THE WORLD BANK

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Agro-Industry Profiles

COCOA

PROFILES IN THIS SERIES:

ABSTRACT

The objective of this Profile is to provide a review of the cocoa processing industry. It examines the industry from harvesting of raw materials to primary and secondary processing, and, finally, marketing. It contains indicative yields and conversion factors, a glossary of key terms, and a bibliography listing useful references. It traces several primary processing steps including pod opening, fermentation, drying, sorting and distribution; secondary processing steps include cleaning, roasting, winnowing, nib grinding, pressing, cocoa powder and chocolate production. Marketing aspects are covered, including prices, quality factors, market barriers and product substitution. Annexes with examples of investment and operating costs, and conversion tables (Metric/US) are included at the end of the Profile.

FOREWORD

The nature of project and sector work in the World Bank is such that staff are often called upon to work outside their major fields of specialization, if only to make an initial judgement on the utility of further, often costly, investigation. Under these circumstances, up-to-date and authoritative reference material is essential.

The profiles in this series are designed for use by operational staff with experience in the agricultural sector but who do not have a technical knowledge of the particular commodity under discussion. Their purpose is not to substitute for technical expertise but to provide a reliable inhouse reference which will help Bank staff to determine when and what expertise is needed in the detailed evaluation of investment proposals in agro-processing.

The conditions for any particular proposal are bound to be unique in a number of respects, and the use of norms and general data in project analyses could give rise to significant errors. On the other hand, by providing responsible staff with a guide to the issues on which appropriate expertise should be sought, these profiles can contribute to the overall quality of agro processing investment. Used with care, they should also facilitate broad pre-screening such as may occur during sector work and reconnaissance.

Questions, comments and further inquiries should be addressed to:

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Cocoa

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Cocoa

DATA SHEET

Average yields:
- 30 seeds per pod
- 300-750 kg dry beans per hectare

100 kg wet unfermented beans produce approximately 40 kg dry beans.

100 kg dry beans produce approximately 84-89 kg 'nibs'.

100 kg dry beans produce approximately 80 kg cocoa liquor.

100 kg dry beans produce approximately 40 kg cocoa butter and 40 kg cocoa cake/powder.

INTRODUCTION

Cocoa is a tropical tree crop, the seeds of which provide an important raw material for the confectionery industry. Raw cocoa beans are sold by growers for domestic processing or, more importantly, to intermediate agencies which export them, primarily to temperate-zone countries, for use in confectionery manufacture.

The main products are cocoa beans, cocoa butter, cocoa liquor, and cocoa powder, all of which are traded internationally. The main by-products are pod husks, sweatings, and shells.

Cocoa processing can be divided into two main groups of operations. Primary processing results in the production of raw cocoa beans from the harvested pods. The main stages of pod opening, fermentation and drying are normally carried out by growers in the producing areas.

Secondary processing has been concentrated in consuming countries, although increasingly the trend is towards more processing in the producing countries. Raw cocoa is cleaned, roasted, winnowed, and ground to produce 'nibs', which are further processed into cocoa liquor, cocoa butter, and cocoa powder; these products are then used in making chocolate.

GLOSSARY

Cocoa bean	Fermented and dried cocoa seeds.
Cocoa butter	Fatty portion obtained from pressing cocoa liquor; gives chocolate its texture and low melting point.
Cocoa cake	Fibrous material obtained from pressing cocoa liquor.
Cocoa liquor	Fat product of nibs which have been ground.
Cocoa powder	Ground and sieved cocoa cake.

Conching	Final mixing process in chocolate production; development of flavor and smoothness.
Curing	Term often used to describe fermentation and drying of cocoa seeds.
Drying	Dehydration of cocoa seeds after fermentation.
Fermentation	Pulp breakdown by micro organisms, initiating development of aroma and flavor in raw cocoa seeds.
Mixing	First stage in chocolate manufacture; ground nibs mixed with other ingredients as required.
Nibs	Broken, de-shelled particles of roasted cocoa beans.
Pod	Mature fruit containing seeds.
Pod husks	Discarded pods after removal of seeds.
Pulp	Mucilage surrounding seeds in the pod.
Refining	Second stage in chocolate manufacture; the mixture is rolled to produce smooth texture.
Roasting	Development of flavor in cocoa beans by heating.
Sweatings	Liquid part of pulp drained from seeds during fermentation.
Tempering	Final stage in chocolate manufacture; controlled cooling of refined chocolate.

RAW MATERIALS

General Aspects

Cocoa (derived from the tree Theobroma cacao) is grown only in tropical areas and is suited to small farmer or estate systems. Traditional varieties cultivated commercially are Criollo, Forastero (commonly Amelonado), and Trinitario which is the result of accidental hybridization between Criollo and Forastero. Criollo produces beans of fine flavor but yields are poor, and its commercial output is rapidly declining. The greatest volume of production is of Forastero from the Amelonado plantings of West Africa and Brazil. New varieties using unrelated crosses in breeding programs to produce vigorous and precocious hybrids have had an increasing impact since the early 1970s. In particular, progeny collected from the Upper Amazon basin and introduced to developed Amazon X Trinitario hybrids, plus clones derived from hybrids, have substantially increased yields. Hybrid cocoa is expected to represent over 50% of total world production by the late 1980s.

National yields vary between 300 kg and 750 kg dry beans per hectare. However, under optimum conditions commercial yields of over 2,200 kg/ha are achieved. Key factors determining yield are climate, soil, genetic make-up, shade, pest/disease control, fertilizer application, and cultivation practices. Large variations in yield occur from year to year, usually due to weather conditions and pest or disease attack. Traditional varieties start yielding beans about five years after planting and hybrid varieties after about three years. Peak yields are obtained after eleven years for traditional varieties and after seven years for hybrids. Given the right conditions, cocoa trees will maintain their high yields for 20-25 years, and will continue yielding for between 30-70 years.

Harvesting

Flowering is triggered by rainfall, and ripe pods are ready for harvesting by hand about five months later. Ripe pods for harvest are available all year round but definite peaks occur, mainly as the result of climatic factors, especially temperature and rainfall. Time of harvest is not as critical as with other crops; pods which are not fully ripe can be fermented as easily as fully ripe pods, and ripe pods can be left on the tree for two to three weeks, although some quality deterioration does occur.

Germination and infestation become problems, however, in pods left on the tree for longer periods.

In addition to pod ripening, harvesting frequency is influenced by processing requirements; a minimum of about 100 kg wet beans is needed for satisfactory fermentation. Frequency of harvesting also influences bean quality. Harvesting every one or two weeks is usually adequate to maintain quality, but longer intervals may be necessary when the area of cultivation is small or the yield low. Infrequent harvesting causes higher losses from germinated seeds or infestation.

PRIMARY PROCESSING

General Aspects

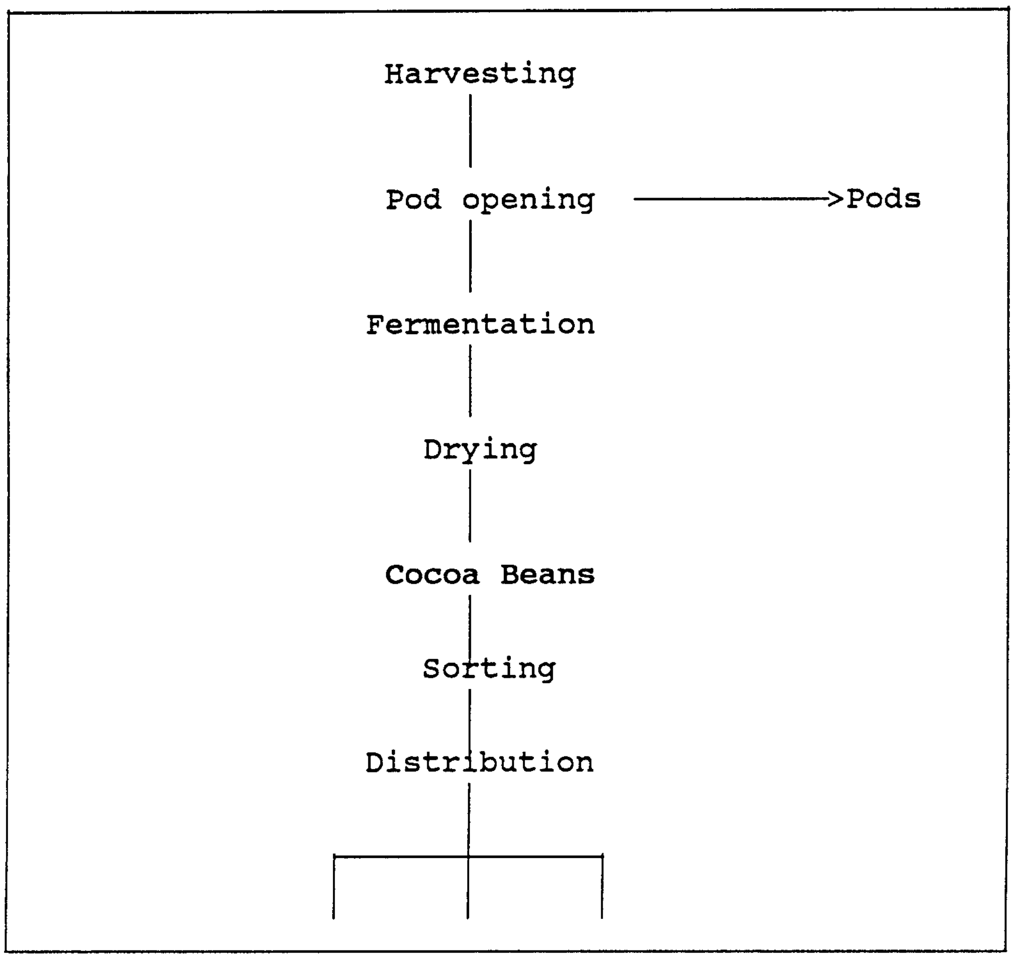
Production of high quality cocoa beans is the objective of primary processing operations. The principal operations are pod opening, fermentation, drying, sorting, and distribution. An overview is shown in Flowchart 1.

Pod Opening

After harvesting, the pods are opened using a machete or wooden baton. The pods are either opened under each tree, or transported to the fermentary for opening. Opening in the growing area reduces transport costs (seeds account for only 25% of the total pod weight) and allows for disposal of the pod husks as mulch or compost. Opening at the fermentary provides more control over the operation, particularly protection against weather and theft.

The interval between harvesting and pod opening influences fermentation. After harvesting, the seed is still 'alive' and postponing the pod opening for too long allows it to germinate. A three to four day interval, however, is desirable as it results in a more rapid rise in temperature during fermentation.

Flowchart 1: Primary Processing of Cocoa



It is preferable to open the pods with a wooden baton since the machete may cut and damage the shell of the seed allowing mold and insect infestation. Losses may be five percent higher when machetes are used for opening. Pod husks are utilized as mulch and compost; their use in animal feed formulations is being studied.

Simple machines that can break as many as 2,000 pods per hour have also been developed. But because much cocoa is in the hands of smallholders, they are usually not economical (Are and Gwynne-Jones, 1974).

Quality control at the pod-opening stage involves the elimination of beans with characterics that affect quality at later stages. These include:

- germinating beans
- small (immature) beans
- dry beans
- diseased beans
- beans from damaged pods
- beans from black or diseased pods.

Fermentation

Correct fermentation and drying are critical operations and no subsequent processing can compensate for poor practice at this stage. Although fermentation and drying are treated separately in this profile, chemical and biological changes in the beans during fermentation continue through drying and the combined operations are often referred to as 'curing'.

The objective of fermentation is the production of cocoa beans possessing the desired stability, flavor, and aroma from which good chocolate can be manufactured. Desirable effects of fermentation on the beans include reduction in bitter taste, destruction of the seed, facilitation of shelling, and most importantly, development of flavor and aroma precursors. Without these precursors chocolate flavor will not develop during roasting.

Within 24 hours of pod opening, the beans and their adhering mucilagenous pulp are removed and transferred to heaps, boxes, or trays for fermentation. The beans ferment for five to seven days and are then dried. During the process almost all of the pulp becomes liquid and drains away as 'sweatings'. The temperature within the beans rises to around 50^{o}C, and occasional turning of the beans is needed to remove excess heat, aerate the beans, and achieve uniformity of fermentation.

Methods of fermentation vary enormously among individual growers and among localities. The major differences relate to the following factors:

- the amount of aeration of the beans;
- provision of drainage for the sweatings;

- temperature control;
- turning, stirring, or movement of beans during fermentation; and
- duration of fermentation.

Fermentation of beans in leaf-covered heaps, leaf-lined holes, and in baskets are the traditional methods. More modern and more efficient methods use sweat boxes or trays.

Harvest size and the frequency of turnings determine the number and size of the boxes. Traditionally they are arranged in a row; more recently the boxes have been arranged in tiers utilizing slopes or specially constructed stands. Boxes vary in size and shape according to local conditions, but all contain drain holes drilled in the bottom for the sweatings. The beans are moved between the boxes to ensure aeration and uniformity. Tray fermentation is relatively new and involves stacking 12 to 14 shallow trays on top of each other. The shallow layers of beans allow uniform fermentation without turning and a quicker fermentation. Labor costs are about 20 percent less than with box fermentation but excessive aeration can lead to low chocolate flavor.

Although the chemical and biological changes during fermentation are not fully understood, some important factors influencing the process are (Wood and Lass, 1985):

- **pod ripeness**: very under-ripe pods do not ferment well;
- **pod diseases**;
- **cocoa variety**: Criollo takes two to three days and Forastero between five and seven; mixing the varieties should be avoided;
- **cocoa quantity**: the minimum quantity of wet beans for normal methods of fermentation is about 100 kg; the maximum amount should not be more than about 2000 kg; the depth of the bean layer is important - using the tray method, beans are usually laid 5-10 cms deep, with about 45 kgs in each tray; in the box and heap methods, the depth should not exceed 0.75 meters; studies have shown that a depth of 25 cm yields optimum pH levels in the fermenting beans (Liau, 1976);
- **duration**: under-fermented beans are more purple, and have greater bitterness and astringency; over-fermented beans develop little chocolate flavor, great color variation, and brittle structure during roasting;
- **turning**: turning ensures aeration and uniformity; recent

research indicates that infrequent turning results in better flavor than frequent turning;

- **seasonal effects:** studies have shown that pods harvested in wet season conditions have a higher pulp:bean ratio and therefore lower recovery rates; in addition, because fermentation depends on temperature increases in the bean, cooler wet season or nighttime temperatures can interfere with proper curing; in these cases, the beans should be shielded from the wind and the cooler air;
- **temperature:** during fermentation, the temperature of the beans rise, usually reaching 40-45°C within 48 hours; it continues to rise, sometimes exceeding 50°C, and then as fermentation is completed, begins to fall; this temperature rise is important, as it aids in the 'killing' of the beans; for this reason it is important to ferment beans in sufficient quantity to generate the heat rise; it is also important to keep the beans covered or insulated so that the higher temperatures are maintained.

During fermentation the acid content of the cocoa bean sometimes rises to levels unacceptable to the buyer. In some countries, particularly in Southeast Asia, this has proved a problem. High percentages of sugars present in the mucilage of wet beans convert to ethanol and subsequently acetic acid. Removal of pulp juices prior to fermentation, intensive aeration during fermentation, and the addition of yeast to fermenting beans are methods adopted in commercial practice to reduce acid levels.

Drying

Physical changes in the bean demonstrated by color changes during fermentation continue during drying. Color darkens, flavor improves, and the shell loosens.

After fermentation the wet beans contain approximately 50-55% moisture, whereas a moisture level of 6-7% is required for safe storage and transport. The two main drying techniques in use utilize either the sun or artificial energy sources.

There are two stages in drying: 1) the removal of free or surface moisture, and 2) the removal of internal moisture from the bean. The rate of drying is critical. Slow initial drying allows completion of the final stages of fermentation. Drying too rapidly inhibits browning and results in shrunken and under-fermented beans, often lacking in chocolate flavor and having brittle shells. Drying too slowly results in mold growth in the beans and off-flavors.

Generally, sun-drying for seven to ten days produces better quality beans. However, unpredictable climatic conditions often require the use of artificial dryers.

Sun drying is simple and can be practiced on a limited scale. The beans are spread on a suitable drying surface (one which minimizes dirt and flavor contamination) and stirred at regular intervals to produce uniform beans. Raised drying platforms or tables are preferred to ground-level concrete areas. Protection from rainfall may be required, and ground-level drying areas, when used, should be fenced to provide protection from livestock. Preliminary sorting and removal of defective beans and other contaminants is usually practiced during sun-drying.

Numerous types of artificial dryers are in use, but they can be classified as either simple platform or mechanical models. Examples of platform dryers are the commonly used 'Samoan' or 'Martin' designs. They consist of a permeable platform over a plenum chamber surrounding a tubular flue. Sliding roofs can also be incorporated to permit supplementary sun-drying. The furnace feeding heat through the flue is normally fueled with wood and drying is achieved by radiation and convection over a three to four day period.

Mechanical dryers are used by large-scale producers and use fans to blow heated air through the bean mass. Usually, but not always, heating is achieved by thermostatically-controlled direct-firing diesel burners. Modern mechanical dryers are of the circular or rotary type incorporating mechanical agitation of the drying bean mass. Fuel consumption is approximately 100 litres per ton dry beans. Labor requirements are minimal and, with resting periods, drying is easily achieved in two days. (For details on dryers see McDonald, et al, 1981, and Wood, 1975.)

Decisions relating to drying should consider the probable quality of the end product and the costs of alternative methods. Selection of an appropriate system requires evaluation of both dryer type and energy source.

Sorting

Before being bagged, the beans are given a preliminary sorting or cleaning. Any defective beans (flat or broken) and other contaminants such as dust particles are removed manually. Mechanical sorting uses reciprocating screens or a rotating drum; size selection may also be incorporated in this process.

Distribution

The distribution process includes the bagging, storage, transport, and shipment of raw cocoa beans. Cocoa is collected from growers in clean baskets or bags. Due to the humidity typical of producing areas cocoa beans must be rapidly transported to their destination.

Cocoa should be shipped only in new jute sacks, with or without polythene liners as desired by the buyer, properly sewn. International stipulations are to pack 16 sacks per ton, each sack containing 62.5 kg raw cocoa.

Cocoa beans can be stored almost indefinitely in temperate regions; storage in the tropics, however, should not exceed three months. Four main hazards to storage in the tropics are:

- **mold development:** mold will grow inside and outside the bean, particularly if it has not been well-dried or if it reaches a moisture content above 8%;

- **fat degradation:** prolonged storage in humid conditions leads to a rise in free fatty acid content;

- **infestation:** numerous moths and beetles infest stored cocoa; fumigation with toxic substances requires close control;

- **contamination:** cocoa is prone to picking up moisture and odors from its surroundings; stored cocoa should be kept away from moisture and other commodities.

During sea transport moisture levels in the beans can rise to 10 or 12%; containers or ships should provide facilities for controlling temperature, humidity, and ventilation surrounding the cocoa.

SECONDARY PROCESSING

General Aspects

Fermented and dried cocoa beans are the basic "raw material" of cocoa processing. The end products are cocoa liquor, cocoa butter, and cocoa powder, which are used either in chocolate manufacture or in other industries. Correct fermentation and drying of the raw beans are essential for development of good color, flavor, and aroma in the finished products..

The main operations of secondary processing are cleaning, roasting, winnowing, nibs grinding, and cocoa liquor pressing, followed by the production of cocoa powder or chocolate. The main operations are outlined in Flowchart 2 on the following page.

Cleaning

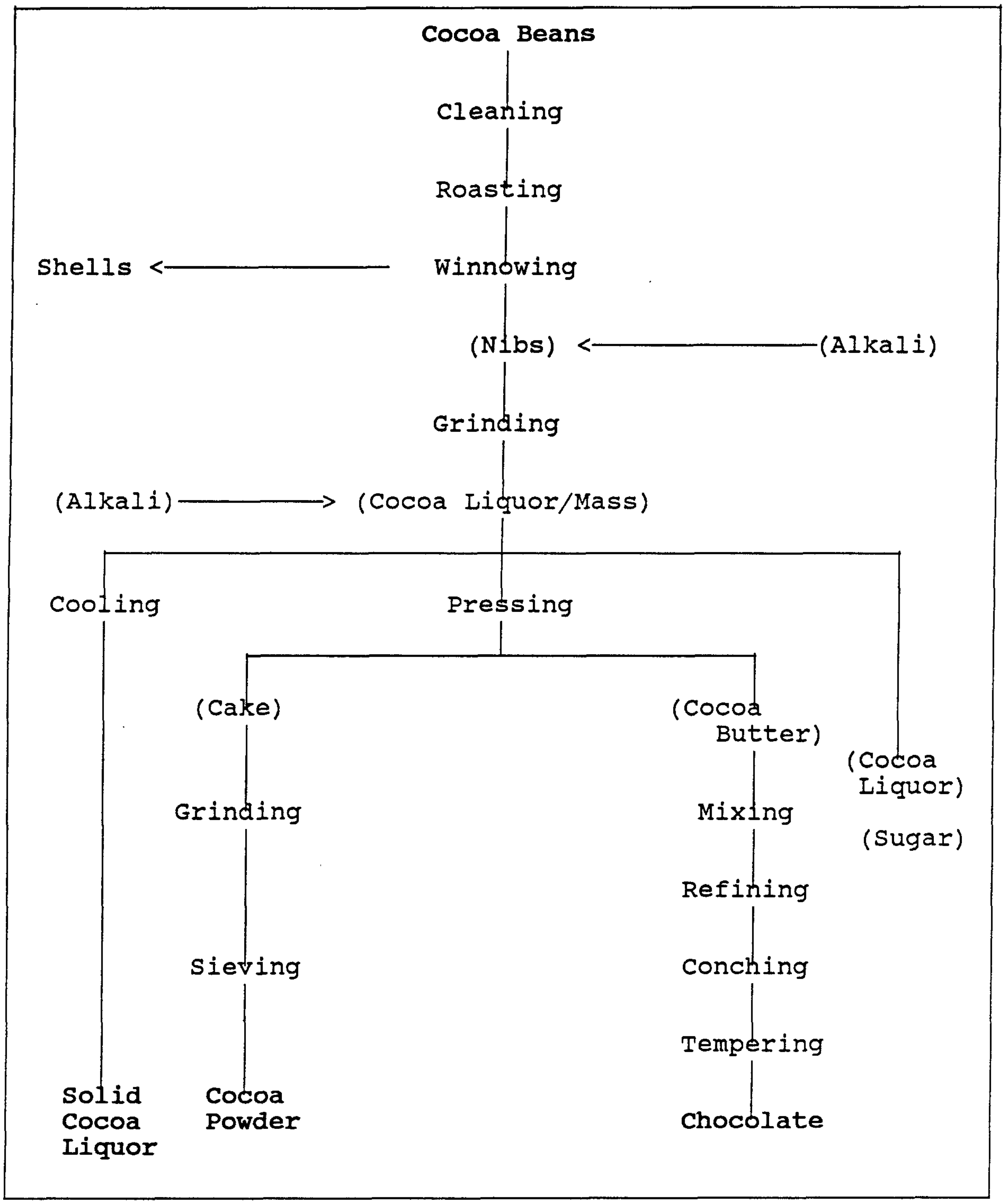
Although the beans have been sorted before bagging, they are further cleaned and graded before processing. Sieves, screens, and magnets are used to separate out dirt, stones, metal, fibers, small or immature beans, and other contaminants. After cleaning, the beans are mixed or blended and stored until needed. Adequate storage capacity and facilities are critical, particularly if the factory is in a humid region.

Roasting

Roasting is essential for the manufacture of chocolate, but less important if the beans are needed only for cocoa butter extraction. The aims of roasting are:

- color development
- aroma and flavor development
- moisture reduction
- modification of shell structure to permit easier separation.

Flowchart 2: Cocoa - Secondary Processing



Batch or continuous rotary roasters heat the beans to 100-140^{o}C for 15 to 90 minutes. The degree of roast varies with the type of bean and the end use (chocolate or cocoa powder). Control of the roast is important; critical factors include the temperature and duration of the roast, and the even application of heat. Serious flavor problems result from poor roasting procedure.

Winnowing

The most valuable part of the cocoa bean is the nib. Winnowing involves breaking the shell and using air to separate shell particles from the the nib. There should be no more than 1.5-2% shell in the nib fraction. The shells can be utilized as fuel for the factory or as fertilizer. The breaking operations generate large quantities of dust which must be controlled to minimize the risk of explosion and fire.

Nib Grinding

Before grinding, the nibs may be further roasted. Disc crushers then break down the nibs and rupture the cell walls of the nibs to release the fat content which ranges between 55% and 58%. the frictional heat of the process melts the fat and the ground mass, in its liquid form, is known as cocoa liquor. The liquor is poured into forms and, upon cooling, solidifies into brown blocks. These may be sold as such, but are normally pressed or extracted to produce cocoa butter and cocoa powder.

The trend in cocoa processing is towards higher capacity, finer grinding, less maintenance, and greater automation. Modern mills produce 500-1200 kg of cocoa liquor per hour, depending on the fineness of the grind.

Pressing

Cocoa liquor is the base material for all chocolate products. It may be sold in solid form or extracted to produce cocoa butter and cocoa cake. Extraction methods used are hydraulic pressing, screw expelling, and solvent extraction. The most commonly used method is hydraulic pressing which produces both cocoa cake with 10-25% fat content and cocoa butter. Solvent extraction is used when the maximum amount of cocoa butter is to be extracted. Cake after solvent extraction contains only about 1% fat.

In pressing, the duration and pressure applied to the liquor depend on the fat content required of the cocoa cake. The butter produced from pressing or expelling requires filtration to remove any impurities, while butter from solvent extraction can go directly to be neutralized, bleached, and deodorized.

Cocoa Powder

Originally cocoa powder was produced from nibs ground together with water. The fat content of the powder produced in this manner was very high, whereas modern systems remove the butter from the nibs to produce a lower-fat cocoa cake which is then broken, ground, and sieved to the required fineness.

Two techniques are used to satisfy market requirements for cocoa with differing flavor and color characteristics. In the so-called 'dutching' process, alkali is added which deepens the color, improves the flavor, neutralizes the acidity and increases the dispersability of cocoa thus treated. Alkalis are added to the nibs before grinding, to the liquor before pressing, or to the cocoa cake before breaking and grinding. Cocoa not treated with the alkali is commonly known as 'natural' cocoa. The other technique involves controlling the amount of butter remaining in the cocoa cake after pressing. The percentage left in the cake varies between 8% and 25% depending on the type of powder required.

Chocolate

The distinctive lfavor associated with brands and qualities of chocolate is the result of a wide range of recipes which evolved in response to taste preferences and ingredient costs. In the first stage, the prescribed proportions of cocoa liquor, cocoa butter, sugar, and other ingredients are mixed. In the past, this involved a time-consuming operation using 'melangeurs' - heavy granite rollers in a revolving granite bed. This method is now almost completely superseded by grinding in a series of rolls.

The mixture is refined by further rolling which results in a reduction in the particle size. Conching involves rolling of the mixture and the addition of flavorings or emulsifiers. Controlled cooling during tempering ensures that the chocolate is stable and has the proper color and gloss. The final operation is molding or pouring of the liquid chocolate into its retail form.

As an edible product for human consumption, chocolate requires efficient quality control; major problem areas are infestation, moisture, and heat damage. (Details on chocolate and confectionery manufacture are provided in: Minifie, [1980].)

Chocolate manufacturing technology is usually sophisticated and utilizes electronic control of mixing, temperature, and flavor for any products beyond basic bars. Special facilities or factories may be needed to provide necessary supplies of milk or milk products for production of milk chocolate.

MARKETING ASPECTS

Introduction

Five major products of cocoa are traded internationally: raw beans, liquor, butter, cake, and powder. Cocoa beans are the product of primary processing, the others are intermediate products used in the manufacture of chocolate and confectionery.

Cocoa liquor is generally processed into butter and powder although it is also used directly by confectioners in making chocolate bars. Cocoa butter is used mainly for chocolate manufacture, in other confectionery and in the pharmaceutical and perfume industries. Cocoa powder is used in confectionery coating, cakes, cake mixes, breakfast foods, beverages, and ice cream.

Most international cocoa trade is in raw bean form. In recent years, however, the proportion of semi-processed and processed cocoa products being exported from producer countries has risen; in 1980, they accounted for 33% of world cocoa grindings. This trend was temporarily reversed during the early 1980s because of consumer resistance and excess processing capacity in importing countries. The share of grindings in the producing countries is forecast to rise, however, and is expected to exceed 40% of the world total by the year 2000. Table 1 on the following page shows export figures for selected producer countries.

In the bean-producing countries, a relatively small group of state-owned or regulated marketing boards, and private or cooperative trading companies, usually market their products on what is known as the 'actuals' markets. These markets comprise the 'origins' markets of Accra, Lagos, Abidjan, Douala and Salvador (Brazil), and the dealers and brokers who operate in the 'secondhand' markets of London, New York, Amsterdam, Hamburg, and Paris. In the 'actuals' market, shipments of cocoa are bought and sold, sometimes directly to manufacturers, but more often to the dealers and brokers who operate in the 'secondhand' market. These dealers and brokers also use what is known as the 'terminal' markets to hedge their contracts, and cover possible losses occuring because of major price shifts on the 'actuals' market. Virtually all cocoa beans are sold with reference to prices on the major terminal markets of London, New York, and Paris. Some of the cocoa purchases made by Eastern Bloc countries are, however, made directly from producing countries under bilateral agreements.

Secondary processors purchase most of their beans through brokers, dealers, and importers who in turn buy at the terminal markets, guiding supplies of cocoa from the exporter to processors and manufacturers. Many of the processing companies have their own distribution and retailing systems.

Table 1: Net Exports of Cocoa Beans and Processed Cocoa by Major Producing Countries
Source: World Bank, 1982 and FAO, 1984

Country	1961	1970	1975	1978	1983	1984
		('000 Metric tons)				
Brazil						
Cocoa Beans	104	120	177	134	152	107
Cocoa Products	37	48	80	111	139	174
Ecuador						
Cocoa Beans	33	36	36	17	5	47*
Cocoa Products	0	5	19	54	27	23*
Ivory Coast						
Cocoa Beans	89	143	170	244	286	390*
Cocoa Products	0	37	51	56	58	66*
Nigeria						
Cocoa Beans	187	196	195	180	170*	108*
Cocoa Products	0	25	25	12	19*	13*
Ghana						
Cocoa Beans	412	367	322	207	153	142*
Cocoa Products	7	45	49	38	14	13*
Cameroon						
Cocoa Beans	66	72	72	62	80	107
Cocoa Products	4	21	26	29	11	14

*Unofficial figure

The market for processed and semi-processed products from producing countries is more complex. It too is dominated by a relatively small number of corporations. There are numerous permutations of secondary processing activities; some corporations produce only cocoa powder, while others produce chocolate, or cocoa butter and cocoa cake, or cocoa liquor. Producers of cocoa powder always produce cocoa butter from the same pressing operation, although they do have some flexibility to respond to market conditions by altering the residual oil in the cake.

Prices

A major feature of the cocoa trade is the degree of involvement by governments in both producing and importing countries. In many cases the involvement is through price control and stabilization schemes at domestic and international levels.

Cocoa prices fluctuate widely in international markets in response to supply fluctuations, and maintain a generally inverse relationship with stocks. Demand is relatively stable, even in the face of substantial price variation. A response to the problems of price fluctuation has been a series of International Cocoa Agreements, the latest of which, agreed to in 1981, incorporates a buffer stock scheme. The basic aim is to maintain the price of cocoa beans between agreed maximum and minimum levels. Important producer countries such as the Ivory Coast and consumer countries such as the USA are not members of the International Cocoa Organization (ICCO), however.

Domestic pricing and allocation policies in producing countries strongly influence processing economics. In several West African countries the raw materials proportion of total production costs for the production of liquor, butter, cake, and powder varies between 78% and 93% depending on bean prices and quality. Overvalued currencies can increase the effective labor costs of domestic processing, and discourage its growth. Policy changes can have an important affect on the profitability of processing industries, e.g., in Ghana, the domestic bean price went from 37% of the f.o.b. price to 96% between 1977 and 1979, thereby eliminating a major subsidy that the domestic industry had enjoyed. (Karunasekera, 1983)

Because processors in consuming countries can buy their cocoa from several markets, they are better able to obtain beans at the lowest price. Fluctuating prices for cocoa cake, butter, and liquor in relation to beans, sometimes make it unprofitable for processing facilities with no guaranteed market. Moreover, tariff barriers that discriminate against processed products still exist in some consuming countries.

Since cocoa is a tree crop there is usually a significant time lag in producers' responses to international price changes or fluctuations with respect to area under production. However, to the extent that domestic marketing arrangements pass price signals to producers, a shorter-term response can be realized with more or less intensive plantation management and use of fertilizers and pesticides.

Quality Aspects

Before buying a consignment of cocoa the manufacturers require samples for purposes of quality determination. Five characteristics which affect the manufacturer's assessment of the 'value' of a particular consignment and, hence, the price paid for it are: flavor, purity or wholesomeness, consistency, yield of edible material, and cocoa butter characteristics.

Flavor is the most important criterion, and is derived from the variety of the tree, and the fermentation, drying, and roasting processes. In addition to off-flavors from pesticides and contamination, other types of off-flavors to be avoided and their causes include:

- **Moldy flavor:**
  - prolonged fermentation
  - slow or inadequate drying
  - storage under conditions of high humidity
  - germinated seeds, which are prone to become moldy;

- **Smoky flavor:**
  - smoke contamination during drying
  - contamination during storage;

- **Acidic flavor:**
  - incorrect fermentation
  - rapid drying;

- **Bitterness and astringency:**
  - insufficient fermentation.

The flavor from 'fine' cocoa is particularly suited to 'plain' chocolate manufacture, while 'bulk' cocoa is used chiefly for milk chocolate. At one time, premiums were paid for 'fine' or 'flavor' beans from Criollo or Trinitario varieties. These were blended with 'bulk' beans from Forastero varieties to achieve the required flavor and aroma. The availability of cocoa substitutes has made it possible to manufacture chocolate products without the addition of 'fine' flavor cocoa, and the price differential between the grades has virtually disappeared.

As a food product, cocoa must comply with strict public health standards. The principal sources of impurities are: pesticide residues, bacteria, insect and rodent infestation, and other foreign matter. Use of approved quantities and types of pesticides is essential; good drying and handling should reduce bacterial infection; fumigation and good storage practice will reduce insect infestation; and thorough sorting and cleaning is needed to remove objectionable foreign matter.

Since manufacturers aim to produce chocolate of consistent quality, they require that the quality of cocoa both between bags and between consignments be consistent. Bulking and mixing poor with good quality beans is not acceptable.

The yield of the edible part of the bean significantly affects its value to the manufacturer. The amount of cocoa nib (the edible part), and the amount of cocoa butter (the most valuable product) that can be obtained from a consignment can be measured objectively against several norms. These are: bean size and uniformity, shell percentage, fat percentage, moisture content, and presence of defective beans.

Small beans have high shell and low fat percentages thus reducing their nib and butter content. They can be processed but factory processes have to be adjusted: this can be inconvenient and costly. For these reasons, beans smaller than one gram should be sorted out and sold separately.

Beans should be reasonably uniform in size so that effective bean cleaning and roasting can be achieved. Manufacturers prefer the shell to be loose, but strong enough to remain unbroken when handled. Shell content is usually measured against West African cocoas which contain approximately 11-12% shell.

Fat percentage relates directly to the yield of cocoa butter. The percentage for West African cocoas is about 56-58% in the dry nib. Moisture content is important, the optimum being between six and seven percent.

Flat, shrivelled, or insect-damaged beans result in lower yields.

Cocoa butter is judged by its 'hardness' and its free fatty acid (FFA) content. Good fermentation and drying should result in beans with a low FFA, typically around 0.5%. The level must be lower than 1.0% so that the butter produced from the beans will be less than 1.75%, the legal limit for cocoa butter in the EC. Butter which contains higher proportions of saturated fatty acids and is 'harder' or semi-solid at room temperature is preferred. The fatty acid composition depends on growing conditions and affects the way chocolate behaves during manufacturing. Butter from Cameroon and Brazil tends to be softer, while butter from Malaysia is harder than that derived from most West African beans.

Various cocoa standards exist which use objective measures to determine quality. They cannot measure or ensure good flavor, but they can detect some of the defects causing off-flavors. The most important are the International Cocoa Standards, and those defined in the contracts of the Cocoa Association of London (CAL), the Association Francaise du Commerce des Cacaos (AFCC), and the Cocoa Merchants Association (CMA) in the USA.

Market Barriers

There are two major consuming centers for cocoa products: the USA and Europe. Secondary processors in producer countries must sell the bulk of their products to these centers, but in so doing they face two major barriers: tariffs, and competition with established concerns. Although primary products face relatively small nominal tariffs in the two major consuming centers, there tends to be tariff 'escalation' as the products become more processed or fabricated.

Competition from the smaller number of large established transnational and multinational corporations is a major problem. This is particularly true for chocolate products where product differentiation and brand names are supported by massive advertising.

To a lesser extent processors in producer countries are also affected by transport costs between their factories and the markets. Overall, transport costs for cocoa beans and cocoa products are between 5% and 6% of the c.i.f. price. They tend to be slightly higher for processed products.

Market Substitution

Competition from other products has already been mentioned as contributing to the reduction in price differential between 'fine' and 'bulk' beans. The only major cocoa product affected by substitution is cocoa butter. Chocolate gets its hardness and 'melt in the mouth' qualities from cocoa butter. Other fats with these qualities are coconut and palm kernel oils. Their main advantages over cocoa butter are their lower cost, and their prevention of 'bloom' or whitening of chocolate. They are limited however, in two ways: they are not fully compatible with the butter content of cocoa liquor, and there are legislative restrictions governing the compostition and labelling of chocolate in many countries.

OTHER FACTORS

Environmental Aspects

There are no serious environmental hazards associated with processing cocoa beans. Air pollution may result, however, from the dust, smoke, odors, and hexane evaporation, the latter only when solvent extraction is used. Controlling the dust and hexane is very important to prevent fires and explosions. Most modern systems use pneumatic equipment and continuous closed systems which handle the dust and vapors.

Water pollution is not a problem. Although large quantities of water are needed, it is used almost exclusively for steaming and cooling, therefore acquiring few contaminants.

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ANNEX I:

EXAMPLES OF INVESTMENT AND OPERATING COSTS

Representative Investment and Operating Costs

COCOA PROCESSING PLANT

Construction of a cocoa processing plant with a 30,000 ton per annum capacity.

COUNTRY: Ghana

NOTE: These data are representative only and are unique to the time, country, and circumstance of the identified investment. Their applicability to other situations may vary considerably.

ANNUAL FULL DEVELOPMENT PRODUCTION:

processing of 25,500 tons of beans

Per Cent of Full Capacity Utilization: 85.00%

I. Investment Costs	US $ '000 Total 1979 prices
Buildings	3172.00
Infrastructure (roads, utility upgrade, etc.)	554.00
Processing Machinery & Equipment	11892.00
Support Equipment	2366.00
Freight, Insurance, Installation	1866.00
Training & Know-How	623.00
Total Investment Costs	20473.00

Representative Investment and Operating Costs

NOTE: These data are representative only and are unique to the time, country, and circumstance of the identified investment. Their applicability to other situations may vary considerably.

II. Annual Full Development Operating Costs (excluding raw materials)	US $ '000 Total 1979 prices
Fixed Costs	
depreciation	140.25
administrative staff	702.27
administrative expenses	771.63
insurance	60.44
maintenance	50.24
spare parts	380.97
rents	11.99
Sub-Total Fixed Costs	2117.78
Variable Costs	
packaging	551.06
energy	410.04
labor	2631.35
miscellaneous	264.69
Sub-Total Variable Costs	3857.13
Total Operating Costs	5974.91

DATA SOURCE: Adapted from Commonwealth Secretariat's Case Studies on Industrial Processing of Primary Products, Vol. II, Cocoa, Coconut Oil, and Tea, 1983.

NOTES:
1. Costs expressed in US $ in the report.
2. Foreign/local cost breakdown is not available.
3. Data are net of contingencies.

ANNEX II:

CONVERSION TABLES

WEIGHTS AND MEASURES

avoirdupois

Ton: short ton	20 short hundredweight, 2000 pounds; 0.907 metric tons;
long ton	20 long hundredweight, 2240 pounds; 1.016 metric tons.
Hundredweight	cwt;
short hundredweight	100 pounds, 0.05 short tons; 45.359 kilograms;
long hundred weight	112 pounds, 0.05 long tons; 50.802 kilograms.
Pound	lb or lb av; also #; 16 ounces, 7000 grains; 0.453 kilograms.
Ounce	oz or oz av; 16 drams, 437.5 grains; 28.349 grams.
Dram	dr or dr av; 27.343 grains, 0.0625 ounces; 1.771 grams.
Grain	gr; 0.036 drams, 0.002285 ounces; 0.0648 grams.

Troy

Pound	lb t; 12 ounces, 240 pennyweight, 5760 grains; 0.373 kilograms.
Ounce	oz t; 20 pennyweight, 480 grains; 31.103 grams.
Pennyweight	dwt also pwt; 24 grains, 0.05 ounces; 1.555 grams.
Grain	gr; 0.042 pennyweight, 0.002083 ounces; 0.0648 grams.

METRIC SYSTEM

Square kilometer	sq km or km^2; 1,000,000 square meters; 0.3861 square mile.
Hectare	ha; 10,000 square meters; 2.47 acres.
Hectoliter	hl; 100 liters; 3.53 cubic feet; 2.84 bushels;
Liter	l; 1 liter; 61.02 cubic inches; 0.908 quart (dry); 1.057 quarts (liquid).
Deciliter	dl; 0.10 liters; 6.1 cubic inchs; 0.18 pint (dry); 0.21 pint (liquid).
Centiliter	cl; 0.01 liters; 0.6 cubic inch; 0.338 fluidounce.
Metric ton	MT or t; 1,000,000 grams; 1.1 US tons.
Quintal	q; 100,000 grams; 220.46 US pounds.
Kilogram	kg; 1,000 grams; 2.2046 US pounds.
Gram	g or gm; 1 gram; 0.035 ounce.