After harvest or slaughter the structural integrity of foods begins to break down due to damage from handling and normal decay processes. This results in the mixing of normally compartmentalized enzymes and substrates, and the generation of flavour compounds. In many cases, the formation of compounds in this way is essential for the typical flavour characteristics of the product. e.g. onions, garlic, peppers, etc. However, in many instances, this leads to the formation of off-flavours and spoilage of the product.

9.1.3 Off-flavours arising as a consequence of microbial deterioration

Microbial spoilage is a major cause of quality loss in foods after harvest or slaughter. As a by-product of growth and metabolism microorganisms produce a range of chemicals, which alter the quality attributes of food, including flavour, ultimately rendering the product inedible.

This chapter reviews certain off-flavours that arise as a consequence of microbial or enzymic action in milk and dairy products, fruit and vegetables, wine, beer, meat and fish.
9.2 Milk and dairy products

Extended refrigerated storage and transport has resulted in new quality problems for milk, related to the growth and metabolic activities of microorganisms at low temperatures. Psychrotrophic microorganisms are ubiquitous in nature and common contaminants in milk. Although they have an optimum growth temperature of 20–30°C, psychrotrophic bacteria will grow at temperatures as low as −10°C, with moulds growing at temperatures as low as −18°C (Kraft and Rey, 1979). During microbial growth heat-stable enzymes are formed. These biochemically alter the milk, eventually causing spoilage. Two types of enzymes are particularly important in the formation of off-flavours in milk and milk products. These are (i) lipases; and (ii) proteinases.

9.2.1 Lipases

Lipase activity has been reported for most psychrotrophs isolated from milk and milk products. *Pseudomonas*, *Flavobacteria* and *Alcaligenes* species are the most active lipolytic bacteria (Muir *et al.*, 1979). Microbial lipases are heat stable and it has been reported that 40% of *Pseudomonas*, *Alcaligenes* and *Aerobacter* species retained 75% of activity after 2 min at 90°C (Kishonti, 1975). Lipase activity in milk leads to the preferential release of medium- and short-chain fatty acids from triglycerides (Olivecrona and Bengtsson-Olivecrona, 1991), hydrolysis of as little as 1–2% triglycerides leading to rancid off-flavours. Milk naturally contains high levels of indigenous lipase, with 1 litre of bovine milk containing 1 mg of pure lipase (Olivecrona and Bengtsson-Olivecrona, 1991). It is therefore extremely likely that indigenous as well as microbial lipases are important in the development of lipolytic rancidity in milk (Allen, 1989).

9.2.2 Proteinases

The major cause of bitterness in milk and milk products is the formation of bitter peptides due to the action of proteinases. Although bitterness is usually indicative of microbial spoilage, indigenous milk enzymes and the activity of starter microorganisms used in cultured milk products may also lead to bitter off-flavours. Proteinase activity has been detected in many bacterial species, in particular *Pseudomonas*, *Aeromonas*, *Serratia* and *Bacillus* species (Sorhaug and Stepaniak, 1991). Heat stability of proteinases from several bacterial species was investigated by Griffiths *et al.* (1981). They found that 20–60% of original proteinase activity remained after heating cell-free culture supernatants for 5 s at 140°C. Strict quality control is therefore critical in ultra heat-treated (UHT) milk products to ensure that heat-stable proteinases do not cause bitter off-flavours.

The most investigated source of bitter peptides is the caseins. Ney (1979) showed bitterness to be related to the hydrophobicity of casein-derived peptides rather than to specific amino acids or chain length. As a measure of