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PROJECT ON PILOT PLANTS TO PROCESS COCOA BY-PRODUCTS

SUMMARY REPORT ON A PILOT PROJECT IN GHANA

Prepared by:

Dr. D.K. Adomako and ICCO secretariat
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CHAPTER I

1. INTRODUCTION

The post-harvest processing of cocoa pods into cocoa beans generates a number of by-products and wastes that are usually discarded but which in fact could be processed into other economic products, using the appropriate technical know-how. The beans extracted from cocoa pods constitute only about 19% of the fresh weight of the pod and the remaining 81% in the form of fresh cocoa pod husk (CPH) and bean pulp juice are discarded as wastes. Equally, germinated beans and other sub-standard beans that do not meet the quality requirements of chocolate manufacturers and thus have little market value are in many cases destroyed as wastes. It could, therefore, be rightly said that the economic potentials of cocoa production have not been fully exploited through the efficient use of all output from cocoa production.

Research work conducted by the Cocoa Research Institute of Ghana (CRIG) from 1970 to 1983 demonstrated that the wastes from the processing of cocoa pods and cocoa beans could be processed into commercially useful by-products. For example, animal feed and potash can be produced from cocoa pod husks. Alcohol, pectin, jelly, soft drinks, wine, and vinegar can be produced from sweatings or bean pulp juice, while cocoa butter soap and cosmetics can be produced from sub-standard beans. Based on these findings, an ICCO/CFC/CRIG project on “Pilot Plants to Process Cocoa By-products in Ghana” was implemented from September 1993 to July 2003 to carry out pilot-scale production and commercialization of the above mentioned by-products.

The project aimed to expand the income generating capacity of the cocoa industry in cocoa producing countries through the development and transfer of appropriate technologies for the commercial processing of cocoa by-products and wastes. The main objectives of the project were:

1. to identify and develop by-products and new products from cocoa;
2. to develop and transfer technology for the commercial processing of cocoa by-products;
3. to promote farm level processing and local use of the by-products;
4. to demonstrate the possibility of generating extra income to supplement farmers’ earnings from the sale of cocoa beans; and
5. to ensure regional participation in the project in order to extend the benefits of the results of the project to other cocoa producing countries in West Africa and in other cocoa growing regions.

At the end of the project in July 2003, three project reports had been prepared. First, the *Final Technical Report* had been prepared by the Cocoa Research Institute of Ghana (CRIG) which identified and outlined the technical processes for the commercial processing of cocoa by-products. Second, a *Report on the Feasibility Study of Pilot Plants for Processing Cocoa By-products in Ghana* had been jointly prepared by a consultant and the secretariat of the ICCO. The feasibility study investigated the economic and financial viability of the various enterprises identified in the technical report of the project. Third, the *Report of an International Workshop on the Utilization of Cocoa By-products* held in Accra, Ghana from 14 – 16 July 2003 had been compiled by CRIG. The theme of the workshop was *"Enhancing farmer incomes through the processing of cocoa by-products"* and it considered the technical and feasibility study results of the project with references to similar experiences in other cocoa growing regions of the world.

Finally, it was considered appropriate to summarize the three aforementioned reports into a comprehensive report that could serve as an investment promotion guide for individual entrepreneurs and farmers' cooperatives, who might be interested in setting up small scale industries to process cocoa by-products. In this report, the technical results of the project, the feasibility study and the report of the international workshop have been summarised to highlight the following:

- The technical and economic feasibility of the cocoa by-product technologies developed by CRIG;
- Opportunities for farmers to earn additional income from selling cocoa by-products or from processing cocoa wastes into marketable products; and
- Investment opportunities for private entrepreneurs and farmers' cooperatives in cocoa by-product processing.

CHAPTER II

2. PROCESSING OF COCOA BY-PRODUCTS

Three distinct categories of wastes are derived from cocoa pods after removing cocoa beans used for the manufacturing of chocolate and other related products. These wastes are cocoa pod husk, cocoa sweatings or pulp juice, and discarded cocoa beans. Cocoa pod husks (CPH) are derived when cocoa pods are opened and the beans still covered with mucilage or pulp are removed. Cocoa sweatings are derived during the fermentation process of the beans when chemical changes cause the mucilage covering the beans to liquidify and run off as “sweatings”. Discarded cocoa beans are germinated beans and substandard beans that would not be accepted by chocolate manufacturers.

Cocoa pod husks can be processed into animal feed, potash for soft soap manufacturing, compost and organic fertilizer. Cocoa sweatings or pulp juice can be processed into soft drinks, wine, vinegar, alcohol and pectin, while discarded cocoa beans can be processed into cocoa butter soap and cocoa butter based cosmetics. The three categories of cocoa wastes and by-products could therefore be used to develop a cocoa pod husk-based industry, a cocoa sweatings-based industry and a discarded cocoa bean-based industry.

2.1 Cocoa pod husk-based industry

The project developed four products from the processing of cocoa pod husks. These products were potash, potassium salt, local soft soap and animal feed formulas. The technical processes for the production of each of these products are described below.

2.1.1. Production of animal feed from cocoa pod husks

Input Cocoa pod husks, guinea grass, corn bran, brewer’s spent grain, fish meal, oyster shells, common salt, copra.

Equipment A cutting or slicing machine, a mincing and pellet-making machine, a stand-by solar drier, a milling machine, a mixing machine.

Process 1

Step 1 Cut or slice cocoa pod husks into small flakes in a slicing machine.

Step 2 Sun dry the wet flakes containing about 84% moisture to about 60% moisture by spreading on raffia drying mats or tarpaulins.

Step 3 The partially dried flakes are then minced and made into pellets in a mincing machine.

Step 4 The pellets are then sun dried as in step 2 to a moisture content of about 14% and then stored in bags or wooden silos as cocoa pod husk (CPH) meal.

Step 5 The dried pellets are later used in compound feed formulas for various animals using other ingredients indicated under the input. Compound feeds could also be prepared by mixing the partially dried flakes in step 3 with dry feed ingredients and milling the mixture into pellets and feeding it fresh to animals or dried and stored for later use.

Process 2 Step 1 Cut or slice fresh cocoa pod husks into flakes in a slicing machine.

Step 2 Sun dry the flakes to about 12-14% moisture content on a drying mat or tarpaulin.

Step 3 The dried flakes are milled in a hammer mill and stored.

Step 4 The milled cocoa pod husks are later mixed with dry feed ingredients and fed to animals as marsh.

Output Cocoa Pod Husk (CPH) based compound animal feed.

Remarks Livestock feeding trials with CPH replacing maize have shown that CPH based animal feed products are a feasible alternative to solely maize based feed products. This method can be used as a prototype for commercialization of animal feed production or as an integral part of cocoa production.

2.1.2. Production of potash from cocoa pod husks for use in soft soap manufacturing

Input Cocoa pod husks.

Equipment Baskets, concrete drying floor, shovels, rakes and ashing kilns.

Process Step 1 Spread and dry cocoa pod husks on a constructed concrete floor in the open air for about two weeks as the case may be.

Step 2 Turn the husks periodically to enhance drying.

Step 3 Incinerate the dried husks in an ashing kiln.

Step 4 Collect the ash from the bottom of the incinerator.

Step 5 Bag the ash.

Output Cocoa pod husk potash.

2.1.3. Production of soft soap using cocoa pod husk potash

Input Cocoa pod husk potash, palm oil or palm kernel oil.

Equipment Aluminium cooking pots and plastic buckets.

Process Step 1 Soak 40kg of raw cocoa pod husk potash in about 100 litres of water.

Step 2 Transfer the mixture into a bag or suitable receptacle and leave for 24 hours for the dissolved salt to drain into a large pot or pan.

Step 3 Boil the solution in a large aluminium pot on fire and stir frequently to evaporate the water.

Step 4 Allow the crystallized salt to cool and then weigh.

Step 5 Dissolve 9 kg of the extracted salt in 4.5 litres of water.

Step 6 Heat 18 litres of palm oil/palm kernel oil in a large aluminium pot until very hot.

Step 7 Add the potash salt in step 5, a little at a time to the hot oil and stir. Continue boiling until soap is formed.

Step 8 Allow the paste to cool then shape into balls as desired and dry in the sun for 2 days to bleach to a light grey colour.

Output Cocoa pod husk-based soft soap.

2.1.4. Production of organic fertilizer (manure) using cocoa pod husks

Cocoa pod husks are biodegradable and as such decompose or rot readily releasing nutrients back to the soil. One way of using cocoa pod husks as organic fertilizer is to scatter the husks on the farm and leave to decompose. The second way is to grind or slice fresh cocoa pod husks into small flakes and compost the flakes to form manure.

2.2 Cocoa pulp juice or cocoa sweatings-based industry

The project developed six products from the processing of cocoa pulp juice or cocoa sweatings. These products were alcohol, pectin, jelly and marmalade, wine, vinegar and soft drinks. The technical processes for the production of each of these products are described below. The pulp which yields cocoa sweatings is also essential for the fermentation process. However, studies have shown that as much as 150 litres/tonne can be extracted for processing into other products without affecting the quality of the fermented beans.

2.2.1. Extraction of cocoa sweatings

Input Fresh cocoa beans still covered with mucilage or pulp.

Equipment Plastic water tank with wooden cover, heavy stones or cement blocks and thick plastic sheets.

Process Step 1 Pack fresh cocoa beans into a modified one ton capacity plastic water tank.

Step 2 Cover the beans with a loosely fitting wooden cover which is capable of sliding to the bottom of the tank when empty.

Step 3 Wrap 22 kg cement blocks in thick plastic sheets and place them on the wooden cover to speed up the extraction process.

Step 4 Collect the sweatings after 20 hours to be used in the production of alcohol and wine, or collect sweatings after 4 hours to be used in the production of pectin.

Output Cocoa sweatings.

2.2.2. Production of alcohol from cocoa sweatings

Input Cocoa sweatings.

Equipment Modified polytanks, Jacob Carl distillation plant or cottage distillation plant, 45 gallon plastic drums and plastic buckets.

Process

Step 1 Put cocoa sweatings in 45 gallon plastic or metal drums leaving sufficient head space. Cover the mouth of the drum with a clean plastic sheet, or loosely with the lid of the drum.

Step 2 Leave the sweatings for four days to ferment into alcohol.

Step 3 Distil the alcohol produced in a pilot Jacob Carl Super 300 Free Standing Distillation Plant.

Output Alcohol which is blended as brandy (70° proof, 40% by vol.) and gin (43% by vol.).

2.2.3 Production of pectin from cocoa sweatings

Input Cocoa sweatings collected after just four hours of extraction. A longer extraction period would result in degradation of the pectin.

Equipment Jacob Carl distillation plant, modified polytank, stainless steel vessel and plastic buckets.

Process

Step 1 Filter freshly collected cocoa sweatings through cheese cloth or a fine mesh. Heat for about 15 minutes and acidify to pH3.2 with diluted hydrochloric acid.

Step 2 Note the volume and add high strength alcohol (83-88%), continue stirring, to about 60% alcohol concentration to precipitate pectin.

Step 3 Allow it to stand for several hours and then filter the precipitate through a piece of cloth and suspend in a known volume of high strength alcohol to dry it.

Step 4 Filter again and oven dry at 60°C.

Step 5 Redistill the spent alcohol using the Jacob Carl distillation plant and recycle.

Output Pectin.

Remarks About 97% alcohol is recovered in the re-distillation process. Therefore, great care must be taken in the handling of the spent alcohol to avoid spillage and excessive vaporization to achieve a high overall recovery of alcohol in the recycling process. 28.5 to 35.5 litres of cocoa sweatings yields about 0.5kg of pectin. The pectin extracted from cocoa sweatings is of high grade compared to apple and lemon pectin.

2.2.4. Production of jelly, marmalade, and jam from cocoa sweatings

Input Cocoa sweatings, sugar, pectin, antioxidant, mucilage degrading enzyme and preservative.

Equipment Jacob Carl distillation plant, 45 gallon plastic drums, plastic buckets, 13 gallon plastic drums and 1,000 litre poly tank assembly.

Process Step 1 Mix together 300 parts of cocoa sweatings, 100 parts of sugar and 0.1 part of pectin in a stainless steel or aluminium saucepan and let it boil.

Step 2 Add mucilage degrading enzyme, antioxidant (ascorbic) acid) and preservative to improve texture and consistency. The mixture is boiled further to the right consistency.

Step 3 Pour the jelly obtained into bottles and allow it to cool to room temperature. Label and the product is ready for the market.

Output Jelly.

Remarks To produce marmalade, add orange to the basic ingredients and boil. To produce jam, add orange or pineapple peels to the basic ingredients and boil.

2.2.5. Production of wine from cocoa sweatings

Input Cocoa sweatings, wine yeast, pectinase, potassium metabisulphite, potassium sorbate and sorbitol.

Equipment Plastic drums, flash pasteurizer, air traps, hydrometer, alcoholmeter and buckets.

Process Step 1 Filter fresh cocoa pulp juice or sweatings through fine cloth or plastic mesh.

Step 2 Add water or sugar to adjust the sugar concentration to the desired level.

Step 3 Add preservatives and clarifying agents and then pasteurise the juice with a flash pasteurizer.

Step 4 Allow to stand overnight and add yeast and potassium phosphate.

Step 5 Leave at room temperature for four weeks for fermentation to almost complete.

Step 6 Siphon into a sterilized plastic drum fitted with an air trap and leave for six weeks for fermentation to complete.

Step 7 Store for three years to mature.

Output Wine.

2.2.6. Production of vinegar from cocoa sweatings

Input Cocoa sweatings, cocoa wine, acetobacter, potassium metabisulphite, potassium sorbate.

Equipment Fermenter (modified polytank), hydrometer, buckets and plastic containers.

Process Step 1 Put fresh sweatings in a bucket or polytank, partially opened, for four weeks to attract fruit flies. After four weeks the surface would have been completely covered with a film of bacteria introduced by the fruit flies. This is called *Acetobacter* culture and is used as inoculum for the production of vinegar (acetic acid).

Step 2 Dilute cocoa wine with sterile water to alcohol strength of 7% (v/v).

Step 3 Transfer to a modified vinegar fermenter in which a built-in glass window allows light into the fermenter, while a window covered with a plastic sheet allows circulation of air within the tank.

Step 4 Add *Acetobacter* culture at room temperature (25°C) and the marsh is left at room temperature for 16 weeks to ferment. By the end of the fourth week, the surface of the marsh would have become completely covered with a film of *Acetobacter*.

Step 5 Determine the acetic acid content by titration with diluted alkali and leave for eight weeks to mature

Step 6 It is centrifuged and flash pasteurized, followed by addition of potassium sorbate and potassium metabisulphite, and then stored in plastic drums.

Step 7 Finally the acetic acid is determined and the product is bottled for the market.

Output Vinegar.

2.2.7. Production of soft drink from cocoa sweatings

Input Cocoa sweatings extracted, using the modified polytank method for up to ten hours, water, sugar, citric acid, sodium metabisulphite and benzoic acid.

Equipment A 1,000 litre modified polytank assembly, mixing tank, flash pasteurizer, plastic drums and graduated plastic buckets.

Process Step 1 Filter the juice using a clean cloth or fine plastic mesh.

Step 2 Determine the desired sugar content by either diluting with water or add more sugar in a holding tank.

Step 3 Add ingredients and preservatives in a mixing tank and stir.

Step 4 Flash-pasteurize at 90°C for 30 seconds.

Step 5 Measure and put into bottles or plastic sachets and store at 0-4°C for sale.

Output Soft drink.

2.3 Discarded cocoa bean-based industry

The project developed two products from cocoa butter extracted from discarded cocoa beans. These products were cocoa butter toilet soap and cocoa butter pomade.

2.3.1 Extraction of cocoa butter from discarded cocoa beans

The amount of cocoa butter extracted from discarded beans depends on the method of extraction and the quality of the beans.

Input Discarded cocoa beans.

Equipment Aluminium cooking pots and milling machine.

Process 1 Manual Extraction of unsorted beans.

Step 1 Roast the beans without sorting the totally mouldy or insect damaged beans.

Step 2 Mill the beans and boil in water.

Step 3 After cooling, the butter is skimmed off. Yield would be about 8%.

Process 2 Manual Extraction of sorted beans.

Step 1 Spread out beans on the floor or tarpaulin or mat.

Step 2 Separate usable beans (not totally damaged) from unusable beans and discard the unusable beans.

Step 3 Roast the usable beans.

Step 4 Mill the beans and boil in water.

Step 5 After cooling, the butter is skimmed off. Yield would be about 14-20%.

Process 3 Mechanical extraction of beans.

Step 1 A large amount of discarded beans is extracted by a mechanical press in an oil mill. The amount of cocoa butter yielded would depend on the quality of the beans but it is usually higher than with manual extraction.

Output Cocoa butter.

2.3.2. Production of cocoa butter toilet soap from cocoa butter

Input Cocoa butter, sodium hydroxide, EDTA, anhydrous sodium carbonate, titanium dioxide, dye and fragrance.

Equipment Boilers, weighing balances, plastic moulds, graduated plastic buckets and a set of soap making machines.

Process Step 1 Melt cocoa butter and mix with bleached palm oil and palm kernel oil in the right proportions, and allow to cool.

Step 2 Add caustic soda and boil with stirring (semi-boiled process) or mix without boiling (cold process) to form soap.

Step 3 Transfer the soap mixture into moulds and leave overnight to set.

Step 4 Manually cut the crude soap into smaller chips and dry in the sun to remove excess moisture.

Step 5 Mould the dried soap chips into tablets.

Step 6 Shred the raw soap in a chipping machine and dry for two more days.

Step 7 Add dye and perfume and mix in a mixing machine.

Step 8 Mill the mixture into ribbons in a milling machine.

Step 9 Transfer the soap ribbons to a plodding machine to be compressed and extruded into a log.

Step 10 Cut the extruded log into standard sizes of about 30cm.

Step 11 Cut the extruded log further into 9cm pieces.

Step 12 Compress in a moulding machine, stamp and package ready for the market.

Output Cocoa butter toilet soap.

2.3.3. Production of cocoa butter pomade from cocoa butter

Input Cocoa butter, paraffin wax, stearic acid, petroleum jelly, mineral oil, preservative and fragrance.

Equipment Melting kettle, sieve, weighing balance and packaging bottles

Process

Step 1 Put together cocoa butter, paraffin wax, stearic acid, petroleum jelly and mineral oil in a melting kettle and heat.

Step 2 Allow to cool to about 55°C and then add fragrance and preservative

Step 3 Continue mixing until set.

Step 4 Fill the mixture into jars to specific weight.

Step 5 Label jars and pack into boxes.

Output Cocoa butter pomade.

CHAPTER III

3. RAW MATERIALS AND MARKETING OF COCOA BY-PRODUCTS

Generally, cocoa is produced in Ghana, as in other countries in West Africa, on smallholder farms, which are widely scattered and located in remote areas. For this reason, for the development of a cocoa pod husk-based industry and a cocoa sweatings-based industry, the organization of the collection of the required raw material is a very important issue to be considered. The need for sourcing of raw materials (cocoa pod husks and cocoa sweating) indicates two possible scenarios for a cocoa pod husk-based industry and a cocoa sweatings-based industry. The first scenario consists of investment by a farmer or farmers' cooperative, integrating production of cocoa beans with processing of cocoa by-products. The second scenario consists of investment by a private entrepreneur in the processing of by-products.

The project established four pilot plants in Ghana. The government of Ghana provided four cocoa plantations to be used for pilot plants. The plantations were located at Worakese, Wantram, and Mabang and at the CRIG main research station at Tafo. The project provided the necessary infrastructure and installed machinery at these plantations to process cocoa pods into cocoa by-products. The plantations supplied most of the raw materials (cocoa pod husks and cocoa sweatings) used in the pilot operations. However, raw materials were also collected from neighbouring farms to augment supplies from the plantations. The Worakese, Wantram and Mabang plantations were used for the cocoa pod husk-based industry and cocoa sweating-based industry. The Tafo plantation was used for a discarded cocoa beans-based industry and for most of the work on soft drinks, potash and soft soap using cocoa pods from experimental farms.

3.1 Cocoa pods

Cocoa pods provide the three main raw materials (cocoa pod husks, cocoa sweatings and discarded cocoa beans) processed into by-products. There are two harvesting seasons for cocoa pods in a year, i.e. the main crop and the light or minor crop. The main crop forms about 85% of the total annual crop and is harvested between September and January, while the minor or light crop is harvested between May and July. The cocoa beans from the main crop are large beans weighing 80-100 beans/100g and developed over the wet period of the year, whilst the beans from the minor crop are generally smaller beans weighing 110-120 beans/100g; they develop during the dry harmattan period of the year. The mucilage or pulp of the main crop beans is juicier and thus yields higher sweatings than the pulp of the minor crop beans which tend to be rather dry with a lower yield of sweatings.

3.2 Cocoa pod husks and cocoa sweatings

The success of the pilot plants depended on the availability of cocoa pod husks and cocoa sweatings. The project estimated the production capacity for cocoa pod husks and cocoa sweatings at Worakese, Wantram and Mabang plantations. The production estimates were based on the following indicators:

- 26 pods give 1 kg of dry cocoa beans.
- 1 cocoa pod weighs approximately 450 grams.
- The pod husk forms approximately 67% by weight of the fresh pod.
- 100 kg of fresh husks gives 16 kg of dry husk or 10 kg of ash (potash).

- 545 pods give 45.5 kg of unfermented beans.
- 1,000 kg of fresh unfermented beans gives 150 litres of cocoa sweatings/pulp juice.
- 150 litres of sweatings gives 6 litres of 85% alcohol.

Based on assumed yields of cocoa pods at the three plantations, the production estimates of fresh cocoa pod husks (CPH), dry husks, potash and sweatings are indicated in Table 1.

Table 1: ***Estimates of production of raw materials for processing into by-products at the three plantations based on 1999/2000 production data.***

Plantation	**(a)**	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**
	(Acres)		**Weight (Kg)**				**(Litres)**	**Weight (Kg)**
	Farm Size	**Nº of pods**	**Pods (bx0.45)**	**Wet Husks (cx0.67)**	**Dry Husks (dx0.16)**	**Ash (ex0.1)**	**Sweatings**	**Dry Beans**
Worakese	189.0	1,339,520	602,784	403,865	64,618	6,462	16,744	51,520
Wantram	82.1	878,800	395,460	264,958	43,336	4,710	10,985	33,800
Mabang	200.0	858,000	386,100	258,687	41,390	4,139	10,725	33,000
Total	**471.1**	**3,076,320**	**1,384,344**	**927,510**	**148,402**	**14,840**	**38,454**	**118,320**

This table indicates that the project produced about 927 metric tons of cocoa pod husks processed into animal feed and potash, while a total of 38,000 litres of cocoa sweatings were produced.

3.3 Sourcing for cocoa pod husks and cocoa sweatings

For a cocoa pod husk-based industry and cocoa sweatings-based industry to be technically and financially viable, the processing plants would need to be located close to easily available sources of raw materials. The project conducted a study on the distribution of cocoa farms within 12km distance of the experimental plantations at Worakese, Wantram and Mabang to identify farmers that could supply fresh cocoa pod husks and cocoa sweatings to augment supplies from the plantations. The results of the study indicated that, in the case of the Worakese plantation, there were 200 farms located within 12 km of the plantation, with farm sizes ranging from 1.0 ha to more than 9.0 ha. The output of the 200 cocoa farms in the area of the Worakese Plantation and their production of cocoa pod husks (CPH) and cocoa sweatings are shown in Table 2 (*on next page*).

Table 2: Production outputs of 200 farms within 12km of Worakese plantation

Output range (kg)	Nº Farms	% of farms	Total beans output	% Total output	Available pod husks (kg)	Available sweatings (litres)
<500	78	39.00	22,808	11.40	179,083	3,017
501 – 1,000	60	30.00	4,792	22.88	328,137	5,527
1,001 – 1,500	32	16.00	39,245	19.61	308,143	5,190
1,501 – 2,000	18	9.00	30,893	15.43	242,561	4,086
2,001 – 2,500	3	1.50	6,628	3.31	52,038	877
2,501 – 3,000	3	1.50	7,930	3.96	62,264	1049
3,001 – 3,500	2	1.00	6,370	3.18	50,016	842
>3,500	4	2.00	44,484	22.23	349,274	5883
Total	**200**	**100**	**200,148**	**100**	**1,571,515**	**26,471**

A total of 628 farmers were interviewed and over 96% of them indicated that they would be able to deliver fresh husks on the day of pod breaking to the collection points that were set up. The farmers were supplied with polytanks for the collection of cocoa sweatings. In all, the study estimated that about 1,515 tons, 1,162 tons and 1,485 tons respectively of cocoa pod husks were collectible from farms around Wantram, Mabang and Worakese plantations. The amount of collectible cocoa sweatings were estimated to be 62,683 litres, 48,367 litres and 61,442 litres respectively from Wantram, Mabang and Worakese plantations. The average price for fresh husks demanded by farmers in the Wantram area was US$0.002 per kg, US$0.002 per kg in Mabang area and US$0.0024 per kg in Worakese area. The cost of haulage of cocoa pod husks and cocoa sweatings to the processing plant was also determined. Tractors were used to carry the raw materials from the collection points to the processing plants. It was estimated that in each area one tractor could make three trips per day over a 12 km distance hauling a total of 9.4 tons or five trips per day over a 6 km distance and hauling a total of 15.6 tons. The estimated cost of hauling one ton of cocoa pod husk over a 12 km distance was US$7.04 or US$4.23 per ton over a 6 km distance. The cost of collecting cocoa sweatings was US$0.0019 per litre.

3.4 Alternative raw materials during the cocoa off-season

As indicated earlier, cocoa pods are harvested twice a year. The main crop is from September to January and the minor crop is from May to July. This means that during the months of February, March, April, July and August, which is the cocoa off-season, the processing plants would be idle. To fully use the capacities of the pilot processing plant, the project conducted a study in the Worakese area on alternative raw materials to cocoa pod husks and cocoa sweatings for the production of alcohol, pectin and jelly during the cocoa off-season. The result of the investigation indicated that banana, pineapple and mango fruits could serve as alternatives to cocoa sweatings. The harvesting period for pineapples and mangoes in the area was from March to July which coincides with the cocoa off-season period. Bananas were available throughout the year.

The study also showed that in the Worakese area, the total production per acre for bananas was 5,000 bunches. For pineapples, it was 92,000 fruits per acre; while for mangoes, it was 1.2 million fruits per acre. The banana, pineapple and mango farms were all located within 10 km distance of the

Worakese Plantation. However, farm owners were not prepared to deliver the fruits to the Worakese Plantation. Therefore, haulage would have to be arranged.

3.5 Marketing of cocoa by-products

Before the project started in September 1993, there were good indications that the by-products from cocoa pod husks and cocoa sweatings would enjoy a ready and growing market. The livestock industry in Ghana was rapidly developing and thus putting high demand on animal feeds. The market potential of the soap making industry was enhanced by a growing number of micro credit facilities available to associations in the soap industry. Although the products developed by the project had to face competition from existing similar products, the marketing approach adopted by the project helped to generate interest and awareness which lead to an increase in demand for the products. The competitive prices of the products gave them an appreciable percentage of the market in the industry.

The products produced by the pilot project were certified for use by the Ghana Standards Board and were then marketed through the following channels:

- Frequent participation in trade fairs and agricultural shows at both national and regional levels, and overseas on a few occasions. A considerable number of sales were made during national and regional fairs and shows. Contacts were also established with business men and women who subsequently followed up with orders.
- Many individuals and shops applied to be considered for wholesale distribution or retailing of the products.
- Some retailers and exporters requested, and were supplied with samples to test foreign markets.
- The general public in and around Tafo bought from CRIG directly, or from special shops designated by CRIG.

The quantities of cocoa by-products produced and sold by the project during the period of 1993 to 1998 are shown in Table 3 (*on next page*).

Table 3: ***By-products produced and sold from 1993-1998***

Product	Production	Proceeds/Unit (US$)*	Customer
Potash	45.0 tons	49/ton	Feanza Industry, Asiama; Gomoa Dawurampong Rural Bank; General public
Compound animal feed	13.45 tons	23/ton	Pig and rabbit farmers
Pelletized cocoa husk feed	73.0 tons	10/ton	GAFCO, Tema; Kpong Farms, Akotokrom Farm, Pig farmers
Cocoa Butter Pomade	3300 jars (100grams/jar)	0.28/jar	Fortunoff Import-Export Ltd. Accra; Union-Dordrecht Ltd. Tema; Public
Cocoa Butter Soap	22681 tablets (2013.7kg)	0.06/tablet	Fortunoff Import-Export Ltd. Accra; Union-Dordrecht Ltd., Tema: Public
Alcohol (Tech. Grade)	1,250 litres	0.27/litre	University of Cape Coast; Ghana Co-operative Distillers' Assoc., Kumasi; Public
Cocoa Jelly/Jam	4.27 Jars (30 kg/jar)	40/jar	General Public
Cocoa Pectin	5kg	3.9/kg	Jam/Marmalade Manufacturers
Cocoa powder based cakes and biscuits			General Public

** US$1 = 7,100 cedis (in 2001)*

All the products received favourable customer acceptance and there was a considerable demand for all products. However, not all demand could be met as the objective of the project was to test the market and establish it and this was largely achieved.

In some cases the superior quality of the products developed by the project attracted higher prices e.g. for potash, cocoa butter soap and pomade. This conservative attitude towards potash persisted even after it was demonstrated that the potash for soap making had much higher potassium carbonate content and as such made a better soap than others in the market. The success of the marketing of the product was such that the Gomoa Dawurampong Rural Bank in the Central Region purchased over 75% of the total potash production for its creditors in soap manufacturing associations. The bank had also placed a standing order for pectin as had the Nkulenu Industries in Accra. It is important to note that the market for cocoa pod husk pellets as animal feed depended on the affordability of a competing feedstuff – wheat bran. When wheat bran was in short supply and expensive, there was a large demand for CPH pellets. However, the market turned around when wheat bran was available with a 50% decrease in prices. Only a rapid switch to production of compound feeds for pigs and rabbits turned around the CPH marketing prospects positively.

An economic and financial feasibility study of the pilot plants to process cocoa by-products in Ghana was conducted. Assumed sale prices used for the analysis in the feasibility are shown in Table 4. The sale price of gin/brandy was adjusted upward from US$3.28/litre to US$4.23/litre, while the price of jelly was adjusted from US$0.92/450g to US$1.41/450g thus transforming a potentially loss-making operation into a profitable venture.

Table 4: ***Assumed sale prices of raw materials and by-products (at 2001 prices) used in feasibility analyses***

Product/Material	**Unit**	**Sale Price (US$) (a)**	**Raw Material Conversion Factor**	**Material Cost (US$) (b)**	**a/b**
Fresh CPH (husk)	ton	7.0	-	-	-
Potash	ton	440	63	440/ton	1
Dry CPH Pellets	ton	44	6.25	44/ton	1
Pig feed	ton	90	-	-	-
Rabbit feed	ton	90	-	-	-
Sweatings	Litre	0.19	-	-	-
Gin/Brandy	Litre	3.28	10	1.9/litre	1.73
Alcohol (technical 86%)	Litre	1.06	20	3.8/litre	0.28
Wine*	Litre	11.27	1	0.19/litre	59.32
Vinegar*	Litre	2.82	1	0.19/litre	14.84
Pulp juice (Soft drink)*	Litre	0.28	1	0.19/litre	1.47
Jelly	450 g jar	1.42	-	-	-
Cakes*	kg	0.14	-	-	-
Biscuits*	kg	0.21	-	-	-
Cocoa butter soap	110g	0.35	-	-	-
Potash soap	500g bottle	0.85	-	-	-
Cocoa butter pomade	100g bottle	0.56	-	-	-
Discarded beans	kg	0.26	-	-	-

The above table indicates that the assumed sales prices used in the project were probably not very realistic for most products. The ratio of the sales prices and material costs, which is indicative of the gross profit margin, was one for the cocoa pod husks-based enterprise. Except for wine and vinegar which had high profitability margins, other products in the cocoa sweatings enterprise had a low gross profitability. This shows that the promotional sale prices used for the feasibility analyses were not very realistic. It is, therefore, necessary to re-examine sales prices of the final products to try to achieve better profitability of the enterprises.

CHAPTER IV

4. ECONOMIC EVALUATION OF COMMERCIAL ENTERPRISE OF PROCESSING COCOA BY-PRODUCTS

4.1 The findings of the feasibility study of pilot plants for processing cocoa by-products in Ghana

The financial and economic feasibility study of the technology developed from research executed by CRIG on the utilization of cocoa by-products was conducted in 2001. CRIG had conducted research work on processing of cocoa by-products (cocoa pod husk, cocoa sweating and discarded cocoa beans) into economically useful products. The financial and economic feasibility studies were based upon scenarios for setting up commercial ventures or farmer enterprises within rural cocoa-growing localities, taking as a model for such localities the areas surrounding the three CRIG plantations at Worakese, Wantram and Mabang on which CRIG's pilot plants were established.

Three types of commercial enterprises were analysed for their economic and financial feasibility.

4.1.1. A cocoa pod husk-based enterprise

An operation that collects and processes fresh cocoa pod husk into the two separate products of animal feed and soft soap using potash obtained from the pod husk. Full annual production capacity was envisaged to be about 5,500 tonnes of pelletized animal feed and 100,000 tablets of soft soap of 500 grams unit weight.

4.1.2. A cocoa sweatings-based enterprise

An operation that collects cocoa sweatings from farmers and processes this into two products for the retail market, namely cocoa gin via the distillation of alcohol from the sweatings, and jelly with the use of pectin produced from the sweatings. Full annual production capacity was envisaged to be 21,000 litres of alcohol processed into about 56,000 bottles of cocoa gin of 750ml. unit volume, and over 200,000 jars of jelly of 450g unit weight.

4.1.3. A discarded cocoa bean-based enterprise

A plant which extracts cocoa butter from cocoa bean discards for use in the production of cocoa butter soap and pomade for the retail market. Full annual production capacity was envisaged to be less than 300 tonnes of cocoa butter soap marketed as about 450,000 bars of 110g unit weight, and 30 tonnes of pomade marketed as 300,000 jars of 100g unit weight.

At individual farm level the analysis covered the potential profitability of small-scale production of potash from cocoa pod husk, pelletized animal feed from fresh pod husk, and alcohol from cocoa sweatings.

The analyses of the enterprises were based on certain assumptions. It was assumed that the size of each of these industries would be the same as those established by CRIG for the pilot-plant operations within the project but set in a fully commercialized environment. Similarly, the location within which to site the industries would have to be close to cocoa farms that are large enough to supply substantial amounts of raw materials. It was also assumed that there would be a start-up year for each of the enterprises, whereby investments would be made and plant and equipment would be established. The capacity utilization would increase gradually from year one and would reach 100% capacity from year 5 onwards. The business would operate for ten years and would then be liquidated. Another assumption was that the price to be paid to farmers for the raw materials (cocoa pod husk and cocoa sweatings) should represent an enhancement of around 10% over the income received from the sale, through the normal channels, of dried cocoa beans. The sale prices of the final products generated by the enterprises would be those applied in the project by CRIG's marketing activities of the output from their pilot plants, updated where necessary to mid-2001 terms.

The results of the economic analysis of the enterprises had indicated a negative Internal Rate of Return (IRR) for the cocoa pod husk based enterprise and positive IRRs for the cocoa sweatings based enterprise and for the discarded cocoa beans based enterprise. The negative IRR for the cocoa pod husk based industry demonstrated that it is very unlikely that this type of enterprise could be made profitable.

These results imply, therefore, that setting up enterprises on the model established by CRIG's pilot plants, and providing an acceptable level of additional remuneration of farmer's incomes, results in enterprises of fairly moderate commercial value. The economic and financial attractiveness of the cocoa sweatings and discarded beans enterprises was found to be marginal from the point of view of attracting entrepreneurial capital and institutional finance. However, the scenarios analysed could possibly be varied in a number of alternative ways according to local conditions, and any significant variation which would be beneficial to the enterprise would lead to more attractively profitable ventures.

In addition to the three commercial operations described and analysed above, three analyses were also performed on the situation where an individual farmer (or small groups of farmers) could participate in the production of products directly derived from cocoa waste material for direct onward sale. The three potential products examined were potash recovered from the incineration of cocoa pod husk, animal feed from fresh pod husk in the form of pelletized dried CPH, and alcohol in the form of either industrial alcohol or local gin from distilled cocoa sweatings.

The results of the analyses show that there is a potential for cocoa farmers to generate a reasonable enhancement of their incomes through the processing of cocoa waste. The production of industrial alcohol would yield an unattractive 3% enhancement of income while production of the other products could result in an enhancement of farm incomes ranging between 10% and 15%.

Realistically, except for the largest farms which may generate sufficient volume of product to independently market it, small individual farmers would be best advised to pool their product for marketing and sale through a common channel, and in such cases a co-operative society would obviously have a role to play. It is also the case that co-operatives could organise central processing of raw materials collected from, or delivered by, their members, and successfully run a profitable enterprise.

4.2 Critical factors in the profitability of processing cocoa by-products

The major critical factors that would improve the profitability of the enterprises are the seasonality of production, resulting in low levels of capacity utilization; sale prices of finished products; and transport and haulage costs. The implications of these critical factors for the profitability of the processing of by-products are discussed below.

4.2.1. Seasonality, resulting in low levels of capacity utilization

The processing of cocoa by-products into useful products requires capital investments in buildings, processing equipment and vehicles. However, the raw materials for the processing of cocoa by-products are only available during the harvesting of cocoa pods which takes place between September and January (the main crop) and between May and July (the mid-crop). It is obvious that it is difficult to make profit in an enterprise, which can only operate during seven or eight months per year.

Analysis indicates that for cocoa by-products seasonality weighs particularly heavily with respect to costs of transport and for the capacity utilization of other equipment. Vehicles for collecting raw materials and transporting finished products are a very significant part of total investments. Therefore, it would seem imperative to use the vehicles of a cocoa by-products enterprise as intensively as possible.

There are two possible ways to reduce the impact of seasonality on the profitability of the enterprises. Firstly, as vehicles would be required on a full-time basis only during seven to eight months in the year, it would appear to be more profitable to lease some of the vehicles rather than buying them. Alternatively, where vehicles are bought, they could be leased out during the off season. The problem with this option is that in Ghana, most of the agricultural enterprises are seasonal and as such there is low demand for use of vehicles during off season. Secondly, with regards to low capacity utilization, the use of alternative raw materials to cocoa pod husks and cocoa sweatings for the production of alcohol, pectin and jelly during the cocoa off-season could be a viable option. As indicated earlier, bananas, pineapples and mangoes, which are available during cocoa off-season, are alternative raw materials in the production of alcohol, pectin and jelly.

4.2.2. Transport and haulage costs

Cocoa production is dominated by smallholder farmers. This presents transport and haulage cost problems for sourcing raw materials for the processing of cocoa by-products. In the case of a discarded cocoa bean-based enterprise, although the sub-standard beans are not very heavy, there is however, the problem of collecting small quantities of beans from many farmers. This easily increases the costs of collection. In the case of a cocoa sweatings-based enterprise, it is difficult to organize the collection of sweatings from farmers in an efficient and effective way. One has to design special tanks to be used by the farmers to collect the sweatings and to organize the transport of the sweatings to the factory sites for processing. The issue is further complicated by farmers completing fermentation at different times.

In the case of a cocoa pod husks-based enterprise, the bulky nature of the pod husks and the finished products (animal feeds and potash) have a serious impact on transport and haulage costs. Collecting cocoa pod husks from several farms and bringing them to the processing sites is a major problem. A problem of similar magnitude is the transportation of the finished products to the market or potential buyers. Moreover, because cocoa farms are scattered over large areas with poor or in some cases non-existent road infrastructure, special vehicles, for example tractors, rather than conventional vehicles have to be used to reach cocoa farms to collect raw materials for the processing of cocoa by-products.

4.2.3. Sales prices of the final products

It is noted that one of the main objectives of the pilot project for the processing of cocoa by-products was to increase the potential for cocoa farmers to enhance their farm incomes through the processing of cocoa wastes and that this enhancement should translate into at least 10% over the income received through the sale of cocoa beans. Therefore, the sales prices of the final products are a critical factor in determining both the achievement of one of the main objectives of the activities and the profitability of the enterprises. The sale prices of the final products that were used in the economic analysis were those discovered in the course of the marketing activities by CRIG, which were probably promotional prices and did not represent actual market values of the products. It was reported that some of the alternative products in the market sold at much higher prices. There is a very limited knowledge on real market values of finished products compared to the promotional prices used in the analysis. Therefore, more work needs to be done to establish attractive and profitable market sales prices for the finished products derived from cocoa by-products. Only entrepreneurs with good commercial skills would seem to be capable to do so in order as to enhance revenues generated from their sale.

4.2.4. Business environment and incentives

An equally important factor in improving the profitability of the enterprises is a conducive business environment and some government incentives especially for small-scale industries. Such incentives could come in the form of tax holidays and the provision of basic infrastructure. In some cases, technical support in the form of dissemination and technology transfer would have to be provided by the government.

4.3 Conclusions

The above analysis indicates that it would seem extremely difficult to make processing of pod husks profitable (except for the production of potash by farmers for local use). The reason for this rather negative conclusion is that the husks are very bulky, with a very low value per unit weight.

The preliminary conclusion regarding processing of cocoa sweatings and sub-grade cocoa beans is that such activities could be modestly profitable. Much depends on the ingenuity of entrepreneurs to make such ventures profitable. They would have to achieve a high degree of capacity utilization in a seasonal industry. This most probably requires a combination of processing of cocoa by-products with other activities in one enterprise. The costs of transport and haulage are, related to the seasonality issue, the most critical cost factor in the processing of cocoa by-products. Finally, potential entrepreneurs in such ventures should be experienced and knowledgeable in the marketing of their products, as realising the highest possible sales prices is critical for the profitability of their enterprises.

CHAPTER V

5. CONCLUSIONS AND RECOMMENDATIONS

During the project period the Cocoa Research Institute of Ghana (CRIG) conducted research work on processing of traditionally discarded cocoa by-products into economic commodities which can help increase rural employment and income and thus reduce poverty. In the process CRIG developed technologies to process cocoa pod husks into potash, potassium salt, soft soap and animal feeds; to process cocoa sweatings into alcohol, pectin, jelly and marmalade, wine, vinegar and soft drinks; to process discarded cocoa beans into cocoa butter toilet soap and cocoa butter pomade. The technical report of the project had demonstrated the technical feasibility of the processing techniques developed by CRIG.

On the financial viability of the commercial enterprises, the applied research into cocoa by-products conducted by CRIG had been partially commercialized and the local market was tested. Some of the by-products were certified by the Ghana Standards Board. The products covered in the feasibility analyses had proved to be of a marketable nature.

The feasibility studies with respect to the set-up of commercial ventures to utilize cocoa by-products and adequately reward farmers for the supply of raw materials shows that their successful establishment may be difficult. However, the conclusion is that it should be possible under the right conditions to form relatively profitable and sustainable enterprises that will benefit the rural communities in which they are established. One of the main problems identified, from a financial and economic point of view, is the expense incurred in haulage facilities, mainly for the collection of raw produce from cocoa farmers. Another main problem identified was the issue of seasonality resulting in low capacity utilization.

A third critical factor for the profitability of these enterprises is the question of sales prices realised for the final products. This emphasises the need for professional research into the domestic and/or export markets for these products to establish levels which are competitive with substitute products and result in maximum benefits for the cocoa by-products processing enterprises.

There are two major conclusions emanating from the analyses of the project on the pilot plants to process cocoa by-products in Ghana. Firstly, it is technically feasible to process cocoa wastes such as cocoa pod husks, cocoa sweatings and substandard cocoa beans into economically useful products. The technologies involved are simple and could easily be applied by cocoa farmers and other interested investors. Secondly, the economic and financial viability of the enterprises analysed varies from enterprise to enterprise. In the case of a cocoa pod husk-based enterprise, analyses have indicated that production of animal feed from cocoa pod husk is unlikely to be economically feasible, but possible economic feasibility existed for the production of potash and soft soap from cocoa pod husks. In the case of cocoa sweatings and discarded cocoa beans-based enterprises, analyses have shown that while the production of wine and vinegar is probably truly profitable, the production of alcohol and alcoholic drinks, pectin, jelly and marmalade, soft drinks, cocoa butter toilet soap and cocoa butter pomade are marginally profitable.

Finally, it is recommended that interested investors should contact the Cocoa Research Institute of Ghana (CRIG) to discuss issues relating to the technical aspects of the processing technologies and to obtain additional information. It is equally recommended that interested entrepreneurs and investors should conduct their own feasibility study, fully taking into account the local conditions regarding the critical factors that were identified in the analyses. The critical factors that would need to be reviewed by potential investors in their local areas include the issues of collecting raw materials, capacity utilization and sales prices.