Figure 2.9 Cocoa fermentation. Reproduced with permission of Ivan Kashinsky.

shallow bean depths (250–500 mm; 0.8–1.5 ft) are preferred, especially at the start of fermentation, to promote good aeration which is needed for fermentation. To increase aeration and ensure uniformity of fermentation, the beans are usually transferred from one box to another each day. The length of fermentation is the same as for smallholders, but some plantations ferment for longer periods such as 6 or 7 days.

2.3.2 Microbiological aspects of fermentation

Micro-organisms are responsible for the breakdown of the pulp that surrounds the beans. Their activities result in the death of the bean embryo and they create the environment that enables the formation of cocoa flavour precursors (see Chapter 8).

The pulp is an excellent medium for the growth of micro-organisms since it contains water and 10–15% sugars. When the beans are removed from the pods, the pulp is inoculated naturally with a variety of micro-organisms from the environment. The fermentation process can be considered in three stages:

Stage 1 – Anaerobic yeasts. In the first 24–36 h, yeasts convert sugar into alcohol under conditions of low oxygen and a pH of below 4 (i.e. quite acidic). Bean death usually occurs on the second day and is caused by acetic acid and alcohol (the rise in temperature is relatively unimportant).

Stage 2 – Lactic acid bacteria. These are present from the start of the fermentation, but only become dominant between 48–96 h. Lactic acid bacteria convert sugars and some organic acids into lactic acid.

Stage 3 – Acetic acid bacteria. These are also present throughout the fermentation, but become more significant towards the end when aeration increases. They are responsible for converting alcohol into acetic acid. This is a strongly exothermic reaction that is mainly responsible for the rise in temperature. This can reach 50 °C (122 °F) or higher in some fermentations.

In practice, there is considerable overlap between the stages. The types of micro-organisms vary between fermentations and between regions.

2.3.3 Development of cocoa flavour precursors

Development of the cocoa flavour precursors occurs in the cotyledons during fermentation and drying (see also Chapter 8). There are two important types of cells within the cotyledons: the storage cells containing fat and proteins and the pigment cells containing polyphenolic compounds and methylxanthines (theobromine and caffeine). During fermentation, there is firstly the initiation of germination of the seed. This causes the uptake of water by the protein vacuoles within the storage cells. Later, after bean death has occurred, the cell walls and membranes break down, allowing the various compounds and enzymes to react together. These reactions produce the cocoa flavour precursors (see Figure 2.10). The reaction rates are determined by the temperature and the level of acidity.

There are several groups of compounds responsible for flavour. The methylxanthines impart bitterness. During fermentation, their levels fall by around 30%, probably due to diffusion from the cotyledons. There are a range of polyphenolic compounds (called flavonoids) which are responsible for the colour, for

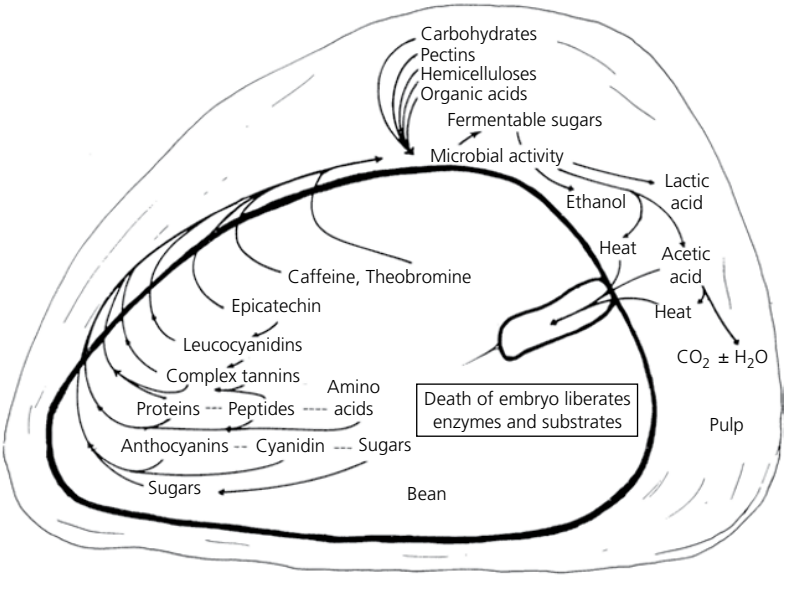

Figure 2.10 Chemical changes within a cocoa bean during fermentation (after Lopez, 1986). Reproduced with permission of The Pennsylvania State University.