Cocoa Production and Processing Technology

Emmanuel Ohene Afoakwa

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This book is dedicated to my dear wife, Ellen and our lovely children Cita, Nana Afra, Maame Agyeiwaa and Kwabena Ohene-Afoakwa (Junior) whose wisdom, prayers and support have helped me achieve great success in my career and life.

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Preface

Over the past few decades, cocoa has increasingly gained spectacular attention on the global market as it continues to become one of the most lucrative and heavily traded food commodities in the world. This has led to interesting continuous increases in cocoa production across the world, most especially by the four main growing countries in West Africa—Côte d'Ivoire, Ghana, Nigeria and Cameroon—now together providing ~75% of the global cocoa market. Coupled with these and the recent expansion of cocoa production from Southeast Asia—Indonesia, Malaysia and Vietnam—has raised questions by various stakeholders in the cocoa business and processors in the confectionery industry over the quality of cocoa that enters the international market. That notwithstanding, the cocoa market has become far more sophisticated than it was in the 1990s and despite the challenges it faces it is still one of the largest food commodities exported from the developing countries to the rest of the world.

Many questions, however, continue to be raised by various organisations involved in the cocoa business as well as manufacturers and consuming countries on the quality, sustainability and traceability of cocoa. Such concerns are not new, but have led to several discussions over the past decades which laid the foundations for the quality assessment of cocoa beans used today. Recent developments on the emergence of Southeast Asia as a new block in the cocoa market and the continuously increasing production capacities by the old players, together with cocoa processors and the consuming public wanting even higher standards, have regenerated these concerns. It is thus important for cocoa producers across the globe to understand the factors that can bridge the gap in the sustainable production of high-quality cocoa beans for the international market. Many of these concerns stem from the fact that the major cocoa-producing countries use far different production and post-harvest practices and strategies which are inconsistent and nonharmonised. This is because the factors leading to sustainable production of high-quality cocoa beans including cocoa genotype, environmental conditions and post-harvest treatments are not well understood.

This book provides overviews of up-to-date scientific and technical explanations of the technologies and approaches to modern cocoa production practices, global production and consumption trends as well as principles of cocoa processing and chocolate manufacture. Principally, it provides detailed information on the origin, history and taxonomy of cocoa, as well as fairtrade and organic cocoa industries and their influence on the livelihoods and cultural practices of smallholder farmers. Other important aspects cover factors that promote production, sustainability and traceability of high-quality cocoa beans for the global confectionery industry.

The chapters cover the entirety of the cocoa cultivation, harvesting and post-harvest treatments with special emphasis on cocoa bean composition, genotypic variations in the bean and their influence on flavour quality, post-harvest pre-treatments (pulp pre-conditioning by pod storage, mechanical and enzymatic depulping, and bean spreading), fermentation techniques, drying, storage and transportation. Details of the cocoa fermentation processes as well as the biochemical and microbiological changes involved and how these influence flavour formation and development during industrial processing are discussed. Much attention is also given to the cocoa trading systems, bean selection and quality criteria. Other important aspects covered include scientific and technological explanations of the various processes involved in industrial processing of fermented and dried cocoa beans into liquor, cake, butter and powder, and these include cleaning and sorting, winnowing, sterilisation, roasting, alkalisation, grinding, liquor pressing into butter, deodorisation and cocoa powder production. It also covers the general principles of industrial chocolate manufacture, with detailed scientific explanations of the various stages of chocolate manufacturing processes including mixing, refining, conching and tempering/fat pre-crystallisation systems. The discussions also cover the factors that influence the quality characteristics of finished chocolates, quality parameters, post-processing defects and preventive strategies for avoiding post-processing quality defects in chocolate. These in tandem with the earlier discussions provide innovative techniques related to sustainability and traceability in high-quality cocoa production as well as new product development with significance for cost reduction and improved cocoa bean and chocolate product quality.

The ideas and explanations provided in this book evolved from my research activities on cocoa and the various interactions I have had with cocoa farmers in Ghana, who produce bulk cocoa beans with the highest quality worldwide, and those from many other countries across the world as well as other stakeholders engaged in the production, storage, marketing, processing and manufacturing of cocoa and chocolate products. It contains detailed explanations of the technologies that could be employed to assure sustainable production of high-quality and safe cocoa beans for the global confectionery industry. With opportunities for improvements in quality possible through improved production practices and more transparent supply chain management, plant breeding strategies and new product development associated with fairtrade, organic and the development of niche premium quality products, there is a need for greater understanding of the variables as well as the science and technologies involved.

It is hoped that this book will be a valuable resource for academic and research institutions around the world, and as a training manual on the science and technology of cocoa production and processing, and chocolate manufacture. It is aimed at cocoa producers, traders and businesses as well as confectionery and chocolate scientists in industry and academia, general practising food scientists and technologists, and food engineers. The chapters on research developments are intended to help generate ideas for new research activities relating to process improvements, product quality control and assurance, as well as development of new niche/premium cocoa and chocolate products.

It is my vision that this book will inspire all bulk cocoa-producing countries across the world to strive to produce high-quality cocoa beans, similar to those of Ghana beans, for the global cocoa market and as well inspire many local and multinational cocoa-processing industries in their quest for adding value to the many raw materials that are produced within these countries, especially cocoa.

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I am sincerely grateful to my parents—the late Mr Joseph Ohene Afoakwa (Esq.) and Mrs Margaret Ohene Afoakwa—for ensuring I obtained the best education in spite of the numerous challenges they faced during some periods of their lives. Their profound love, prayers, support and advice strengthened me from my childhood, giving birth to the many dreams and aspirations which have all become realities in my life today. As well, I am thankful to the government of Ghana and to all cocoa farmers in Ghana whose toil and sweat were used to fund my education through the Ghana Cocoa Board Scholarship Scheme, which I earned all throughout my secondary education, without which I could not have remained in school to make it to the university level. I am indeed grateful for the support received from the government and the people of Ghana throughout my education.

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Finally, my profound appreciation and love go to my siblings Sammy, Juliana and Regina for their prayers and support throughout my education, and again to my dear wife, Ellen and our children Cita, Nana Afra, Maame Agyeiwaa and Kwabena Ohene-Afoakwa (Junior) for supporting me and most importantly providing the much needed love, encouragement and affection that have strengthened me throughout my career.

About the Author

Emmanuel Ohene Afoakwa, PhD, is an associate professor in food science in the Department of Nutrition and Food Science, University of Ghana. He holds a PhD degree in food science from the University of Strathclyde, Glasgow, UK and MPhil and BSc (Honours) degrees in food science from the University of Ghana, Legon-Accra, Ghana. He also holds a certificate in international food laws and regulations from Michigan State University, East Lansing, Michigan, USA. In addition, he holds a post-graduate certificate in food quality management systems from the International Agricultural Centre of Wageningen University, Wageningen, the Netherlands. He is also a trained and licensed food auditor of the World Food Safety Organization, UK.

Dr Afoakwa has vast relevant experience in food science and technology and international food laws and regulations. He is a member of several professional bodies including the Institute of Food Technologists (IFT), Food Science and Nutrition Network for Africa (FOSNNA), Information Technology for the Advancement of Nutrition in Africa (ITANA), The African Network for School Feeding Programmes (ANSFEP), the Ghana Institute of Nutrition and Food Technology (GINFT) and the Ghana Science Association (GSA). He has authored and co-authored 160 publications (including 70 peer-reviewed journal publications, 4 books, 4 book chapters, 2 encyclopaedia chapters and 80 conference presentations with published abstracts) in food science and technology, food and nutrition security, and school feeding programmes.

In the pursuance of his duties as a food technologist, he has travelled to 34 different countries across the globe where he has gained high international recognition for his work. He is a member of the board of directors of the Global Child Nutrition Foundation (GCNF) in Washington, DC, USA; the executive secretary to the African Network for School Feeding Programmes; the executive secretary to the Ghana Institute of Nutrition and Food Technology, and the scientific secretary to the Society on Information Technology for the Advancement of Nutrition in Africa (ITANA). He also serves as a member of editorial boards of several international journals as well as a technical reviewer for more than 10 international peer-reviewed journals around the world. In addition, he is a technical advisor to the International Foundation for Science (IFS) within the area of food science and nutrition. As well, he is a consultant trainer in scientific writing and grant proposal development with the African Women in Agricultural Research and Development (AWARD). He has vast experience in food technology and nutrition, and translates his research findings through process and product development into industrial production towards the achievement of the UN Millennium Development Goals (MDGs) mainly on food and nutrition security, and sustainable agricultural development.

Dr Afoakwa is an expert in cocoa and chocolate technology and has published extensively and given several presentations at international conferences around the world including the Annual Meeting of International Food Technologists (IFT) in the United States, the International Conferences of Food Science and Technology, World Congress of Food Science and Technology (IUFoST Bi-annual Congresses) in France, China and Brazil, and the ZDS Chocolate Technology International Congress by ZDS Solingen in Cologne, Germany.

1 Introduction to the World Cocoa Economy

1.1 INTRODUCTION

Cocoa (*Theobroma cacao* L.), generally known to have originated from Central and South America, is an important agricultural export commodity in the world and forms the backbone of the economies of some countries in West Africa, such as Côte d'Ivoire and Ghana. 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 foreign exchange earner and many farmers and their families depend on it for their livelihood (Afoakwa 2010). The World Cocoa Foundation estimates the number of cocoa farmers worldwide currently to be 5–6 million and the number of people who depend upon cocoa for their livelihood, worldwide, 40–50 million. Hence the economic importance of cocoa cannot be overemphasised and current global market value of the annual cocoa crop is US $5.1 billion (Ghana Cocoa Board 2010; World Cocoa Foundation 2010).

Cocoa continues to be an important source of export earnings for many producing countries, in particular in Africa. Africa's heavy dependence on cocoa as well as 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 2010, after gold, generating US $2.2 billion. In Côte d'Ivoire, dependence on cocoa exports has been declining in recent years, with export revenues from crude oil and petroleum products increasing significantly over the same period. These are estimated to have surpassed revenues from cocoa in 2005. However, with lower oil prices in 2009 and the price of cocoa surging, cocoa-derived export revenues increased significantly in 2009, surpassing oil revenues and reaching a total of US $3.7 billion in 2009 and US $3.8 billion in 2010 (ICCO 2012a).

The African region accounts for approximately 75% of net world exports of cocoa, and is by far the largest supplier of cocoa to the world markets, followed by Asia and Oceania (16%) and the Americas (6%). The cocoa market remains highly concentrated, with the top five countries accounting for 87% of world net exports, whereas over 98% originated from the top 10 countries during the five-year period from 2006/2007 to 2010/2011. Côte d'Ivoire is the world's leading exporter of cocoa, representing 37% of global net exports, followed by Ghana (22%) and Indonesia (15%). With increased processing at the origin, cocoa products now represent a slightly higher proportion of total cocoa exports in most cocoa-producing countries (ICCO 2012b).

1.2 MAJOR CHANGES IN THE WORLD COCOA TRADE

Major changes have taken place in the world cocoa economy over the last 10 years up to the current 2012/2013 season. These include, among others, the development of supply and demand of and for cocoa, cocoa farm gate prices, trade flows of cocoa beans between regions, past and present price developments, the reliance of cocoa-producing countries on the cocoa sector in terms of export revenues and recent developments concerning chocolate consumption.

World cocoa production rose from nearly 3.2 million tonnes in the 2002/2003 cocoa season to an estimated 4 million tonnes forecast for the 2012 season. This represents an average annual growth rate of 3.3%, using a three-year moving average to smooth out the effect of weather-related aberrations. Annual production levels have deviated considerably from the trend value, mainly arising from the influence of climatic factors. Although production suffered in the 2006/2007 season, declining by nearly 10% and resulting in the record deficit of nearly 280,000 tonnes, an all-time record output of over 4.3 million tonnes was achieved during the 2010/2011 cocoa year, arising from excellent weather conditions favouring crop development across Africa, the world's largest cocoa-producing region.

World cocoa consumption, as measured by grindings of cocoa beans by the industry, also increased on average by 2.9% per annum over the review period. Grindings have shown a more consistent trend than production, rising from nearly 3.1 million tonnes in 2002/2003 to over 3.9 million tonnes in 2010/2011 with a forecast of nearly 4 million tonnes for 2011/2012. The review period witnessed only one decline, albeit notable, in 2008/2009 when consumer demand fell in the midst of global economic woes and the steady increase in cocoa bean prices.

Taking the period 2002/2003 to 2011/2012 as a whole, production surpluses occurred in five out of the last ten seasons and production deficits in the other five of the last ten seasons. Total end-of-season stocks rose from 1.395 million tonnes in 2002/2003 to an estimated 1.732 million tonnes at the end of the current season. However, as a result of increased grindings, the ratio of world cocoa bean stocks to grindings is estimated to have declined from 46% in 2002/2003 to 43% at the end of the 2011/2012 crop year.

There has been an increased demand for cocoa beans in Asia, Eastern Europe and Latin America, which reflects the increasing consumption of chocolate in these countries. Over the past decade, cocoa consumption, as measured by grindings, has increased by 2.5% from the 3,608,000 tonnes in 2006/2007 to 4,008,000 tonnes in 2012/13. Despite a relative slowdown during that 2006/2007 season, the cocoa market has been characterised over the last five years by a sustained demand for cocoa, rising by 3.8% per annum (based on a three-year moving average). This was supported by a strong demand for cocoa butter to rebuild stocks, as well as by rising chocolate consumption in emerging and newly-industrialised markets and changes in chocolate consumption behaviour in mature markets towards higher cocoa content chocolate products (Afoakwa 2010; ICCO 2012b). Other market trends such as growing interest in 'ethically' produced chocolates (organic, Fairtrade, rainforest) have marginally increased demand for beans produced according to specific requirements. These trends suggest an increased demand for cocoa beans produced under more controlled conditions, whether for quality or certification (organic, Fairtrade) purposes (ICCO 2012b).

Fairtrade is concerned with ensuring a fair price and fair working conditions for producers and suppliers, promoting equitable international trading agreements. Over the past decade Fairtrade has experienced considerable growth in the food sector with direct influence on Fairtrade cocoa sourcing and supply. This growth has been significantly aided by labelling and certification through the Fairtrade Foundation mark and its availability in the mainstream cocoa marketing system. Sales in Fairtrade cocoa have increased remarkably over the past decade with annual purchases increasing progressively from 1996 to 2012, and almost doubling between 2005 and 2012. In 2006, Fairtrade cocoa attracted a relatively larger market worldwide with annual purchases of 10,919 MT representing about a 93% increase in sales of 2005, an indication that the sustained Fairtrade certification process has been a viable strategy to achieving the objectives of ethical trading. Paying premium prices means that Fairtrade cocoa in niche markets is positioned as premium-priced produce in the market. Further progress made within the Fairtrade and organic cocoa industries would be examined. As well, the entire Fairtrade labelling and certification systems provides an overview of trends in world sourcing, marketing systems and supply chain management of Fairtrade cocoa over the past decade.

Projections for the next five years predict that cocoa prices will remain steady, with both supply and demand increasing by about 3% per year. Africa has been and is projected to remain the principal cocoa producer with 70% market share, assisted by recent improvements to political and social conditions in Côte d'Ivoire. Another predicted growth factor is the continued increase of chocolate consumption in Asian markets (ICCO 2012a,b). Furthermore, the market share held by dark and specialty chocolate is expected to continue to increase, thus also increasing demand for quality cocoa beans. At the same time, concerns have been raised over the impact of climate change, the international economic downturn and a growing awareness of child labour on cocoa production and prices. These all have the potential to reduce supply, or decrease prices gained at market (COPAL 2008).

1.3 POST-HARVEST TREATMENTS AND COCOA BEAN QUALITY

Market trends have fuelled the overall demand for cocoa beans; at the same time, much greater attention is being paid to the quality of the cocoa beans being produced worldwide. Over the past 50 years, much of the research into cocoa bean fermentation, drying and processing has been aimed at solving certain quality or flavour problems. This book also outlines the progress that has been made in improving cocoa quality, focussing on the role of fermentation and to a lesser extent, drying.

The impact of post-harvest treatment on fresh cocoa beans and the effects of these treatments on fermentation and final bean quality have been investigated. Three basic processes have been evaluated for the treatment of fresh cocoa beans prior to fermentation: pod storage, mechanical depulping and enzymatic depulping. All three of these treatments were developed or investigated in attempts to reduce the problem of acidity in dried fermented cocoa beans. Over-acidity in processed cocoa beans has been linked to the production of high levels of lactic and acetic acid during fermentation. By removing a portion of the pulp, or reducing the fermentable sugar content of the beans, it has been shown that less acid is produced during fermentation, leading to less acidic beans (Duncan et al. 1989; Sanagi, Hung, and Yasir 1997). Removal of up to 20% of the cocoa pulp from fresh Brazilian cocoa beans significantly improved the flavour quality of the beans produced (Schwan and Wheals 2004). Methods for mechanically depulping fresh cocoa beans include presses (Rohan 1963; Wood and Lass 1985), centrifuges (Schwan, Rose, and Board 1995) or simply spreading beans onto a flat surface for several hours prior to fermentation, causing a significant increase in the sweating produced in the first 24 hours of fermentation. In addition to reducing acidity, benefits of depulping include shorter fermentations and increased efficiency and the ability to use the excess pulp in the manufacture of jams, marmalade, pulp juice, wine or cocoa soft drinks (Buamah, Dzogbefia, and Oldham 1997; Schwan and Wheals 2004; Dias et al. 2007; Afoakwa 2010).

Storage of cocoa pods before the beans are removed for fermentation can also be beneficial to fermentation outcomes (Sanagi et al. 1997). It has been shown that upon storage, the pulp volume per seed decreases, due to water evaporation and inversion of sucrose (Biehl et al. 1989) and the total sugar content is diminished, reducing acid production during fermentation. The flavour quality of Malaysian beans was improved by pod storage for up to 21 days prior to fermentation (Barel et al. 1987; Duncan et al. 1989; Aroyeun, Ogunbayo, and Olaiya 2006). Findings from our recent work on Ghanaian cocoa also revealed that storage of cocoa pods for five days after harvest enhances the fermentative quality of the beans and as well reduces the fermentation time from six days to four days (Afoakwa et al. 2012).

Generally, quality may be considered as a specification or set of specifications which are to be met within given tolerances or limits. However, in the context of cocoa quality, it is used to include not just the all-important aspects of flavour and purity, but also physical characteristics that have direct bearing on manufacturing performance, especially yield of cocoa nib (Biscuit, Cake, Chocolate and Confectionery Alliance, BCCCA 1996). The different aspects or specifications of quality in cocoa therefore include: flavour, purity or wholesomeness, consistency, yield of edible material and cocoa butter characteristics.

The quality of cocoa beans is an important trade parameter because the quality of chocolate depends to a large extent upon the quality of the cocoa beans used to make the chocolate. After cocoa is harvested, the beans have to be fermented and dried, a process which enables them to develop the characteristic cocoa flavour after they have been roasted. Nearly all exported cocoa is sold on the international markets in London, New York and Paris. Inasmuch as chocolate is sold in a very competitive market, manufacturing companies would like to buy the best quality cocoa. Fine and flavour cocoas have distinctive aroma and flavour characteristics and are therefore sought after by chocolate manufacturers but they represent only 5% of global cocoa production. Generally to make good quality chocolate, cocoa beans must have cocoa flavour potential; be free from off flavours such as smoky and mouldy flavours; should not be excessively acidic, bitter or astringent; should have uniform sizes and on the average weigh 1 gram, should be well fermented, thoroughly dry with a moisture content of between 6 and 8%; have a free fatty acid content of less than 1%; cocoa butter content of 50 to 58%; shell content of less than 11 to 12% and be free from live insects, foreign objects, harmful bacteria, and pesticide residue. In recent times, concerns regarding the chemical and microbial safety of cocoa beans continue to emerge in the global cocoa trade. These largely focus on the presumably high concentrations of pesticide residues and ochratoxins (OTA) in cocoa beans produced within the West African sub-region.

That notwithstanding, questions continue to be raised by various organisations involved in the cocoa business as well as manufacturers and consuming countries on the quality, sustainability and traceability of cocoa. Such concerns are not new, but have led to several discussions over the past decades which laid the foundations for the quality assessment of cocoa beans used today. Recent developments on the emergence of Southeast Asia as a new block in the cocoa market and the continuous increasing production capacities by the old players, together with cocoa processors and the consuming public wanting even higher standards, have regenerated these concerns. It is thus important for cocoa producers across the globe to understand the factors that can bridge the gap in the sustainable production of high-quality cocoa beans for the international market. Many of these concerns stem from the fact that the major cocoa-producing countries use far different production and post-harvest practices and strategies which are inconsistent and unharmonised. This is because the factors leading to sustainable production of high-quality cocoa beans including cocoa genotype, environmental conditions and post-harvest treatments are less well understood.

1.4 CONCEPT OF THIS BOOK

This book provides overviews of up-to-date scientific and technical explanations of the technologies and approaches to modern cocoa production practices, global production, grinding, stocks, surplus and consumption trends as well as principles of cocoa processing and chocolate manufacture. Principally, it provides detailed information on the origin, history and taxonomy of cocoa, as well as Fairtrade and organic cocoa industries and their influence on the livelihoods and cultural practices of smallholder farmers. It discusses some of the factors that promote production, sustainability and traceability of high-quality cocoa beans for the global confectionery industry.

The chapters broadly cover the traditional and some modern cocoa cultivation practices, growth, pod development, harvesting and post-harvest treatments with special emphasis on cocoa bean composition, genotypic variations in the bean and their influence on flavour quality, post-harvest pre-treatments (pulp pre-conditioning by pod storage, mechanical and enzymatic depulping and bean spreading), fermentation techniques, drying, storage and transportation. Details of the cocoa fermentation processes as well as the biochemical and microbiological changes involved and how these influence flavour formation and development during industrial processing are discussed. Much attention is also given to the cocoa trading systems, bean selection and quality criteria.

Some chapters cover the scientific and technological explanations of the various processes involved in industrial processing of the fermented and dried cocoa beans into liquor, cake, butter and powder. These include cleaning and sorting, winnowing, sterilisation, roasting, alkalisation, grinding, liquor pressing into butter, deodorisation and cocoa powder production. It also covers the general principles of industrial chocolate manufacture, with detailed scientific explanations on the various stages of chocolate manufacturing processes including mixing, refining, conching, tempering/fat pre-crystallisation systems and moulding. The discussions also cover the factors that influence the quality characteristics of finished chocolates, quality parameters, post-processing defects and preventive strategies for avoiding post-processing quality defects in chocolate. These in tandem with the earlier discussions provide innovative techniques related to sustainability and traceability in high-quality cocoa production as well as new product development with significance for cost reduction and improved cocoa bean and chocolate product quality.

The ideas and explanations provided in this book evolved from my research activities on cocoa and the various interactions I have had with cocoa farmers in Ghana, who produce the bulk cocoa beans with the highest quality worldwide, and smallholder farmers from many other countries across the world as well as other stakeholders engaged in the production, storage, marketing, processing and manufacturing of cocoa and chocolate products. It contains detailed explanations of the technologies that could be employed to assure sustainable production of high-quality and safe cocoa beans for the global confectionery industry. With opportunities for improvements in quality possible through improved production practices and more transparent supply chain management, plant breeding strategies and new product development associated with Fairtrade, organic and the development of niche premium quality products, there is a need for greater understanding of the variables as well as the science and technologies involved.

It is hoped that this book will be a valuable resource for academic and research institutions around the world, and as a training manual on the science and technology of cocoa production and processing and chocolate manufacture. It is aimed at cocoa producers, traders and businesses as well as confectionery and chocolate scientists in industry and academia, general practising food scientists and technologists and food engineers. The chapters on research developments are intended to help generate ideas for new research activities relating to process improvements and product quality control and assurance, as well as development of new niche/premium cocoa and chocolate products.

It is my vision that this book will inspire all bulk cocoa-producing countries across the world to strive at producing high-quality cocoa beans, similar to those of Ghana beans, for the global cocoa market and as well inspire many local and multinational cocoa-processing industries in their quest for adding value to the many raw materials that are produced within these countries, especially the magic beans from the golden pod, cocoa.

2 History and Taxonomy of Cocoa

2.1 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 the 37 collecting expeditions listed by End, Wadsworth, and Hadley (1990) to seek 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 Linneaus named the cocoa tree *Theobroma cacao*, now its official botanical name, from the Greek word *ambrosia* (Alvim 1984; Anon 2008). Based on archaeological information, Purdy and Schmidt (1996) reported that the Mayans cultivated cocoa 2,000–4,000 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 as both currency and as the base for a bitter drink (Purdy and Schmidt 1996; Nair 2010; Anon 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, Hernán 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, they introduced the crop into Fernando Pó in the seventeenth century, and thus laid the foundation of the future economies of many West African countries. Currently, West Africa produces ~75% of world cocoa (ICCO 2012a,b).

The use of cocoa beans dates back at least 1,400 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) emphasised that the European arrivals in the New World, including Christopher Columbus and Cortés were unimpressed with the Mayan beverage, sweetening it with honey. Nevertheless, conquistadors familiarised 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 throughout Europe. After the conquest of Central America in 1521, Hernán Cortés and his conquistadores 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 Surinam) in the seventeenth century and to Brazil in the eighteenth century. From Brazil it was taken to São Tomé and Fernando Pó (now part of Equatorial Guinea) in 1840; and from there to other parts of West Africa, notably the Gold Coast (now Ghana), Nigeria and the Côte d'Ivoire. The cultivation of cocoa later on spread to the Caribbean islands, Asia, and Africa. It is currently grown on a number of Pacific islands, including Papua New Guinea, Fiji, Solomon Islands, Samoa, and Hawaii (Hebbar, Bittenbender, and O'Doherty 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 (Ghana Cocoa Board 2010). However, these did not result in the spread of cocoa cultivation until Tetteh Quarshie, a native of Osu, Accra, who had travelled to Fernando Pó 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 (Ghana Cocoa Board 2010). In 1886, Sir William Bradford Griffith, the governor, also arranged for cocoa pods to be brought in from São Tomé, 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 Ashanti, Brong Ahafo, Eastern, Volta, Central and Western regions. Ghana is the world's second largest producer of cocoa beans, producing approximately 20% of the world's cocoa (ICCO 2013a).

As the consumption of chocolate became more and more widespread during the eighteenth century, the Spanish monopoly on the production of cocoa soon 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 of Coenraad Van Houten of a cocoa press which 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 in 1847, Joseph Fry 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 mechanised with the development of cocoa presses for production of cocoa butter and cocoa powder by Van Houten in 1828, 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 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 8.0 kg/person per annum in many European countries.