Table 22.2 Vitamin and mineral content of cocoa and chocolate (per 100 g)[a].

Ingredient	Weight of ingredient	Cocoa powder	Chocolate		
			Dark (45–59%)	Milk	White
Iron	Milligram	13.8	8	2.35	0.24
Calcium	Milligram	128	56	189	199
Zinc	Milligram	6.8	2	2.3	0.45
Magnesium	Milligram	499	146	63	12
Manganese	Milligram	3.84	1.42	0.47	0.008
Selenium	Microgram	14.0	3.0	4.5	4.5
Potassium	Milligram	1524	559	372	286
Phosphorus	Milligram	734	206	208	176
Thiamine	Microgram	78.0	25.0	112	63.0
Riboflavin	Microgram	241	50	298	282
Niacin	Milligram	2.19	0.725	0.386	0.745
Vitamin B_{12}	Microgram	0	0	0.75	0.75
Vitamin E	Milligram	0.1	0.54	0.51	0.96

[a] USDA National Nutrient Database for Standard Reference, Release 27.

22.3 Vitamins and minerals

Cocoa and chocolate contain a number of minerals (Table 22.2). Potassium, magnesium and calcium are the most abundant minerals in cocoa powder. Lesser amounts of iron, selenium and magnesium are also present. The mineral content of the cocoa is dependent on the soil conditions in which the cacao is grown. Cocoa powder also contains lesser amounts of several vitamins including thiamine, riboflavin, and vitamin E (Table 22.2). The final concentrations of vitamins and minerals in chocolate products are dependent on the amount of non-fat cocoa solids, the amount of cocoa butter and the presence of other ingredients including milk and nuts which can enhance the levels of certain vitamins and minerals (i.e. calcium and vitamin E).

22.4 Flavanols and proanthocyanidins

Cocoa beans contain high concentrations of polyphenols. Although total polyphenol content depends on the variety of cocoa beans, growth conditions, and processing steps, typically studies have reported levels of 12–18% by dry weight (Miller *et al.*, 2009; Hurst *et al.*, 2011). The monomeric polyphenols [largely (–)-epicatechin (EC) and (+)-catechin] account for approximately 10% of the total polyphenols, whereas the oligomeric and polymeric proanthocyanidins (PaC)s represent nearly 90%. Processing has been shown to impact the polyphenol content and composition of cocoa products. Fermentation, roasting and

alkalisation have generally been shown to reduce the levels of total polyphenols in the finished cocoa powder (Miller *et al.*, 2009; Hurst *et al.*, 2011). With regard to individual polyphenols, both roasting and alkalisation has been shown to induce epimerisation of EC to catechin. Roasting appears to induce polymerisation of PaCs, and studies in our laboratory have shown that the lower degree of polymerisation (dp) PaCs (i.e. dimers and trimers) decrease as a function of roasting time, whereas the higher dp PaCs increase (Stanley, personal communication). Alkali treatment reduces PaC levels as a function of time, however the identity of the end products of this reaction are unclear.

22.5 Methylxanthines

Cocoa and chocolate contain significant levels of the methylxanthines, theobromine and caffeine, with the former being more abundant. The theobromine and caffeine components of chocolate have been suggested to play a role in the human health effects of chocolate, principally through their antagonism of the adenosine receptor (Franco *et al.*, 2013). These compounds can stimulate the central nervous system and cardiac muscle, induce smooth muscle relaxation and bronchodilation and induce diuresis. In general, studies have shown that caffeine is more potent at inducing these effects than theobromine. The amount of these compounds present in the final cocoa product depends on the source of the cocoa beans used, the processing steps and the composition (i.e. amounts of non-fat cocoa solids, cocoa butter etc.). The levels of theobromine and caffeine in non-fat cocoa bean solids are typically 2.5% and 0.24% of the dry weight, respectively (Franco *et al.*, 2013). Although variable from product to product, an average bar of milk chocolate (50 g) contains 10 mg caffeine, whereas a similar size bar of dark chocolate may contain 50 mg, depending on the non-fat cocoa solid content.

22.6 Cardiovascular disease

Since 2000, 68 human intervention studies have examined the effect of cocoa and chocolate-based interventions (or cocoa-derived compounds) on biomarkers of cardiovascular disease (CVD) risk. In addition a number of epidemiological and laboratory studies have examined cocoa and chocolate in relation to CVD. Although considerable effort has focused on the polyphenolic fraction of cocoa (i.e. flavanols and PaCs), other studies have demonstrated beneficial effects on CVD from cocoa fibre and cocoa butter lipid components. In general, epidemiological studies have shown the consumption of 50–100 g of chocolate per week may reduce risk of CVD. For example, Buijsse *et al.* (2010) have reported that CVD mortality was inversely associated with long-term cocoa consumption.