

# The utilisation of cocoa and cocoa by-products

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## Introduction

In the history of mankind there are examples of many discoveries made whose significance to man was not fully appreciated at the time. The cocoa bean was such a discovery. When Cortez discovered it in 1519, he viewed it only as a curiosity but realised it was revered by the Aztecs and drunk only by the Emperor Montezuma. This changed in 1828 when van Houten, a Dutch manufacturer found a way to make it more palatable. Today, cocoa is an essential ingredient in a wide range of foods, delicacies and indirectly in many other products. High quality cocoa beans offer confectionery manufacturers a world of opportunity in the range of products that can be made from them. The cocoa bean and chocolate with its unique flavour and textural characteristics combined together has almost universal appeal.

## Definition of terms

### Cacao and Cocoa

It is useful to clarify the use of the terms “cacao” and “cocoa”.

**Cacao:-** is essentially the botanical name and refers to the tree, the pods and the unfermented beans from the pods.

**Cocoa:-** refers to the manufactured product - the powder sold for drinking of manufacturing purposes, but recently it has also been frequently used to describe the fermented beans in bulk. This pattern has been adopted and will be used in this document.

### Bulk or Ordinary and Fine or Flavour Beans

The world community generally classifies cocoa beans into two broad categories. These distinctions are made from a commercial and processing point of view, and are not always a function of geographical, genetic, climatological, or post harvest preparation factors.

**Basic, Bulk or Ordinary:-** Beans in the first category are generally known as **basic** beans in the United States of America and **ordinary** or **bulk** beans in Europe. The first consists of beans used in the manufacture of cocoa butter and high - volume chocolate lines and in the production of the general use cocoa powders that serve as a flavour in home recipes and in the various convenience foods and beverages.

**Fine or Flavour:-** Beans of the second category are also used, but less and less often, in the production of the fine cocoa powders that serve as a flavour in home recipes and in the various convenience foods and beverages. They also provide specific flavour or colour distinctions in fine chocolates and coatings. The second group is referred to as “fine” beans in Europe, and “flavour” beans in the United States.

### The cocoa plant and its distribution

The cocoa tree belongs to the genus *Theobroma* (Meaning “the food of the Gods”) in the family, Sterculiaceae. The natural habitat of the genus *Theobroma* is the lower storey of the tropical rain forest ranging from 18° N in southern Mexico to 15° S at the southern edge of Bolivia. This tropical equatorial zone is characterised by heavy, well distributed rainfall (2,000 mm), constant high humidity (over 90%),

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<sup>1</sup> Lecture notes for M.Sc. Tropical Commodity Utilisation Class (2003)

uniformly high temperatures throughout the year (26-36° C), and heavy shade from the primary forest canopy.

The Genus *Theobroma* contains some 22 species all originating in the tropical rainforest of equatorial America (See Table 1). Of these 22 species the cocoa tree, *Theobroma cacao* L. is the only one cultivated widely.

The headwaters of the Amazon basin have been said to be the origin of the cocoa tree but it is more correct to describe that area as the primary centre of diversity, that is, an area where great variation in morphological and physiological characters are found.

### Cultivar characteristics

*Theobroma cacao* has been conveniently subdivided into two subspecies:

- 1) *T. cacao* spp. *Cacao*: This consists of the Criollo populations of Central America. Criollo is derived from “Creole” meaning, of native birth but foreign origin.
- 2) *T. cacao* spp. *Sphaerocarpum*: This represents the Forastero populations of South America. Forastero means “of the forest”.

These two different types of cocoa have different morphological characteristics, the Forastero has purple cotyledons, and the Criollo has white cotyledons. The colour is derived from anthocyanins which belong to a group of chemicals which give most blue and red flowers their colours.

This colour difference and related anthocyanin content is important because anthocyanins are involved in the production of the unique flavour of cocoa. The purple anthocyanins are associated with the stronger, more astringent and robust flavours, these define the Forastero cocoas and are generally classified as bulk or ordinary cocoas. Criollo cocoa lack these anthocyanins and therefore have a much milder flavour. This flavour is highly regarded and Criollo therefore traded as Fine or Flavour cocoa.

There is a third subtype generally described as Trinitario meaning “native of Trinidad”. This is believed to be a hybridisation between Forastero and Criollo cocoa. This occurred naturally in Trinidad when Spanish plantation owners introduced the Forastero from South America to replace the native Criollo after it was destroyed by a mysterious “blast” in 1727.

Trinitario cocoas are of great importance in breeding, the only definable unit being the clone. In trade it is regarded as a Fine or Flavour cocoa.

Table 2. The characteristics of the main types of cocoa.

	<b>CRIOLO</b>	<b>FORASTERO</b>	<b>TRINITARIO</b>
<b>Pod Husk</b>			
- Texture	Soft	Hard	Mostly hard
- Colour	Green/ Red	Green	Variable
<b>Bean</b>			
- Average No.	20 – 30	30 or more	30 or more
- Colour of Cotyledon	White, Ivory, Grey	Pale or Deep purple	Variable

## **Overview of the International cocoa industry**

### **General characteristics**

Cocoa is a major agricultural commodity grown exclusively in tropical areas in three principal producing regions: Africa; Latin America and the Caribbean; and Asia and Oceania (See Map). At the start of the 20<sup>th</sup> century, Latin America and the Caribbean region accounted for between 60% to 80% of the world's supply of cocoa beans. However, Africa became the world's leading cocoa-producing region soon after the end of the First World War. This was coupled with the rapid expansion of cocoa cultivation in Asia in recent years and has caused the share of the Latin America and the Caribbean region to decline to 16% of world cocoa production in 1996/97, compared with 18% for Asia and 66% for Africa.

Cocoa is vital to the economies of some countries in the regions that produce it. Cocoa exports comprise a significant proportion of the foreign exchange earnings generated by these countries and are used to service external debt obligations. This is a great challenge when one considers that approximately 86% of the world production of cocoa is grown by farmers with small land holdings of generally a few hectares. Average production from these farms varies between 400 to 800 kg/ha.

In general, the global cocoa economy is characterized by cyclical trends in supply and relatively steady growth in demand, yet international cocoa prices remain close to historical lows in real terms. (See Graphs from ICCO). Low prices have discouraged investments in new plantings, mainly in Latin America and the Caribbean, whose share of international trade still accounts for the majority of fine and flavour cocoa supplies.

The principal consuming areas include the industrialised countries of the temperate regions, with the largest markets being in Western Europe and North America (See Graphs from ICCO). There are now, however, significant developing markets in other regions, particularly in Asia, Eastern Europe and Latin America. There is a high degree of concentration of both production and consumption in the world cocoa market: the 10 leading producer countries account for over 95% of total world exports and the leading 10 consuming countries represent around 75% of global imports. This has prompted closer co-operation between a relatively small number of producers and consumers to alleviate some of the undesirable features of the market, in particular the volatility of prices, to achieve more transparency in the market, and to take joint or coordinated action to enhance the development of the world cocoa sector, through the establishment of International Cocoa Agreements.

### **Production**

World cocoa production peaked at 2.9 million tonnes in 1995/96, following exceptionally favourable climatic conditions in the cocoa-growing regions of West Africa in that year, and has returned to a trend value of around 2.7 million tonnes in 1996/97. The three regions of the world involved in cocoa production have been displaying differing overall trends, with production in both the Africa and the Asia and Oceania regions increasing, while cocoa production in the Americas declined. The Ivory Coast is the world's foremost cocoa producer, with about 40% of world production, this is followed by Ghana and Indonesia each accounting for 12% of the world crop, while Brazil has slipped to a fourth place, with a share of just over 6%. Other leading producers from this region, Ecuador, the Dominican Republic, Colombia and Mexico, rank 8<sup>th</sup> to 11<sup>th</sup> respectively in the world, followed by Peru and Venezuela in 13<sup>th</sup> and 14<sup>th</sup> place.

The medium-term prospects for world production of cocoa are for continued growth, but probably at somewhat lower rates than achieved in the recent past. This growth is related to recent modest increases in prices, which are likely to result in relatively moderate growth of both production and consumption. Modest increases in production are also expected in Ghana. Farmers in the Latin American and Caribbean region, including Ecuador and the Dominican Republic, are trying to revitalize the cocoa sector by replacing less productive, older trees with newer hybrid varieties.

## **Consumption**

Cocoa consumption has evolved more predictably. World grindings of cocoa beans account for the primary consumption of cocoa and have continued along a steady upward trend, reaching a record level of 2.8 million tonnes in 1996/97, with increases in all regions, with the exception of Eastern Europe. Changes in the political and economic systems in the countries of Eastern Europe, during the late 1980's, were accompanied by a slow-down in economic activity, and cocoa processing declined.

Cocoa consumption at the country of origin account for around one third of world grindings, with Brazil, Ivory Coast, Malaysia, Ghana, Indonesia, Colombia and Ecuador among the leading cocoa-producing countries which also process cocoa beans.

World consumption of cocoa is expected to continue growing, in response to rising incomes, but at a slower rate than in the past, as rising prices constrain demand.

By the year 2002/3, both production and consumption are forecasted to reach 3 million tonnes. As a result, the prospects show that the general level of prices is expected to be around 30% higher in real terms by the year 2002/3, but still well below the mean value in real terms over the last 30 years.

### **Over view of Fine or Flavour Cocoa Production**

When compared to the international market for bulk cocoa, the market for fine or flavour cocoa is generally regarded as a relatively small, highly-specialised and separate market, with its own supply and demand characteristics. Fine or flavour cocoa brokers buy directly from fine or flavour origins for specific chocolate companies. The price received is determined by the supply-demand balance for that particular origin and type of cocoa, with the quality and flavour requirements of the consumer being the primary considerations. Short-term factors influence the offers and bids in this small market, and hence the price obtained is highly variable. Final prices for fine or flavour cocoa normally commands a premium of US\$80 to US\$400 per tonne over London terminal markets, although in exceptional circumstances it could reach above US\$800 per tonne.

The International Cocoa Agreement, 1993, recognizes 17 countries as producers of fine or flavour cocoa. Of these, eight are classified as exclusive producers of fine or flavour cocoa (including Dominica, Grenada, Jamaica, Saint Lucia, Saint Vincent and the Grenadines, Samoa, Suriname, and Trinidad and Tobago) and the others as part producers of fine or flavour cocoa. The latter include Ecuador (75%), Venezuela (50%), and Costa Rica and Colombia (25%) from the Latin American and Caribbean region. (See Maps showing: Production of Fine or Flavour Cocoa and Regional Producers of Fine or Flavour Cocoa).

The share of fine or flavour cocoa in the total world production of cocoa beans has fallen dramatically, from about 50% at the beginning of the 20<sup>th</sup> century to just under 5% (120 thousand tonnes) per annum now. The collapse in the relative importance of the production of fine or flavour cocoa is explained essentially by the fact that virtually all major activity over the past five decades has involved only bulk cocoa.

The Latin American and Caribbean region supplies 80% of world fine or flavour cocoa, followed by Asia and Oceania (18%) and Africa (2%). Ecuador, the world's largest supplier of fine or flavour cocoa (producing around 60 to 70 thousand tonnes per annum), accounts for over half the total world production of fine or flavour cocoa. Colombia, Indonesia, Venezuela and Papua New Guinea produce around 10 thousand tonnes each. Jamaica, Trinidad and Tobago, Costa Rica and Grenada, each producing between 1 and 3 thousand tonnes per annum, are also important growers of fine or flavour cocoa in the Latin American and Caribbean region.

The decline in consumption of fine or flavour cocoa over recent decades has been brought about by a general shift in consumer demand away from solid to filled products, containing other ingredients endowed with stronger flavours (such as nuts, fruits, creams, etc.), thus reducing the dependence on the aromatic and flavour characteristics of fine or flavour cocoa. Nowadays, chocolate manufacturers use fine or flavour

cocoa beans in traditional recipes, mainly for a limited number of expensive, up-market finished products.

Traditional cocoa-consuming countries of Western Europe (Belgium, France, Germany, Italy, Switzerland and the United Kingdom) represent the largest consumer market for fine flavour cocoa, while the United States of America and Japan are notable users of this type of cocoa in other regions. Imports of fine flavour cocoa beans range from between 5% to 20% of total imports in these countries.

### **Prospects for the sector**

Based on current trends, there is little prospect for a substantial increase in the supply of fine or flavour cocoas over the medium term. On the other hand, lower cocoa-bean prices have stimulated the demand for chocolate worldwide and recent years have seen an increase in the consumption of solid chocolate, and a trend in origin specific chocolates especially in the main cocoa-consuming countries of Western Europe. This has resulted in a relative shortage of supply of fine or flavour cocoa.

### **Brief aspects of the local cocoa industry**

The introduction of cocoa in Trinidad occurred around 1575 but the Spaniards reported the discovery of the tree in Trinidad in 1617. However, it was not until the beginning of the 18<sup>th</sup> century that cocoa first became a staple product of Trinidad.

Trinidad is highly regarded as fine or flavour cocoa producer and has traditionally received a premium well above the price on the international market. Throughout the 18<sup>th</sup> and 19<sup>th</sup> century the cocoa industry flourished in Trinidad and by 1900 cocoa had displaced sugar as the leading agricultural industry. Vast plantations were established in almost every corner of Trinidad at the foothills of the Northern, Central and Southern mountain ranges where both soils and climatic were favourable for the growth of cocoa.

The tradition of cocoa in Trinidad and Tobago continues today despite losses caused by disease and change in the world market for cocoa. Cocoa is produced at a much reduced level with modest production levels ranging between 1,550,000 – 2,000,000 kgs which earns approximately TT\$14,000,000 - TT\$ 19,000,000 depending on world market conditions. Presently it is estimated that there are about 300 large farmers producing over 1000 kgs of cocoa and about 4,800 small farmers producing under 1000 kgs of cocoa.

Traditionally, Trinidad cocoa beans have been demanded mainly in Europe and North America where it is used to make expensive dark chocolates but demand has spread in recent times to Japan. There continues to be a steady demand today at premium prices which exceeds our present modest production levels. (See graphs on cocoa production in Trinidad)

### **Cocoa Processing**

There are only a few instances where unprocessed beans are utilized. Cocoa must be processed before it can be utilized. The following outlines the steps in cocoa processing:

#### **Harvesting**

The development of the pod takes 5 – 6 months from fertilizing to flower to full ripeness. Cocoa pods are harvested when ripe. For optimal processing only fully mature, un-diseased and undamaged are harvested. This is done via the use of a special knife fixed on to a long bamboo pole. Care is taken that the pod is not damaged during removal from the tree and more importantly that the tree and flower cushion itself are not damaged.

#### **Pod breaking**

Pod breaking or opening is not a minor operation that merely consists of breaking open the pods and removing the beans. Pod breaking has a considerable effect on subsequent operations and ultimate bean quality.

After harvesting, pods are either broken by means of a cutlass or machete or a wooden billet. The pod is struck halfway across the longitudinal axis and opened by twisting the tip of the cutlass. This is done in one fluid motion. Opening using the wooden billet involves one or two sharp blows with the edge of the billet. The distal portion of the pod falls away and the beans remain conveniently attached to the placenta where they can be conveniently extracted.

The beans are removed from the placenta being careful to exclude any germinated, black or diseased beans and pieces of shell.

The time frame between harvesting and opening the pods has been found to influence subsequent fermentation and ultimate flavour development.

In Trinidad, it is the practice to crack the pods in the field, fill bags with the wet beans and transport them to the fermentation facilities. The wet beans should reach the fermentation facility within 24 hours of the pods being broken to avoid any problems during fermentation.

### **Fermentation**

Fermentation boxes are usually constructed of cedar preferably in dimensions typically 1.2 m × 1.2-m × 1.2 m. They are constructed in such a way that the heat evolved during fermentation is conserved and liquids produced during fermentation can freely drain away. The floors of the sweatbox are therefore slatted about 5 mm apart. A sweatbox of these dimensions can hold between 900 – 1000 kg of wet cocoa when filled to a height of approximately 0.75-m. Sweatboxes may also consist of a double wall in which the space between the internal and external walls of a side are filled with either sawdust or sugar cane bagasse for improved insulation.

Only clean, disease free and non-germinated beans should be used for fermentation. Beans must also be free from pieces of placenta or pod shell and other fragments.

Beans are then covered in the box with fresh banana leaves and jute sacks to initiate fermentation. Plastic should not be used. Covering conserves the heat evolved during fermentation.

Fermenting beans are turned every other day ensuring that beans from the top and bottom is thoroughly mixed together. Therefore for a 7day fermentation there are usually 2 turnings. The beans may or may not be covered with fresh banana leaves after each turning. Fermentation usually lasts between 6 – 8 days depending on weather conditions and time during the cocoa season. Fermentation usually takes longer at the start and peak of the cocoa crop but shortens towards the end of the crop, as there is less mucilage available for fermentation.

The optimal end of fermentation is checked from the end of the 5<sup>th</sup> day by either measuring the temperature of the mass of beans. This should be between 47 – 49°C. Also, when a sample of beans are cut longitudinally, the inner surfaces of the beans should show defined ridges and the colour inside should be light pink to brown. The outer edge of the cotyledon should have a dark brown colour.

### **Drying**

At the end of fermentation, the moisture content of the whole bean is approximately 60%, and this must be reduced to less than 8% before the cocoa can be stored, sold or transported. If the moisture is reduced too much, the shells become too brittle and break. If moisture is too high, mould growth occurs during storage.

The rate of drying is critical to final quality. Too rapid a drying rate results in overly acid beans with case hardening (shrivelling). Dried beans must be plump. Drying can take the form of sun drying or artificial drying or a combination of sun and artificial drying.

Freshly fermented beans are spread on the drying floor of a cocoa house during the day to a depth of not less than 5 cm and banked in two long rows in the centre of the floor at night for the first 2 or 3 days of drying. Mixing is done regularly with wooden rakes or paddles to ensure even drying.

Artificial drying usually comes towards the end of drying it is done after sun drying reduces the moisture content to approximately 20%. A large mechanical dryer usually comprises a diesel burner with a blower. This blows hot air through a plenum onto the base of a wooden drying bed. The hot air passes through 8-mm holes drilled in the wooden floor through an 8-10 cm layer thickness of cocoa beans. The beans are placed in small ridges on the floor and turned continuously.

Alternatively, the dryers may comprise 6 arms which radiate from the centre of the dryer fixed to an annular ring which functions as a large cog, the stirring mechanism is driven from the edge. The arms carry strips of wood inclined downwards to facilitate stirring. Hot air is directed into the drying chamber from under the platform through holes drilled at the base of the circular platform.

### **Polishing**

During drying the beans are polished to improve their appearance. The beans are polished at a stage where they are hard but not brittle and are done in the rotary type dryer described above. Polishing improves external appearance of the beans and it is suggested that polishing protect the beans from fungal infestation during storage.

### **Cleaning and Bagging**

After drying and polishing, the beans are cleaned of any extraneous matter and packed in jute bags. New requirements dictate that the bag fibres must have only been treated with vegetable oil. The bags must also be clean, sound, sufficiently strong and properly sewn.

### **Grading**

Grading is done via a mechanical grader which uses different sized mesh attached to a rotating cylindrical drum with a helical screw inside to convey the beans along accomplishes grading. The larger beans pass through last. In Trinidad there are 3 grades: Grade I, Grade II and Defective.

A well-fermented and dried Trinidad cocoa bean is plump in appearance and when cut shows a chocolate brown cotyledon with clearly defined internal ridging. No mould or insect damage must be present.

### **Storage**

The great emphasis to achieve optimum quality from harvest to drying must continue during transport and storage. There must be proper humidity control to avoid re-humidification of the beans, which leads to mould growth. Also, storing on gratings or decking which allow at least 7-cm air space above the floor can avoid rodent and insect pests. In Trinidad, cocoa is never stored for a significant period of time before shipment; thus reducing the chance of increased moisture levels and mould growth. Forced air ventilation, fumigation and good phytosanitary practices all contribute towards optimal storage conditions.

## **The Uses of Cocoa**

### **The Tree**

The cocoa tree is an ecologically sound crop to cultivate. Since it is a natural forest under story tree, it is ideally suited for long term land rehabilitation and conservation. The traditional layered planting system with various temporary and permanent shade trees ensures complete ground cover. Also seedling plants suited for slope cultivation.

### **The Leaves**

Many of the *Theobroma* species are regarded as medicinal plants in the Amazon and the leaves are utilised by local tribes. Research has yet to be conducted regarding the medicinal value of cocoa leaves.

### **The Fruit**

#### **Pod Husk**

The cocoa pod husk has long been dried and incorporated as feedstock for poultry and livestock. It is also fed "fresh" to livestock in many instances. Pod husks are also left to rot in the fields on cocoa estates where they recycle nutrients back into the soil as manure and also serve as a breeding ground for midges.

Midges are the chief pollinators of cocoa and increasing the amount of midges enhances pollination efficiency and ultimately pod yields.

### **Pulp/Juice**

The pulp of *T. bicolor* of Mexico and *T. grandiflorum* of Brazil are used for juices. The pulp of *T. subincanum* is eaten by some indigenous tribes of the Amazon. In many cocoa producing countries spin off industries have been created utilising the pulp and juice of cocoa. In Brazil the juice is fermented to give a good quality wine and liqueur. Also a range of jams and jellies are produced from the pulp and juice. The juice is extracted by pressing the beans just before they are fermented. Success in this area relies on proper harvesting protocol and removal of any diseased beans before pressing. Also the area where pressing is done must be clean for hygienic extraction of the juice and pulp. This is often very difficult to achieve on a large scale and therefore restricts the size of this industry. Pod breaking is largely a manual operation and hence further restricts the scale of operation and efficiency.

### **Shell**

The cocoa bean shell or testa is widely used as a mulch and manure in the countries where cocoa is processed. Also in some instances the shell has been used as a feedstock ingredient for livestock and poultry. The shell contains fat and is a source of vitamin D and Theobromine.

### **Unfermented cotyledon**

The unfermented cotyledon has limited food use but can be ground and pressed or passed through and expeller to extract cocoa butter. Cocoa butter has a range of commercial uses in the food, cosmetic and pharmaceutical industries. It is the most valuable product that can be extracted from the cocoa bean and accounts for up to 55% of mass of the bean. The press cake from unfermented beans can be used as a feedstock but may be too bitter and unpalatable to some animals. The press cake is also used as manure.

### **Fermented cotyledon**

The fermented cotyledon offers the widest range of uses for the cocoa bean. As a food it is roasted, winnowed, ground to give a mass or liquor. This is then pressed to extract the cocoa butter. The press cake can then be milled and sieved to give cocoa powder for drinks, baking and dessert toppings. The cocoa butter that is extracted can then be recombined with mass or liquor together with sugar and other ingredients which are mixed, ground and conched to produce plain chocolate.

Cocoa butter has a range of other non- food uses. In the cosmetic industry it is used directly as a skin toner and moisturizer, or indirectly as a base for other cosmetics. Recently it has been used in sunscreens and “anti-aging” creams. In the pharmaceutical industry it is used as a base for many medicinal creams and lotions since it melts at skin temperature.

A new range of pharmaceutical uses and benefits have recently been discovered for the cocoa bean and chocolate. Recent research has shown that there are beneficial antioxidant properties contained in cocoa beans. Also it has been shown that cocoa flavanols, similar to those found in wine stimulate the processing of Nitric Oxide in the body which greatly reduces the incidence of high blood pressure.

Chocolate has also been demonstrated to be a quick source of energy, the theobromine and caffeine present stimulates the central nervous system. Chocolate also contains Glucides, Lipids and Proteins. It is a source of Calcium, Magnesium and Phosphate as well as Vitamins A, B<sub>1</sub>, B<sub>2</sub>, C, D and E. Trace elements of Iron and Copper are also found in chocolate.

Chocolate for a long time has been included in soldiers war rations in the field and if one looked at world production and consumption figures, there were substantial increases in cocoa consumption during both world wars.

Chocolate has also been shown to contain an average cholesterol content of 1mg per 100 g and therefore plays a negligible role in cholesterol intake. Indeed the consumption of chocolate in reasonable quantities (less than 50 g per day) has no ill effects.

## **Conclusion**

Cocoa has long been considered an orphaned commodity when compared to other crops and is only now beginning to receive the focus of international research. As research in cocoa – the plant, the pod and the bean continues, a whole realm of possibility exists in what new food, cosmetic and pharmaceutical uses we can find for this versatile crop. Truly, it may be regarded as the food of the Gods.