CHAPTER 1

History, origin and taxonomy of cocoa

1.1 Introduction

Chocolate is derived from the cocoa bean, which is obtained from the fruit of the cocoa tree, *Theobroma cacao* (Linnaeus). The term 'Cocoa' is a corruption of the word 'Cacao' that is taken directly from Mayan and Aztec languages. It is indigenous to Central and South America and believed to have originated from the Amazon and Orinoco valleys. Cocoa (*Theobroma cacao* L.) is one of the most important agricultural export commodities in the world and forms the backbone of the economies of some countries in West Africa, South America and South-East Asia. It is the leading foreign exchange earner and a great source of income for many families in most of the world's developing countries. In Ghana, cocoa is the second highest foreign exchange earner and an estimated 1 million farmers and their families depend on it for their livelihood (Afoakwa, 2014).

Currently, in 2016, cocoa is cultivated on an estimated land size of 8 million hectares in the tropics and secures the livelihoods of about 50 million people globally. More than 8 million of them are mainly smallholder farmers with an average farm size of just 3–4 hectares and an average family size of eight. Of these, some 1.5 million are within West Africa, the most important cocoa-growing region. Such families frequently live exclusively on cocoa farming and processing and are thus dependent mainly on cocoa for their livelihoods. Hence the economic importance of cocoa cannot be over-emphasized and the current global market value of annual cocoa crop is over $8.1 billion (World Cocoa Foundation, 2014).

Cocoa continues to be an important source of export earnings for many producing countries, particularly in Africa, Latin America and South-East Asia. Africa's heavy dependence on cocoa and also on other primary commodities as a source of export earnings has been vulnerable to market developments, in particular price volatility and weather conditions. However, in some circumstances, real exchange rates, domestic marketing arrangements and government intervention have acted to buffer price movements for cocoa producers. Cocoa was the second source of export earnings in Ghana in 2014, after gold, generating US$2.0 billion.

Chocolate Science and Technology, Second Edition. Emmanuel Ohene Afoakwa.

The African region accounts for approximately 72.3% of net world exports of cocoa and is by far the largest supplier of cocoa to world markets, followed by the Americas (16.7%) and then Asia and Oceania (11.0%), and the cocoa market remains highly concentrated, with the top five countries accounting for 87% of world net exports, and over 98% originated from the top 10 countries during the 5-year period 2010–2015. Côte d'Ivoire (Ivory Coast) is the world's leading exporter of cocoa, representing 40.6% of global net exports, followed by Ghana (19.2%) and Indonesia (8.9%) (ICCO, 2015a). Interestingly, there has been continuing repositioning of some countries, which in recent years have shown tremendous interest in advancing their cocoa production. In 2014, Ecuador exported ~230 000 tonnes of cocoa, which positioned it as the fifth largest producer of cocoa in the world, displacing Cameroon and Brazil to sixth and seventh positions, respectively, and surpassed only by Nigeria, Indonesia, Ghana and Côte d'Ivoire. This means that Ecuador has advanced its position in the global market for the second consecutive year, having overtaken Brazil, one of the leading producers in Latin America, in 2013 (Ricky and Moncayo, 2015). With increased processing at origin, cocoa products now represent a slightly higher proportion of total cocoa exports in most cocoa-producing countries (ICCO, 2015a).

1.2 History of cocoa

Cocoa (*Theobroma cacao* L.) is a native species of tropical humid forests on the lower eastern equatorial slopes of the Andes in South America. Allen (1987) reported the centre of genetic diversity of *T. cacao* to be the Amazon Basin region of South America and all 37 collecting expeditions listed by End *et al*. (1990) seeking germplasm of wild cacao were to the Amazon Basin region. The word cacao is derived from the Olmec and the subsequent Mayan languages (Kakaw) and the chocolate-related term cacahuatl is Nahuatl (Aztec language) derived from Olmec/Mayan etymology (Dillinger *et al*., 2000). Cocoa was considered divine in origin and, in 1737, the Swedish botanist Carolus Linnaeus (Carl von Linné) named the cocoa tree *Theobroma cacao*, now its official botanical name, from the Greek word 'ambrosia', which refers to the mythical background of the tree, literally meaning 'cocoa, food of the gods' (Alvim, 1984; Barry Callebaut, 2008). Based on archaeological information, Purdy and Schmidt (1996) reported that the Mayans cultivated cocoa 2000–4000 years before Spanish contact. It is recorded that cocoa was domesticated and consumed for the first time by the Maya and Aztecs. The Maya, Olmec, Toltec and Aztecs used the beans of cocoa both as currency and as the base for a bitter drink (Purdy and Schmidt, 1996; Nair, 2010; ICE Futures U.S., 2011).

The name 'cocoa' is a corruption of the word *cacao*, which originated from the Amazons in South America. Its cultivation and value spread in ancient times

throughout central and eastern Amazonia and northwards to Central America (Afoakwa, 2010). Cocoa was first cultivated by the Aztecs in Mexico, South America, and spread throughout the Caribbean islands. Later, in the 1520s, Hernandos Cortés, a Spaniard, took cocoa to Spain as a beverage and to Spanish Guinea as a crop. The Spanish not only took cocoa to Europe, but also introduced the crop into Fernando Po in the seventeenth century and thus laid the foundation of the future economies of many West African countries. Currently, West Africa produces ~73% of world cocoa (ICCO, 2015).

The use of cocoa beans dates back at least 1400 years (Rössner, 1997), when Aztecs and Incas used the beans as currency for trading or to produce the so-called *chocolatl*, a drink made by roasting and grinding cocoa nibs, mashing with water, often adding other ingredients such as vanilla, spices or honey. In the 1520s, the drink was introduced to Spain (Minifie, 1989), although Coe and Coe (1996) emphasized that the Europeans arrivals in the New World, including Christopher Columbus and Herman Cortes, were unimpressed with the Mayan beverage, sweetening it with honey. Nevertheless, conquistadors familiarized the chocolate beverage throughout Europe and, being expensive, it was initially reserved for consumption by the highest social classes, and only in the seventeenth century did consumption of chocolate spread through Europe. After the conquest of Central America in 1521, Hernan Cortez and his conquistadors took a small cargo of cocoa beans to Spain in 1528, together with utensils for making the chocolate drink. By 1580 the drink had been popularized in the country and consignments of cocoa were regularly shipped to Spain. The popularity of chocolate as a drink spread quickly throughout Europe, reaching Italy in 1606, France in 1615, Germany in 1641 and Great Britain in 1657 (Fowler, 2009; Afoakwa, 2010).

Large-scale cultivation of cocoa was started by the Spanish in the sixteenth century in Central America. It spread to the British, French and Dutch West Indies (Jamaica, Martinique and Surinarn) in the seventeenth century and to Brazil in the eighteenth century. From Brazil it was taken to Sao Tome and Fernando Po (now part of Equatorial Guinea) in 1840; and from there to other parts of West Africa, notably the Gold Coast (now Ghana), Nigeria and Côte d'Ivoire. The cultivation of cocoa later spread to the Caribbean islands, Asia and Africa. It is currently grown in a number of Pacific islands, including Papua New Guinea, Fiji, Solomon Islands, Samoa and Hawaii (Hebbar *et al*., 2011). In Ghana, available records indicate that the Dutch missionaries planted cocoa in the coastal areas of the then Gold Coast as early as 1815, and in 1857 Basel missionaries also planted cocoa at Aburi (Jonfia-Essien, 2004). However, these did not result in the spread of cocoa cultivation until Tetteh Quarshie, a native of Osu, Accra, who had travelled to Fernando Po and worked there as a blacksmith, returned in 1879 with Amelonado cocoa pods and established a farm at Akwapim Mampong in the Eastern Region. Farmers bought pods from his farm to plant and cultivation spread from the Akwapim area to other parts of the Eastern Region

(Jonfia-Essien, 2004). In 1886, Sir William Bradford Griffith, the Governor, also arranged for cocoa pods to be brought in from Sao Tome, from which seedlings were raised at Aburi Botanical Gardens and distributed to farmers. In recognition of the contribution of cocoa to the development of Ghana, the government in 1947 established the Ghana Cocoa Board (COCOBOD) as the main government agency responsible for the development of the industry. Currently, there are six cocoa-growing regions in Ghana, namely the Ashanti, Brong Ahafo, Eastern, Volta, Central and Western regions. Ghana is the world's second largest producer of cocoa beans, producing approximately 17% of the world's cocoa (ICCO, 2015).

As the consumption of chocolate became more and more widespread during the eighteenth century, the Spanish monopoly on the production of cocoa became untenable and plantations were soon established by the Italians, Dutch and Portuguese. At this point, chocolate was still consumed in liquid form and was mainly sold as pressed blocks of a grainy mass to be dissolved in water or milk to form a foamy chocolate drink. The mass production of these chocolate blocks also began in the eighteenth century when the British Fry family founded the first chocolate factory in 1728 using hydraulic equipment to grind the cocoa beans. The first US factory was built by Dr James Baker outside Boston a few decades later, and in 1778 the Frenchman Doret built the first automated machine for grinding cocoa beans. The production of cocoa and chocolate was truly revolutionized in 1828 by the invention by Coenraad Van Houten of a cocoa press that succeeded in separating cocoa solids from cocoa butter. The resulting defatted cocoa powder was much easier to dissolve in water and other liquids and paved the way, in 1848, for the invention of the first real 'eating chocolate', produced from the addition of cocoa butter and sugar to cocoa liquor (Dhoedt, 2008).

In the United Kingdom, Joseph Fry, in 1847, was the first to produce a plain eating chocolate bar, made possible by the introduction of cocoa butter as an ingredient (Beckett, 2000). Demand for cocoa then sharply increased and chocolate processing became mechanized with the development of cocoa presses for the production of cocoa butter and cocoa powder in 1828 by Van Houten and milk chocolate in 1876 by Daniel Peters, who had the idea of adding milk powder – an invention of Henri Nestlé, a decade earlier. This was followed by the invention of the conching machine in 1880 by Rudolphe Lindt, from where chocolate came to take on the fine taste and creamy texture that we now associate with good-quality chocolate. It was still very much an exclusive product, however, and it was not until 1900 when the price of chocolate's two main ingredients, cocoa and sugar, dropped considerably that chocolate became accessible to the middle class. By the 1930s and 1940s, new and cheaper supplies of raw materials and more efficient production processes had emerged at the cutting edge of innovation, with fast manufacturing technologies and new marketing techniques through research and development by many companies in Europe and

the United States, making chocolate affordable for the wider populace. Chocolate confectionery is now ubiquitous, with consumption averaging around 8 kg per person per annum in many European countries.

1.3 Taxonomy of cocoa

Cocoa (*Theobroma cacao*) belongs to the genus *Theobroma* and it is classified in the subfamily Sterculioidea of the mallow family Malvaceae. *Cacao*, together with kola nut, was once classified under the now obsolete family Sterculiaceae. The name given to the plant provides an indication of how valuable it is; the generic name *Theobroma* is derived from the Greek for 'food of the gods'; from *θεοζ* (*theos*), meaning 'god' and *βρομα* (*broma*), meaning 'food' (Wikipedia, 2013).

There are 22 known species assigned to the genus *Theobroma* and, of these, *Theobroma cacao* is the only species widely cultivated outside its native range of distribution (Hebbar *et al.*, 2011) and is reported to be the only species of economic importance. The 22 species are sub-divided into six sections based on their morphological characters:

1 Andropetalum (*T. mammosum*);
2 Glossopetalum (*T. angustifolium*, *T. canumanense*, *T. chocoense*, *T. cirmolinae*, *T. cirmolinae*, *T. gradiflorum*, *T. hylaeum*, *T. nemorale*, *T. obovatum*, *T. simiarum*, *T. sinuosum*, *T. stipulatum*, *T. subincanum*);
3 Oreanthes (*T. bernouillii*, *T. glaucum*, *T. speciosum*, *T. sylvestre*, *T. velutinum*);
4 Rhytidocarpus (*T. bicolor*);
5 Telmatocarpus (*T. gileri*, *T. microcarpum*); and
6 Theobroma (*T. cacao*)
(Figueira *et al.*, 2002; Hebbar *et al.*, 2011).

The 22 species are grown in Brazil except those of Andropetalum (*T. mammosum*). *T. grandiflorum*, *T. obovatum*, *T. speciosum*, *T. sylvestre*, *T. subincanum*, *T. microcarpum*, *T. bicolor* and *T. cacao* are native to the Amazon basin of Brazil (Figueira *et al.*, 2002). All of these species have at least one fatty acid component similar to that of *T. cacao* (Figueira *et al.*, 2002). The composition of the fatty acids in terms of palmitic acid for the *Theobroma* species differs from that of *T. cacao* while at least one of the other fatty acids is similar to that of *T. cacao*. For example, species from the section Glossopetalum have stearic acid contents similar to that of *T. cacao* whereas *T. sylvestre* and *T. microcarpum* have oleic acid contents similar to that of *T. cacao* (Figueira *et al.*, 2002). The chemical compositions of the nibs of *T. sylvestre* and *T. speciosum* in terms of fatty acid composition are similar to that of *T. cacao* (Carpenter *et al.*, 1994; Figueira *et al.*, 2002; Quast *et al.*, 2011).

Cupuassu (*Theobroma grandiflorum*) is a fruit native to the Amazon region (Figueira *et al.*, 2002; Quast *et al.*, 2011). Among the *Theobroma* species, *Theobroma grandiflorum* has the largest fruit, with the unfermented seeds containing about 84% moisture and 60% fat on a dry weight basis (Quast *et al.*, 2011). *Theobroma*

grandiflorum has found applications in the food, pharmaceutical and chemical industries. The fat is found to be an alternative fat substitute for cocoa in chocolate production (Figueira *et al.*, 2002; Lannes *et al.*, 2003; Medeiros *et al.*, 2006). Just like cocoa, *Theobroma grandiflorum* seeds are fermented, dried and deshelled and the nibs are milled to obtain cupuassu liquor, which is used in a Brazilian product called 'cupulate', which has nutritional and sensorial characteristics that are very close to those of chocolate (Awua, 2002).

Several other species are cultivated or wild-harvested on a relatively small scale for human consumption. These are *T. bicolor* (mocambo, pataste), *T. grandiflorum* (cupuaçu) and, to a lesser extent, *T. speciosum* and *T. subincanum* (Hebbar *et al.*, 2011). Nair (2010) reported that *Theobroma bicolor* Humb. and Bonpl. are cultivated for the edible pulp around the beans and the beans are used like those of cocoa. The beans of *Theobroma angustifolium* Moc. and Sesse. are mixed with cocoa in Mexico and Costa Rica and the sweet pulp around the beans of *Theobroma grandiflorum* (Wild. ex Spreng.) Schumann are used for making a drink in parts of Brazil and is also eaten.

1.4 Morphological and varietal characteristics of cocoa

1.4.1 The cocoa plant

The cocoa plant is usually a small tree, 4–8 m tall, although when shaded by large forest trees it may reach up to 10 m in height. The stem is straight, the wood is light and the bark is thin, somewhat smooth and brownish. The fruit (pods) reach up to 15–25 cm in length. The mature fruit or pod consists of a comparatively thick husk containing between 30 and 50 seeds embedded in a thick mucilaginous pulp. All cultivated cocoas show great variability and it is generally agreed that they can be divided within the species. The principal varieties of the cocoa tree *Theobroma cacao* are as follows:

1. *Forastero* from the Amazonas region, and grown mainly in West Africa as bulk cocoa;
2. *Criollo*, rarely grown because of susceptibility to disease;
3. *Trinitario*, a hybrid of *Forastero* and *Criollo*;
4. *Nacional*, with fine flavour, grown in Ecuador.

Forastero varieties form most of the 'bulk' or 'basic' cocoa market. World annual cocoa bean production is approximately 4.23 million tonnes and major producers are Côte d'Ivoire, Ghana, Indonesia, Nigeria, Ecuador, Cameroon, Brazil and Malaysia. There are also a number of smaller producers, particularly of 'fine' cocoa, which constitutes less than 5% of world trade. In 2013, West Africa alone produced ~75% of global production with Côte d'Ivoire and Ghana producing ~38% and ~22%, respectively, thus totalling ~60%.

1.4.1.1 *Forastero* cocoa

Forastero means 'foreigner' in Spanish and refers to any cocoa trees that are not *Criollo* or a hybrid, and usually produces deep purple seeds (Hebbar *et al.*, 2011). *Forastero* is native to the Amazon region and largely grown in West Africa and South-East Asia. It represents 95% or 'bulk' of the world production of cocoa (Delonga *et al.*, 2009; Fowler, 2009; Afoakwa, 2010; Afoakwa *et al.*, 2012) and is the most widely used as it has a higher yield than *Criollo* variety. *Forastero* varieties exhibit greater variability in both tree and fruit morphology. The pods when ripe are hard, yellow and have a more rounded shape like a melon (Figures 1.1 and 1.2), containing 30 or more pale to deep purple beans. This variety is generally more vigorous and less susceptible to diseases, such as swollen shoot, mottle leaf, yellow mosaic, cocoa necrosis, witches broom and black pod (Afoakwa, 2010; Dzahini-Obiatey *et al.*, 2010), and also pests, such as capsids and cocoa pod borer (*Conopomorpha cramerella*) (Fowler, 2009; Afoakwa, 2010; ICCO, 2012) than the *Criollo* variety. *Forastero* cocoa beans are characterized by darker brown cotyledons which are slightly bitter but have the strongest flavour. Chocolate products from these beans are rich in chocolate flavour but low in complex or fruity flavour notes (deZaan Cocoa Manual, 2009; Hebbar *et al.*, 2011).

Several cultivars of *Forastero* are grown in Ghana. The main cultivars are Amelonado (13.3%) and Amazonica (34.4%), including a new hybrid, the

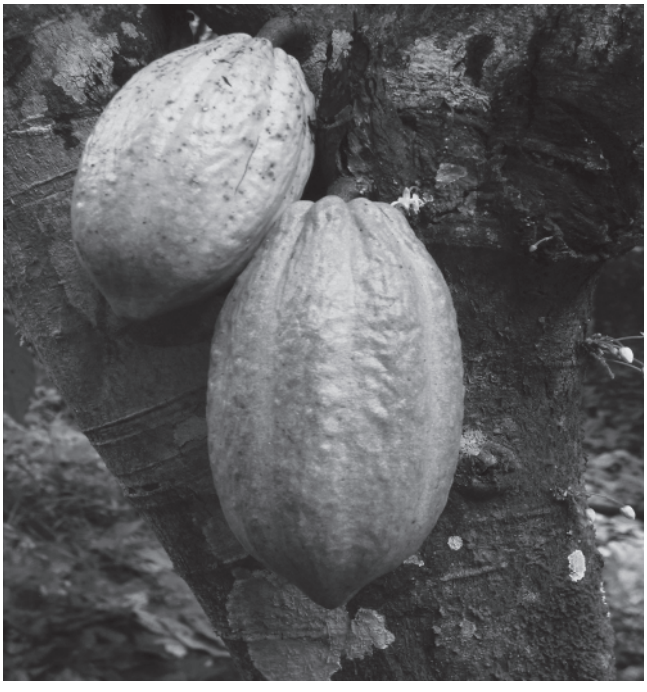

Figure 1.1 Typical unripe *Forastero* cocoa pods. (*See plate section for color representation of this figure*.)

Figure 1.2 Typical ripe *Forastero* cocoa pod. (*See plate section for color representation of this figure*.)

mixed hybrid (52.3%). The farmers in Ghana locally call the mixed hybrid variety *akokora bedi*, which literally means *the aged will surely enjoy*. This is due to the short duration needed to begin bearing fruits. Amelonado is the *Forastero* variety widely grown in West Africa (Fowler, 2009; Hebbar *et al.*, 2011) with the varieties including Comum in Brazil, West African Amelonado in Africa, Cacao Nacional in Ecuador and Matina or Ceylan in Costa Rica and Mexico (ICCO, 2012).

The *Forastero* type of cocoa now forms the greater part of all cocoa grown and is hardy and vigorous, producing beans with the strongest flavour. It is a much more plentiful variety of high-quality cocoa, representing most of the cocoa grown in the world. Grown mainly in Brazil and Africa, it is hardier, higher yielding and easier to cultivate than *Criollo* and is used in just about every blend of chocolate that is made. The pods are short, yellow and smooth without warts, with shallow furrows, and a pod has 30 or more pale to deep purple beans.

1.4.1.2 *Criollo* cocoa

Criollo refers to a group of genetically similar trees that produce lightly pigmented seeds and share several other morphological traits (Hebbar *et al.*, 2011). This variety exhibits symptoms of inbreeding depression and has a history of low vigour, poor productivity and a high susceptibility to diseases, insects and stress attack,

and hence is less cultivated (Afoakwa, 2010; Hebbar *et al.*, 2011). This type is now very rare and found only in old plantations in Venezuela, Central America, Madagascar, Sri Lanka and Samoa (Fowler, 2009). The *Criollo* bean has the highest aromatic flavour quality on the international market. It is less bitter and more aromatic and therefore has a mild and nutty cocoa flavour (Fowler, 2009; deZaan Cocoa Manual, 2009; Rusconi and Conti, 2010) than any other beans, they are therefore highly priced. The yield of a *Criollo* cocoa plantation is lower than that of a *Forastero* plantation of the same size. The fruits of the *Criollo* variety typically have a soft, thin husk or pod with a textured surface and usually have some degree of red pigmentation with 20–30 white or faint purple beans. When *Criollo* pods are ripe, they are long, yellow or red, with deep furrows and large warts (Figure 1.3).

1.4.1.3 *Trinitario* cocoa

Trinitario cocoa variety is a hybrid between the *Criollo* and *Forastero* varieties. *Trinitario* developed in Trinidad (Willson, 1999; deZaan Cocoa Manual, 2009), hence the name, but later spread to Venezuela, Ecuador, Cameroon, Samoa, Sri Lanka, Java and Papua New Guinea (ICCO, 2012). Some *Trinitario* varieties produce cocoa beans with special flavours. They have mostly hard pods and are variable in colour, can be long or short, and they contain 30 or more beans of variable colour (Figure 1.4), but white beans are rare.

1.4.1.4 *Nacional* cocoa

Nacional cocoa variety grows in Ecuador. It is believed to have originated from the Amazonian area of Ecuador (deZaan Cocoa Manual, 2009; Fowler, 2009;

Figure 1.3 Typical *Criollo* cocoa. (*See plate section for color representation of this figure.*)

(a) (b)

Figure 1.4 Typical *Trinitario* cocoa pods.

Afoakwa, 2010) and has distinctive aroma and flavour characteristics (Afoakwa, 2010; Hebbar *et al.*, 2011) but is less cultivated hence contributes about 5% of global cocoa production. Currently, pure *Nacional* cocoa varieties are rare. The one with Arriba flavour in Ecuador is a hybrid between *Nacional* and *Trinitario* (Fowler, 2009). Typical *Nacional* cocoa pods are shown in Figure 1.5. Research conducted in 2008 in Latin America suggested a new classification of cacao germplasm into 10 major groups: Marañon, Curaray, Criollo, Iquitos, Nanay, Contamana, Amelonado, Purús, Nacional and Gulana (Motamayor *et al.*, 2008; deZaan Cocoa Manual, 2009;). This classification reflects much more accurately the genetic diversity of cacao. Important characteristic differences between typical *Criollo*, *Forastero* and *Trinitario* cocoas are presented in Table 1.1.

1.5 Varietal effects on cocoa bean flavour

The different cocoa bean genotypes or varieties discussed above influence both flavour quality and intensity in chocolate during manufacturing (Taylor, 2002; Luna *et al.*, 2002; Counet *et al.*, 2004). The differences are largely due to the wide differences in the chemical compositions of the derived beans, likely determining the quantities of flavour precursors and activity of enzymes and thus contributions to flavour formation. Reineccius (2006) concluded that varietal differences were primarily due to quantitative (as opposed to qualitative) differences in flavour precursor and polyphenol contents. The contents of sugars and

Figure 1.5 Typical *Nacional* cocoa pod.

Table 1.1 Characteristics of the different cocoa varieties.

Characteristics		Criollo	Forastero	Trinitario
Pod husk	Texture	Soft, crinkly	Hard, smooth	Mostly hard
	Colour	Red occurs	Green	Variable
Beans	Average No. per pod	20–30	30 or more	30 or more
	Colour of cotyledons	White, ivory or very pale purple	Pale to deep purple	Variable; white beans rarely
Agronomic	Tree vigour	Low	Vigorous	Intermediate
	Pest and disease susceptibility	Susceptible	Moderate	Intermediate
Quality	Fermentation need	1–3 days maximum	Normally 5 days	4–5 days
	Flavour	Weak chocolate; mild and nutty	Good chocolate	Good chocolate; full cocoa
	Fat content	Low	High	Medium
	Bean size (g/100 beans)	85	94	91

enzymic breakdown of polysaccharides constitute an important source of precursors. However, post-harvest processes (fermentation and drying) and roasting have a strong influence on the final flavours (Kattenberg and Kemming, 1993; Clapperton *et al.*, 1994; Luna *et al.*, 2002; Counet and Collin, 2003). The three primary cocoa types, *Forastero* (bulk grade), *Criollo* (fine grade) and the hybrid *Trinitario* (fine grade) show wide variations in final flavour (Beckett, 2000; Awua, 2002; Amoye, 2006). *Nacional* cacao is viewed as a third fine variety, producing the well-known Arriba beans with distinctive floral and spicy flavour notes (Despreaux, 1998; Luna *et al.*, 2002; Counet *et al.*, 2004). These differences in flavour can be ascribed to variations in bean composition from botanical origin, location of growth and farming conditions. Bulk varieties dominate blends whereas fine grades, used in lesser quantities, are selected to make specific contributions to the overall flavour profile.

Each bean variety has a unique potential flavour character, but growing conditions such as climate, amount and time of sunshine and rainfall, soil conditions, ripening, time of harvesting and time between harvesting and bean fermentation all contribute to variations in final flavour formation. Table 1.2 summarizes how differences in genetic origin, cocoa variety and duration of fermentation influence the flavour profile, but different conditions may lead to significant differences in flavour from a single cocoa variety. A good example is the difference in flavour profile between a single *Forastero* variety produced originally in Ghana

Table 1.2 Effects of origin, cocoa variety and fermentation duration on flavour character.

Origin	Cocoa type	Duration (days)	Special flavour character
		Short	
Ecuador	*Nacional* (Arriba)	2	Aromatic, floral, spicy, green
Ecuador	*Criollo* (CCN51)	2	Acidic, harsh, low cocoa
Ceylon	*Trinitario*	1.5	Floral, fruity, acidic
Venezuela	*Trinitario*	2	Low cocoa, acidic
Venezuela	*Criollo*	2	Fruity, nutty
		Medium	
Zanzibar	*Criollo*	6	Floral, fruity
Venezuela	*Forastero*	5	Fruity, raisin, caramel
Ghana	*Forastero*	5	Strong basic cocoa, fruity notes
Malaysia	*Forastero/Trinitario*	6	Acidic, phenolic
		Long	
Trinidad	*Trinitario*	7–8	Winy, raisin, molasses
Grenada	*Trinitario*	8–10	Acidic, fruity, molasses
Congo	*Criollo/Forastero*	7–10	Acidic, strong cocoa
Papua New Guinea	*Trinitario*	7–8	Fruity, acidic

Source: Afoakwa *et al.* (2008a). Reproduced with permission of Taylor & Francis.

and now grown in Malaysia (Clapperton, 1994), arising possibly through geographic and climatic conditions and duration and/or method of fermentation.

Bulk cocoas typically show strong flavour characters; fine cocoas are perceived as *aromatic* or *smoother* (Kattenberg and Kemming, 1993; Jinap *et al*., 1995; Luna *et al*., 2002). Clapperton *et al*. (1994) noted consistent differences in flavour attributes, specifically overall cocoa flavour intensity, *acidity*, *sourness*, *bitterness* and *astringency*. Bean origins include the West African Amelonado variety (AML), four Upper Amazon clones [Iquitos Mixed Calabacillo 67 (IMC67), Nanay 33 (NA33), Parinari 7 (PA7) and Scavina 12 (SCA12)] and Unidentified Trinatario (UIT1) grown in Sabah, Malaysia. The flavour characters in UIT1 differed from those in West African Amelonado, characterized by intense *bitterness* and *astringency* associated with caffeine and polyphenol contents. Fermented beans from South-East Asia and the South Pacific are characterized by a higher *acidity* (more lactic and acetic acids) than West African beans (Clapperton *et al*., 1994) due to varietal differences, box fermentation and rapid artificial drying.

Cocoa liquors differ in sensory character. The West African group (Ghana, Côte d'Ivoire and Nigeria) are generally considered sources of standard (benchmark) cocoa flavour with a balanced but pronounced cocoa character with subtle to moderate *nutty* undertones. Cameroon liquors are renowned for *bitterness* and those from Ecuador for *floral–spicy* notes. American and West Indian varieties range from *aromatic* and *winy* notes from Trinidad cocoa to the floral or *raisin–fruity* notes of Ecuadorian stocks making unique contributions to blends. Asian and Oceanian beans exhibit a range of flavour profiles ranging from *subtle* cocoa and *nutty/sweet* notes in Java beans to the intense *acid* and *phenolic* notes of Malaysian beans (De La Cruz *et al*., 1995).

Figure 1.6 shows an infograph prepared by Sean Seidell depicting the different cocoa varieties grown in different cocoa-growing countries around the world.

Counet *et al.* (2004) reported that fine varieties with short fermentation processes had high contents of procyanidins, while *Trinatario* from New Guinea and *Forastero* beans were specifically higher in total aroma. Aroma compounds formed during roasting were found to vary quantitatively directly with fermentation time and inversely with the procyanidin content of cocoa liquors.

High concentrations of phenol, guaiacol, 2-phenylbutenal and γ-butyrolactone characterize Bahia beans known for typical *smoked* notes. Also reported are higher contents of 2-methylpropanal and 3-methylbutanal in Caracas (Venezuela) and Trinidad dried fermented beans (Dimick and Hoskin, 1999). Of Maillard products, Reineccius (2006) reported that roasting yields higher levels of pyrazines in well-fermented beans (Ghana, Bahia) than in less-fermented (Arriba) or unfermented beans from Sanchez (Dominican Republic) or Tabasco (Mexico). Lower in *astringency* and *bitterness* imparted by polyphenols, C*riollo* beans, in which anthocyanins are absent, are often less fermented than *Forastero* beans (Carr *et al*., 1979; Clapperton, 1994; Clapperton *et al*., 1994; Luna *et al*., 2002).

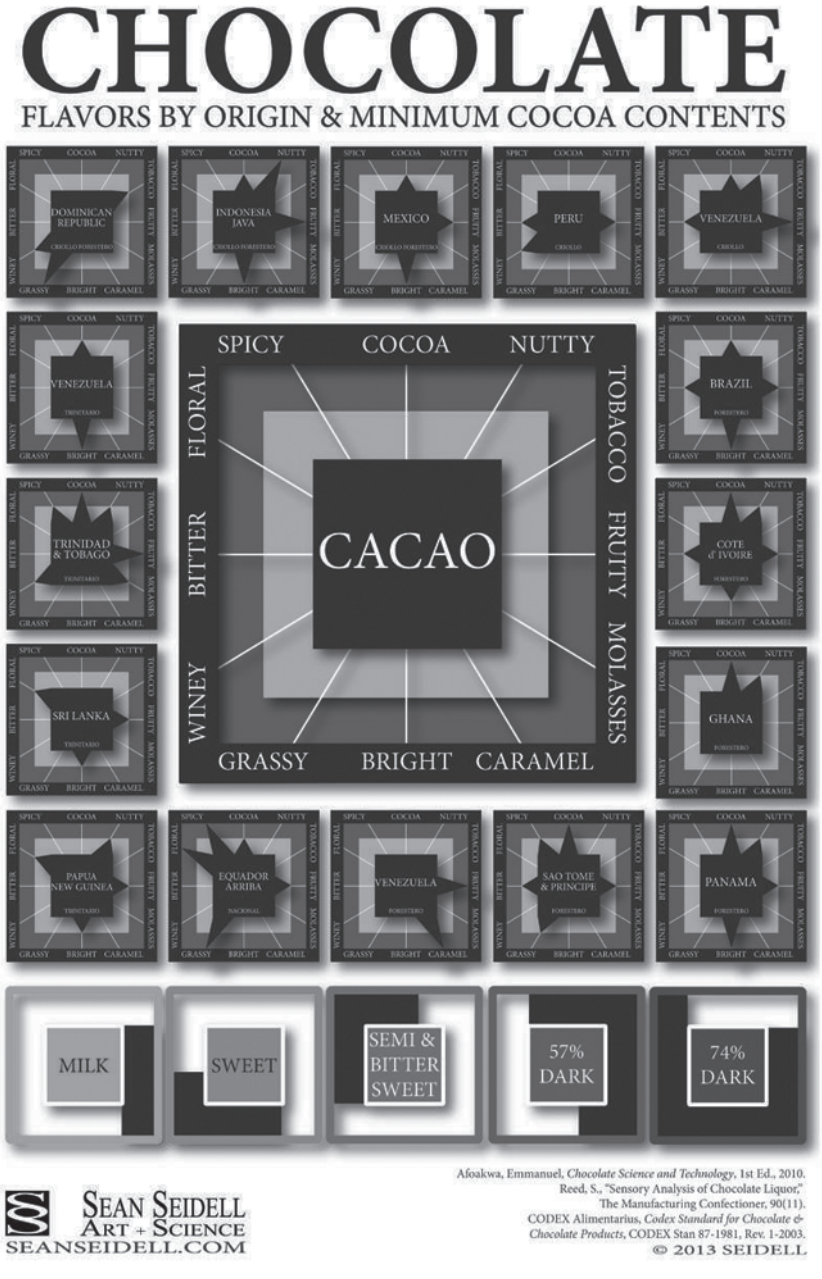

Figure 1.6 Infograph showing cocoas of different origins and their dynamic flavours. Source: courtesy of Sean Seidell. (*See plate section for color representation of this figure*.)

1.6 The concept of this book

The chocolate industry is undergoing dynamic changes in the nature of the demand for chocolate. The trends towards niche or premium chocolate products have engendered not only new challenges but also opportunities for all participants in the sector. Until recently, the general perception was that consumption of chocolate in Europe and the United States would begin to stagnate, as these major chocolate markets were reaching saturation. However, consumption behaviour across these mature markets has recently experienced major change, with the increasing appeal of premium chocolate, including organic, Fairtrade, single-origin, reduced-sugar, sugar-free, dark and high cocoa content chocolates. Indeed, the confectionery market has increasingly been characterized by consumer demand for taste, convenience and health and products addressing sustainability, traceability, ethical and environmental concerns.

New product developments and 'functional foods' with wholesome ingredients (foods that provide health benefits beyond basic nutrition) have played an important role in the upward trend of the confectionery market. In recent times, many research studies have increasingly been conducted on the health and nutritional benefits of cocoa and chocolate. The findings indicate that flavanoids in cocoa may decrease low-density lipoprotein (LDL or 'bad' cholesterol) oxidation, helping to prevent cardiovascular diseases. In addition, the high content of antioxidants in cocoa has been proven to reduce the risk of cancer. The demand for dark and high cocoa content chocolate in particular has surged in response to these positive findings.

The chocolate industry has demonstrated a strong ability to meet these challenges and to benefit from the new opportunities brought about through changing consumer demands. Companies traditionally known for milk chocolate products have been introducing new dark and high cocoa content chocolate products. The dark chocolate global market is now estimated to represent about 10% of the total market for chocolate tablets (the others being plain milk, plain white and filled chocolate tablets), with a higher share in continental Europe than in the United States and the United Kingdom. Similarly, the certified organic and Fairtrade chocolate markets have been booming, increasing at double-digit percentage rates.

The advent of increased demand for chocolates has impacted significantly on the demand for cocoa beans in terms of both quantity and quality. Although the chocolate industry has responded proactively to this development, the need for cocoa producers to have further information on this issue has been brought to the fore. Such information would provide cocoa-producing countries with a better basis for formulating and implementing policies and programmes regarding cocoa production. One of the main challenges facing producing countries, to enhance their revenues from cocoa, is to meet the changing face of consumer demand. As a result of these increasing chocolate consumption trends, the cocoa

processing and chocolate manufacturing industry faces an enormous challenge of meeting the demand and quality criteria expected by the consuming populations. This has to be addressed vigorously by increasing the production capacities of the chocolate manufacturing industries, which also requires a great deal of understanding of the science and technology of chocolates.

As chocolate manufacturing is complex and requires numerous technological operations and the addition of a range of ingredients to achieve products of suitable physical and chemical attributes, and appearance and taste parameters with pre-specific ranges, understanding the science of its manufacture and the technological processes that can result in the expected product quality is paramount. Additionally, chocolate processing differs due to historical development within a producing company and the geographical locations in which products are sold, and therefore requires the necessary expertise to achieve the required quality attributes, rheological characteristics, flavour development and thus sensory perception that are needed to satisfy a specified consuming population.

This book is therefore a mediator in bringing modern fundamental, scientific and technological knowledge and understanding of the processes involved in cocoa processing and chocolate manufacture to all who are engaged in the business of learning, making, consuming and using cocoa and chocolate products worldwide.