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FACT FINDING AND PREPARATIVE ASSISTANCE TO ASSESS THE POTENTIAL FOR THE PROCESSING OF HERBAL PHARMACEUTICALS BASED ON TRADITIONAL GHANAIAN THERAPIES

GHANA

Technical report: Preparatory Assistance Mission*

Prepared for the Government of Ghana
by the United Nations Industrial Development Organization

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* This document has not been edited.

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ACKNOWLEDGEMENTS

The authors express their sincere thanks and gratitude to all the people contacted during the fact-finding mission to Ghana.

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EXECUTIVE SUMMARY

The objective of this fact-finding and preparatory assistance mission was to assess the potential for the processing of herbal pharmaceuticals based on the traditional Ghanaian therapies. The consultants were asked to assess the potential of the indigenous medicinal and aromatic plants for industrial utilization, their cultivation and post harvest treatment, their use in the current production of herbal pharmaceuticals; to assess industrial and institutional infrastructure related to medicinal and aromatic plants and development of pharmaceuticals based on traditional preparations; to assess current research capability at CSIR for natural products based drug development and finally to recommend on the mechanisms and modalities of a technical assistance project for the development of a production capability based on plant derived pharmaceutical materials.

It is estimated that 70% of the population in Ghana is dependent on Traditional forms of medicine. There are about 100.000 traditional medical practitioners practicing mainly in rural areas. Since, in general, health services in Ghana can reach only about 30% of the population, the Government has decided to give more emphasis to herbal medicine and appointed a Deputy Director at the Ministry of Health in charge of Herbal Medicine.

Centre for Scientific Research into Plant Medicine (CSRPM) at Mampong-Akwapim is the only research institution established and supported by the Ministry of Health. The Centre has an out-patients clinic, herbal preparation production and dispensing unit with herbarium, library, phytochemistry, pharmacology/toxicology and microbiology laboratories, and an arboretum and a farm. It has modest research facilities and rather unsatisfactory production facilities. The Centre uses the services of herbalist consultants in the formulation of herbal preparations.

The following institutions with scientific and commercial interest and regulatory role in plant medicine were visited: Botany Department, University of Ghana, Faculty of Pharmacy, University of Science and Technology, Kumasi; Council for Scientific and Industrial Research (CSIR) and its institutions, namely Scientific Instrumentation Centre, industrial Research Institute, Food Research Institute, Forestry Research Institute in kumasi; Ghana Standards Board; Pharmacy Board; Ministry of Health; Ministry of Industry, Science and Technology (MIST), Technology Transfer Centre (TTC); Ghana Export Promotion Council; GIHOC Pharmaceuticals Division; Forestry Enterprises; The Complex Hospital of herbal Medicine, Nsawam.

Having visited the above-mentioned institutions, the mission came to the conclusion that the Centre at Mampong-Akwapim could meet the national goal of upgrading and standardization of herbal preparation through the provision of a multipurpose pilot plant and supporting phytochemical monitoring and quality control facilities.

1. GENERAL INTRODUCTION

1.1 Brief Information On Ghana

Ghana is a West African State with a land area of 238,537 sq. Km supporting a population of 15.2 million (1990). The estimated population growth rate is 3.2% with a density of 64 persons per sq. km. The major exports of Ghana are cocoa, gold, diamonds, manganese, timber, electricity, etc. amounting to a total of US$ 807 million f.o.b. for 1989. The major export markets are Switzerland, U.K., The Netherlands, USSR, Japan, Germany, USA and Togo. The country imports a wide range of products, i.e. machinery, transport equipment, iron rods, petroleum, cement, etc. These are imported mainly from U.K., Germany, USA, Italy, Nigeria, Japan, Togo and The Netherlands. The country enjoys a tropical climate and has abundant resources in forestry and agricultural products. About 11% of the total land surface is under cultivation and 34% is under forest zone. The rest is bushland.

Some economic indicators for Ghana are as follows: GDP (current prices US$ 5249 million (1989); 6324 million (1990); GNP per head US$ 345 (1989); External debt US$ 3078 million (1989); Exchange rate Cedi 380 to US$ 1 (November 1991).

The country has nine administrative regions, namely Western, Central, Accra, Eastern, Volta, Ashanti, Brong-Ahafo, Northern and Upper (Annex 1).

1.2 Information on Chemical Industries in Ghana.

The purpose of this mission was to collate information on Traditional Medical Practices and preparations, therefore it is relevant to give an overview of the Chemical Industries in Ghana.

The Chemical Industries is one of the least developed sectors in Ghana. The manufacture of pharmacueticals, cosmetics, detergents, agrochemicals, etc. is based on imported materials. Finished products are also imported in bulk form for local packing and distribution.

The pharmaceutical industry deals mainly with grinding, mixing and packaging of imported products for retail sale. Although there are more than 20 manufacturing enterprises, they supply only 32 items out of a list of 211 national essential drugs. The production machinery are old and lack of spare parts make their maintenance extremely difficult resulting in low capacity utilization due to frequent breakdown and interruption of production. This leads to high cost of production which would eventually result in higher retail prices.

The pharmaceuticals industry sector in Ghana needs to be strengthened to provide health facilities to the people so that WHO declaration of health for all by the year 2000 can be achieved.

Even though Herbal Preparations are largely used by 70% of the population, they are not produced in industrial scale by any company for general distribution.

1.3 Current situation as regards Plant Medicine in Ghana

It is estimated that 70% of the population of Ghana is dependent on Traditional Medicine. This is largely due to non availability of orthodox medical practitioners and modern pharmaceuticals. There are about 100,000 Traditional Medical Practitioners (TMP) in Ghana practicing especially in the rural areas. Due to ever-increasing popularity of plant medicine, their numbers are on the increase. The ratio of population to TMP and to Orthodox Medical Practitioners (OMP) is estimated as 1:400 (TMP) to 1:12,000 (OMP). However, in remote rural areas the ratio is 1:70.000 (OMP) while in urban areas like Accra it is 1:4000 (OMP). In general, health services in Ghana can reach only about 30% of the population.

Traditional Medical Practitioners (TMP) are largely illiterate people carrying out their practice in highly unhygienic conditions. They acquire their skill and knowledge from relatives or through short periods of apprenticeship with already known TMP. After diagnosing the patient, they collect the raw materials from the wild and make the preparation in their premises and dispense to the patient. A large number of plant number of plant drug preparations produced in unlicensed backyard factories are sold by peddlers at lorry parks and on long distance buses. Obviously, these preparations have very low keeping qualities and due to empirical method of preparation, their safety and efficacy are dubious. Some TMP are said to collect the raw materials needed for their preparations and store them for long periods after drying.

For recognition purposes, TMP register themselves with local government authorities in every administrative district. The registration procedure is simple. Their names and addresses are recorded and each TMP is given a registration number. They are required to pay to the local government a certain amount as an annual fee. Some of the reputed TMPs have grouped themselves into three main professional associations (e.g. Ghana Psychic Traditional Healing Association, Traditional Medical Practitioners Association (TMPA)).

Recognizing the important role of traditional medicine in health-care, the Ministry of health has appointed a deputy director of health services in charge of herbal medicine only a few months ago.

"Code of Ethics" binding TMP is planned to be drafted by the Ministry of Health.

At the Center for Scientific Research into Plant Medicine (CSRPM), herbalists from all over Ghana are interviewed and their names, addresses, medical skills and preparations are recorded. Each herbalist is asked to bring along the plant drugs used in his preparations. The local names of the plants and the parts used are recorded. Then the officer in-charge of the herbarium attempts to identify the scientific or botanical name.

Research into plant medicine in Ghana is undertaken by CSRPM, CSIR, University of Ghana, Legon; UST, Kumasi, University of Cape Coast. Besides, the Ghana Medical School, Korle Bu Teaching Hospital and GIHOC (Pharmaceutical Division) are also carrying out pharmacological, toxicological, chemical investigations on Ghanaian Traditional Plant Medicine. Apart from CSRPM there are three establishments producing TDP as follows: The Complex Hospital, Nsawam; Noamesi Laboratory Ltd; Astek Ltd., Nsawam.

The Centre for Scientific Research into Plant Medicine (CSRPM) at Mampong, Akwapim was established in 1973 by the Ministry of Health to carry out scientific research for improving traditional plant medicines for ensuring purity of plant drugs, for authenticating botanical identity of medicinal plants; for cultivating medicinal plants used in Traditional Drug Preparations (TDP). Besides the above activities, the Centre also establishes contact and working relationships with the Ghana Psychic and Traditional Healers Association and other research institutions and commercial organizations. The Center also runs out patients clinic for patients seeking herbal therapy, TDP production unit and a dispensary. The clinic keeps record of each patient and disease.

1.4 Previous studies into Plant Medicine related to this Mission

There has been a renewed interest in Ghana into strengthening existing institutions engaged in plant medicine in early 1990s. Some studies have been conducted on the request of the Government to this effect. The following six documents have been brought to our attention.:

1. Project Draft titled "Establishment of a Pilot Plant to Produce drugs from Traditional Drug Preparations (TDP)." prepared by Dr.K. Bryden, Consultant contracted by the Technical Transfer Centre (TTC) of CSIR.

2. Project Draft titled "Strengthening the National Centre (Mampong) for Research into Plant Medicine."

3. Proceedings of Workshop on Strategies Towards Commercialization of Traditional Drug Preparations in Ghana, February 1 1990. (March 1990).

4. Strategy Towards Commercialization of Traditional Drug Preparations (TDP) in Ghana. Report by Prof. Xiao Pei-Gen, Consultant contracted by UNDP/TTC (CSIR), February 1990.

5. Report on Pharmaceutical Industry with emphasis on Traditional Medicine by Mr. E.O. Agbettor and Prof. A.N. Tackie, (1990).

6. Towards a rational scientific basis for herbal medicine - A phytochemist's two-decade contribution, inaugural lecture by Prof. Ivan Addae-Mensah, University of Ghana, Legon (April 1991).

1. This UNDP Project Document deals with the establishment of a Pilot Plant for the production of TDP in CSRPM. The immediate objectives are stated as:

A) To promote production of TDP on commercial scale;
B) to promote the utilization of traditional drugs and integrate them into primary health-care system;
C) to train TMP and recognize them as complementary to orthodox medicine.

<u>The expected outputs are:</u>

1) Process Technology
2) Attractively packaged drugs and
3) Trained traditional practitioners.

For output 1

A pilot plant is recommended for solid-liquid extraction of plant materials and their concentration. The figure given for process flowsheet is rather confusing and explanations given are not at all relevant.

For output 2

Attempts to achieve attractively packaged TDP, their supply to rural clinics and their dispensing by certificate holder TMP are recommended.

For output 3

An integrated medical curriculum incorporating the benefits of traditional medicine in medical schools, training of TMP in Seminars and Courses, Categorization of TMP into Traditional Medicine certificate holders, middle level personnel and practitioners equivalent to orthodox medical practitioners are recommended.

The activities to achieve the above-mentioned outputs are time-scaled according to a workplan. Total UNDP input as estimated for 1990 amounts to US$ 722.00. This includes 11 m/m of expert time, 4 m/m of fellowships and 2 m/m of study tours. Equipment component covers extraction unit, formulation unit, 2 vehicles,

spareparts and expendables. The Government inputs (in kind) envisaged in the document are follows: Pilot Plant space at Mampong, Akwapim, the Arboretum, adjoining the Centre and at Ayikuma and quality control laboratory. The project duration is for 2 years with government implementing agency being TTC of CSIR and executing agency being CSRPM. The proposed equipment component comprises 80.6% of the total project budget.

2. This project draft titled as "Strengthening the national Center (Mampong) for research into plant medicine" is also proposed as an UNDP project. The Government implementing agency is TTC of CSIR and CSRPM is proposed to be the executive agency. This two-year project envisages a UNDP input of US$ 624.000. The immediate objectives are stated as:

a) The establishment of a strong research and development facility at CSRPM, Mampong, Akwapim.

b) Building a core of trained scientists to spearhead the development of traditional medicine to the frontiers of scientific knowledge. The expected outputs are not specified but in general terms, seem to be focused on strengthening the processing, chemistry, pharmacology, toxicology and clinical departments, and well trained scientists and technologists.

A timetable of activities spread into two years is outlined. The Government inputs (in kind) are envisaged as personnel, land, buildings and transportation. The UNDP inputs include 12 m/m of local experts, 1 m/m international expert, 6 m/m of training. Equipment budget of the project covers expendable and non-expendable equipment for pilot plant, quality control and analytical laboratories, a computer system and two vehicles. The project budget amounts to US$ 624.000. The proposed equipment component comprises 95.5% of the total project budget.

3. A one day workshop titled "Strategies towards commercialization of TDPs in Ghana" was held on February 1, 1990 in Accra, Ghana. The workshop consisted of four technical sessions. After the opening ceremony, technical sessions covering topics on R&D of herbal medicine in Ghana by Dr. G.L. Boye, Director, CRSPM; overview of the pharmaceutical sector in Ghana with particular reference to Industry by Prof. A.N. Tackie, Consultant, CSRPM, "Technological problems in the pharmaceutical sector by Mr. E.O. Agbettor, Local Expert, Strategy for Commercialization of TDP in Ghana by Prof. Xiao Pei-Gen, Director IMPLAD, Beijing, China. The proceedings of the workshop were published in March 1990.

Dr. Boye in his lecture gives a general account of traditional medicine as practiced in Ghana and its role in the primary health-care. He points out that there is a need for the certification and registration of herbal drugs and the training of TMP. He also recommends legislations to be enacted for Traditional Medical

Practitioners and for the integration of traditional medicine into primary health-care. He also emphasizes the need to strengthen CSRPM.

Prof. Tackie gives an overview of the pharmaceutical industry in Ghana. According to his account there are 11 pharmaceutical companies producing generic drugs from imported granules. All raw materials, excipients and machinery are imported and the companies are able to use only about up to 50% of their installed capacity. The pharmaceutical forms produced include tablets, capsules, syrups and intravenous fluids.

Mr. Agbettor outlines the development of the pharmaceutical industry in Ghana and points out the problems and obstacles to local drug development. He emphasizes on the need of R&D of technology for the production of local drugs. As regards traditional herbal medicine, he mentions some of the problems in the development of technologies for the production of TDP. In view of the high cost of orthodox medicine, he stresses the need to put the traditional medical practice and the production of TDP on a sound footing. He also recommends the strengthening of the Centre at Mampong to enable it to continue with clinical and scientific investigation on traditional methods of treatment. Finally, Prof. Xiao gives an account of the traditional medical practices in Ghana and China. He gives a selected list of 20 plants for commercialization. He recommends strategies for achieving short-term goal, to commercialize 10-15 items in 5 years (1990-1995) and long-term goal for 15 years (1996-2010) to commercialize 80-100 TDP and their integration into Primary Health Care System. His criteria of selecting TDP include their widespread use, their safety and efficacy, easy availability of large amount of raw materials, adequate amount of scientific information to justify their industrialization, and their use in the treatment of commonly occurring diseases. He recommends that a commercialized TDP should consist of either single or at most 2-3 herbal drugs. It should be effective and safe for the treatment of commonly occurring diseases. It should be in an appropriate dosage form. It should be stable and should conform to specific standards. It should be packed well, labelled with clear and easily understandable instructions.

4. This report elaborates the points covered by Prof. Xiao Pei-Gen during the workshop held in Accra on February 1, 1990. He further emphasizes the need to establish a Department at the Ministry of Health in charge of Traditional Medicine in Ghana and proposes a 5 year development plan for CSRPM to equip it with a pilot plant and modern equipment. He estimates a total expenditure of US$ 680.000. He recommends three levels of training TMP:

1) Primary level
2) Middle level and
3) High level training

He states that only TMP with at least primary level certificates should be recognized as legal practitioners.

5. This lengthy report focuses on the pharmaceutical sector in Ghana with particular emphasis on traditional medicine. The report appears to be the result of a team work with Mr. E.O. Agbettor, Prof. A.N. Tackie and Prof. Xiao Pei-Gen as principal contributors. The report contains nine chapters and nine appendices. It is in two parts. Part One deals with traditional medicine whilst part two concentrates on aspects of orthodox medical drugs. The final chapter is devoted to conclusions and recommendations. The conclusions based on this report are the existing inadequate facilities in the delivery of primary health-care services to the people and the apparent problems brought out from the survey which inhibit the development of local resources for cost effective and efficient administration of medical services.

The report recommends:

1) Commercialization of selected TDP based on their production in a pilot plant;

2) Integration of traditional medical practice into primary health-care by training and legalizing TMP, setting up mechanisms to supervise, regulate and implement policies related to traditional medical practice.

3) Research and development should focus on basic and industrial research into herbal medicine.

4) Strengthening of CSRPM with professional staff, modern equipment and a fully furnished and equipped clinic.

6. In this inaugural lecture, Prof. Ivan Addae-Mensah gives an overview of modern scientific work throughout the world into plant medicine followed by an account of his scientific contribution to the science of medicinal plants of Ghana. Among the plants he examined, the following species are worth mentioning. They are Bridelia ferruginea (Euphorbiaceae), Cryptolepis sanguinolenta (Periplocaceae), Lippia multiflora (Verbenaceae), Zanthoxylum xanthoxyloides (Rutaceae).

Bridelia preparations lowered blood sugar levels in clinical trials in CSRPM, Mampong, Akwapim. Cryptolepis extracts eliminated malarial parasites after 5 days of oral administration in clinical trials carried out at CSRPM, Mampong, Akwapim. The essential oil of Lippia multiflora had marked antifungal, antimicrobial and larvicidal activities. It was also found to be effective against Colletotrichum coffeanum, the causative agent of coffee berry disease. The same fungus is responsible for the Elgon die-back, a disease which results in progressive death of the coffee plant from

the tips to the roots. Extracts of Zanthoxylum xanthoxyloides showed hypotensive activity, antibacterial activity and had effect on sickle cell anemia. It is being clinically prescribed at CSRPM, Mampong-Akwapim. Prof. Addae-Mensah has also worked out the chemistry of the above-mentioned species.

2. VISITS TO INSTITUTIONS

2.1 Centre for Scientific Research into Plant Medicine (CSRPM) Mampong-Akwapim.

CSRPM was established by the Ministry of Health on November 2, 1973 and given legal recognition on July 10, 1975 by National Redemption Council (NRC) Decree 344. The Founding-Director of this Centre is Dr. Oku Ampofo. The governing body of the Centre is a Council, members of which are selected from areas directly involved in or concerned with the execution and functions of the Centre or in the application of its research findings. As a functional body, the Council is charged with the following responsibilities: (1) Overall control of the Centre; (2) encouragement of the use of medically proven preparations as effective substitutes to conventional drugs; (3) advising the government on the preservation and restriction of the export and import of certain medicinal plants; (4) proper management and administration of the revenue and property of the Centre; and (5) subject to the powers and functions of the Centre, maintaining general control over the conduct of the affairs of the Centre.

From its inception, the Centre was managed by an Advisory Committee until 1976 when the first Council was inaugurated. The Council consists of a chairman with recognized qualification or experience in plant medicine or a related subject. The Chairman is appointed by the Government and 13 members. The members of the Council are (1) A representative of the National Council for Higher Education; (2) The Dean of the Medical School of the University of Ghana or his representative; (3) The Dean of the Faculty of Pharmacy, the University of Science and Technology or his representative; (4) The Chairman of the Council for Scientific and Industrial Research (CSIR) or his representative; (5)The Director of Medical Services or his representative; (6) The General Manager, Pharmaceutical Division, Ghana Industrial Holding Corporation (GIHOC) or his representative; (7) Representative of the Ghana Pharmaceutical Society; (8) two persons with special interest in plant medicine nominated by the Government, consideration to be given to traditional rulers; (9) a representative of the Ghana Medical Association; (10) a Herbalist nominated by the Government in consultation with the Council; (11) a member of the Ghana Psychic and Traditional Healers Association; (12) the Director of the Centre.

There are three committees of the Council: (1) Executive and Financial; (2) Research; and (3) Coordinating Committee for Orthodox and Traditional Medicine.

The Centre is charged with the following responsibilities: (1) To conduct and promote scientific research relating to the improvement of plant medicine; (2) to ensure the purity of drugs extracted from plants; (3) to cooperate and liaise with the Ghana Psychic and Traditional Healers Association, Research Institutions and Commercial Organizations in any part of the world in matters of plant medicine; (4) to undertake or collaborate in the collation, publication and dissemination of the results of research and other useful technical information; (5) to establish, where necessary, botanical gardens for medicinal plants; and (6) to perform such other functions as the Government may assign to it from time to time.

The Centre consists of the following Departments: (1) The Herbarium, (2) The Library, (3) Arboretum and the Farm, (4) Phytochemistry Laboratory, (5) Pharmacology/Toxicology Laboratory, (6) Microbiology Laboratory, (7) Clinical Laboratory, (8) O-P Clinic, (9) Production Unit and (10) Dispensary (Annex 2).

We visited all the above departments and interviewed the heads in charge of them. Our findings of their present activities are as follows:

2.1.1 **Herbarium:** An officer trained at UST, Kumasi in horticulture is in charge of the Herbarium. He has one assistant. He worked as an apprentice with the former Curator of the Herbarium. His functions include mainly, interviewing traditional herbalists and keeping records of their names, addresses, parts of the plants used in preparations for treating specific diseases. The specimens of the plant materials are pressed, dried and deposited in the herbarium along with their local names. Attempts are made to give appropriate botanical names with the help of published floras of the region and other books. In difficult cases, the herbarium specimens are sent to the Botany Department of the University of Ghana for identification. The staff of this department also make periodic excursions to different parts of Ghana to collect plants used in traditional medicine. Over the past 1.5 years, the staff of this Department have collected over 500 specimens of Medicinal Plants. These represent 74 families and 300 species of flowering plants. The Department has facilities for pressing and drying of plant materials and storing mounted specimens in wooden cabinets labelled according to the Hutchinson's system. The specimens are poisoned with an alcoholic solution of Mercuric Chloride to prevent infestation. The Department lacks the following facilities: plant drier for preparation of dried herbarium specimens, binocular stereo-microscope, complete set of floras for identification and computer facilities for recording and

storing of information supplied by Herbalists. The Herbarium officer pointed out that it was generally difficult to get precise information from herbalists and financial incentives were necessary to obtain information.

2.1.2 **Library:** The library was established 3 years ago. The officer in charge of the library has a diploma for Library Science from the University of Ghana. There are about 450 volumes of technical books dealing mainly with clinical medicine, pathology, and other branches of medicine. Most of the books are already out of date. Under the British Council "resale scheme" 76 volumes of books were recently purchased. Only recently subscriptions to some international journals such as Phytochemistry, the Lancet and the British Medical Journal have been realized. The library receives some UNDP and WHO publications free of charge. The library also receives book donations from the British Council, etc. Books have been catalogued according to Universal Decimal Classification Scheme (UDC). The librarian pointed out the need to acquire the latest issue of UDC for proper classification. The library has a photocopier which is heavily utilized. The library does not seem to provide literature search and abstracting service and lacks abstracting Journals.

2.1.3 **Arboretum and Farm:** The Arboretum is situated adjoining the Centre at Mampong-Akwapim. It serves as a study garden and provides a quick supply of plant parts for the clinic and scientific studies. During the year 1990, the Arboretum supplied all the dried Indigofera arrecta leaves used for the preparation of decoction for the treatment of diabetes. It also supplied 150 kilograms of dried Xylopia aethiopica as an adjuvant to the production/dispensary section. At present, 35 medicinal plant species belonging to 21 families are cultivated in the Arboretum (Annex 3).

The Centre has a farm at Ayikuma, about 45 minutes ride from the Centre, close to a main road. The farm is located in a valley and is part of Chipa Forest Reserve. 700 Acres of land have been given to the Centre. Of this, about 100 acres have been developed and planted with 13 different annual and perennial medicinal plants. A sketch of the farm is annexed. The species cultivated are Balanites aegyptica (Zygophyllaceae), Xylopia aethiopica (Annonaceae), Khaya senegalensis (Meliaceae), Gossypium arboreum (Malvaceae), Canthium glabriflora (Rubiaceae), Blighia sapida (Sapindaceae), Clausena anisata (Rutaceae), Cymbopogon nardus (Graminae/Poaceae), Lippia multiflora (Verbenaceae), Zingiber officinale (Zingiberaceae), Datura stramonium and D. metel (Solanaceae), Cryptolepis sanguinolenta (Periplocaceae) and the following leguminosae plants: Indigofera arrecta, Cassia alata, C.occidentalis and C. podocarpa.

Besides the above species, some other plants of medicinal interest have been grown with a view to multiplication and propagation. They are Croton membranaceus (Euphorbiaceae), Trema guineensis (Ulmaceae), Ocimum gratissimum (Lamiaceae). Some attempts to propagate Balanites from stem cuttings are in progress. Cryptolepis, Clausena and Xylopia plantations are performing well despite the clay soil which tends to get waterlogged during the rainy season and gets extremely hard during the dry periods. The officer in charge of the farm has a diploma in Hoiticulture from the UST, Kumasi. He has four supervisory staff and 26 workers to assist in land preparation, planting, weeding, maintenance and harvesting. A solar drier has been constructed and is partly functional. Irrigation facilities and steady supply of water appear to be limiting better production. A farm house with modest facilities is located at the entrance to the farm (Annex 4).

The Ayikuma farm serves as a main source of supply for Lippia multiflora, Indigofera arrecta, Cassia podocarpa, Cassia alata, C. occidentalis, Cryptolepis sanguinolenta to the production/dispensary section. According to the annual report of 1990, Cymbopogon nardus harvested from this farm yielded four gallons of essential oil.

2.1.4 Phytochemistry laboratory: The phytochemistry laboratory has a staff of seven including the head of the department with MSc degree in Chemistry, three assistant research officers (with BSc degrees in Biochemistry (2) and Pharmacy), one technician, one part-time assistant technician and a labourer.

Prof. A.N. Tackie works as a part-time consultant. Organizing the research activities and supervising the young researchers.

The Department did not have a working laboratory until 1987. The functions of the laboratory include extraction, isolation and identification of phytoconstituents from medicinal plants and a certain degree of quality control of TDP produced by the production/dispensary section. They can perform some qualitative precipitation and colour reactions to detect certain phytochemical groups. Tney have also attempted to carry out some semi-quantitative estimation of alkaloids using paper chromatography and titrimetry.

The facilities available are laboratory glassware, chemicals, solvents, reagents, chromatography columns, spreader, tanks and plates for thin layer chromatography (TLC), melting point apparatus, rotary evaporator, microscope, still for distilled water, fume cupboard, refrigerators (2), a filter press hand operated and an oven. Metal percolators (2, with 5 and 3.5 kg capacity, Soxhlet apparatus (2, with 1 liter liquid volume), heating mantles. The polarimeter, refractometer and two vacuum

pumps are not in working condition. The laboratory has access to some equipment in other departments/ laboratories such as freeze drier and UV/VIS spectrophotometer but both these pieces of equipment are also out of order.

This laboratory is an important department of the Centre for the development and quality control of plant based medicines. Without the identification of main active constituents of its ingredients, standardization of plant medicines cannot be achieved. Clinical trials will not be reliable if the standardization is not sustained. However, the laboratory lacks several basic equipment to carry out the essential phytochemical analyses, such as water baths, balances, pH meter, stirrers, UV lamp, filter paper, Buchner funnels, centrifuge, solvent distillation units, essential oil distillation units, adequate amount and range of chemicals. solvents, laboratory glassware, spectroscopic and chromatographic equipment. The facilities at the laboratory need urgent strengthening.

A new laboratory with benches and utilities is being created next to the existing one.

Some of the research activities of the Phytochemistry Laboratory includes the following: (a) preparation of aqueous and alcoholic extracts of various plant materials for pharmacological and clinical screening in the United States of America (USA) under the collaborative arrangement with Health Search Inc. (USA); (b) phytochemical investigation of Indigofera arrecta. This study has resulted in the isolation of a flavonoid Kaemferitrin and an unidentified one designated "IA-2". A spectrophotometric method for the standardization of I. arrecta decoction has been established; (c) phytochemical screening of Chromolaena odorata (Eupatorium odoratum) leaf which is reputed to be used for the treatment of wounds, eye diseases and infertility has indicated the presence of reducing sugars, flavonoids and polyphenols. The leaf extract showed the absence of tannins, anthraquinones, sterols and triterpenes; (d) the leaves of Momordica charantia, Alchornea cordifolia, Gossypium arboreum and Ocimum viride in the preparation of Wound Ointment-13 were screened separately for their phytoconstituents. M. charantia was found to contain saponins. Unsaturated sterols and phenolic compounds were detected in A. cordifolia. G. arboreum gave positive test for flavonoids, tannins, unsaturated sterols and phenolic compounds. O. viride reported to contain alkaloids (?), flavonoids and unsaturated sterols. (e) Further studies were carried out with the leaf extracts of Gossypium arboreum using thin layer chromatography. Three flavonoids were detected and one of these was isolated by column chromatography but has not been characterised. (f) phytochemical studies of the root bark of Croton membranaceus showed the presence of volatile oils, fixed oils, reducing sugars, flavonoids, triterpenes, polyuronides and alkaloids; (g) studies

on Cryptolepis sanguinolenta led to the isolation of cryptolepine and three other alkaloids. These studies are being pursued. These alkaloids have been found to be effective in treating malaria; (h) the stem bark of Khaya ivorensis, Kigelia africana and Mitragyna stipulosa are the major components of Mist Tonica which is prescribed as a blood tonic were screened for their phytochemical constituents. Screening showed the presence of cardiac glycosides, flavonoids, anthraquinones, reducing sugars, unsaturated sterols and iron in K. ivorensis, K. africana contained alkaloids, reducing sugars, unsaturated sterols and iron. M. stipulosa showed the presence of reducing sugars, flavonoids, alkaloids and iron; (i) phytochemical screening of the leaves of Ageratum conyzoides used in treatment of infertility showed the presence of alkaloids, flavonoids, unsaturated sterols, triterpenes and reducing sugars; (j) Heliotropium indicum. Leaf extract of this plant is also used in infertility. Phytochemical screening gave positive results for alkaloids, saponins, unsaturated sterols, triterpenes and reducing sugars; (k) Combretum mucronatum. This plant is used in the treatment of Guinea worm infection. Phytochemical screening indicated the presence of saponins, unsaturated sterols, triterpenes, leucoanthocyanins, tannins, reducing sugars and cardiac glycosides. (l) Capparis erythrocarpos leaves were shown to contain alkaloids and saponins; (m) Diodia scandens had cardiac glycosides, saponins, leuco-anthocyanins; (n) Erigeron floribundus was found to contain saponins, sterols and reducing sugars. Besides the above-mentioned plants screened in 1990, they have carried out further work on Cryptolepis sanguinolenta roots and examined Trichisia gletii, T. patens, T. microphylla roots and root bark and found 1 % alkaloids. Stembark of Alstonia boonei has also been subjected to phytochemical analysis. These plants are reputed to have antimalarial activity.

2.1.5 Pharmacology/Toxicology Laboratory: This laboratory is managed by the Director of the Centre and supported by two research assistants. The laboratory has the following facilities: Metabolic cages for rats (10 pieces), flame photometer, experimental animal weighing balance (2, one is faulty), centrifuge, glucose analyser, thermoregulator (water-bath), analgesymeter, tail flick test equipment, activity cage, E.C.T. (Electro Convulsive Treatment) unit, B.P. (Blood Pressure) recorder are in good working condition. Hot plate and single-beam non-scanning spectrophotometer are not in satisfactory condition. The freeze dryer is out of order. There is no animal house and experimental animals such as rats, mice, guinea pigs and rabbits are obtained when necessary from Nogouchi Memorial Institute for Medical Research of the University of Ghana, Legon. The laboratory carries out some pharmacological studies to test diuretic, analgesic, antipyretic, antidiabetic and antiallergic activities. Toxicological studies include acute and subacute toxicity and skin sensitization tests.

Some of the research activities undertaken by the laboratory are as follows: (a) Acute toxicity studies of a herbal soap brought to the Centre by a herbalist, on male albino mice were carried out after intraperitoneal administration. The study established the short term toxicity and gave an LD50 1000+/- 106 mg/kg; (b) skin sensitization test with Krobea Herbal Cream was conducted using rabbits. The cream contains Cassia alata and Alchornea cordifolia. The herbalist Mr. Krobea uses this cream for managing the following skin conditions; rashes, scabies, ringworm and pimples; (c) Analgesic and antipyretic studies of the ethanolic extract Capparis erythrocarpos (Capparidaceae) used in the treatment of joint pains showed the expected activity. The effective median dose was found to be 800 mg/kg; (d) Diuretic effects of Diodia scandens and Erigeron floribundus were studies using male albino rats. The studies revealed that both the species had some diuretic action; (e) studies on antidiabetic studies of Indigofera arrecta using experimental rabbits. Effect of the plant extract on Fasting Blood Glucose (FBS) and its response to glucose load were investigated.

With the existing facilities at the laboratory there are constains in carrying out appropriate pharmacological/toxicological follow up studies of reputed herbal preparations.

2.1.6 **Microbiology Laboratory**: This laboratory has been set up quite recently with two researchers with background training in clinical microbiology and general microbiology. One of the researchers is expected to carry out antimicrobial screeing of herbs and the other researcher will be largely involved in clinical microbiology. At present the laboratory has very limited facilities with a 20-Liter capacity autoclave, 20 petri dishes, an improvised incubator and a water bath. Stains, mediums and some reagents are available. They lack a good high resolution microscope with oil immersion lenses. They also need a sterile inoculating cabinet, a good set of incubators and adequate consumables and laboratory ware.

2.1.7 **Clinical laboratory**: This laboratory has been functional for the last three years under the supervision of a medical technician. The other supporting staff consists of one technician, two assistants and a laborer. Total staff strength is five. They carry out clinical tests on out-patients. They examine blood, urine and stool. Blood tests include HB, PCV, WBC-totals, WBC-differential counts, BF, ESR, FBS, Glucose tolerance test, sickling test for sickle cell anemia. If this test is positive, HB genotype examination is conducted by electrophoresis. Urine analysis consists of the examination of protein, sugar, bile salts, bile pigments and urine deposits. Routine stool examination involves ova and parasites of infecting organisms. About 25 upto max. 40 tests are carried out per day and the results are made available the same day for diagnosis. At present the following facilities

are available: Haemocytometer, Binocular microscope (one lens defective), centrifuge (very old), colorimeter (for sugar), oven, centigram balance (not working properly), paper electrophoresis outfit.

2.1.8 The Clinic: The clinic is conducted by a orthodox medical doctor. The founder of the Centre Dr. Oku Ampofo works as a clinical consultant. The out-patients clinic (OPC) consists of a records unit, nursing unit, clinical laboratory (described above) and the dispensary. The record unit maintain records of patients' attendance to the clinic. 40-50 patients a day (80 on mondays and thursdays) are examined by the clinician who treats between 10-20 diseases. He always prescribes the preparations produced at the Centre. In some cases he also prescribes antibiotics to support the treatment. There is no X-ray equipment. When necessary patients are directed to a nearby hospital for X-ray. For the examination and treatment, a patient is charged a nominal sum not exceeding Cedis 400 (=US$ 1). According to the statistics kept at the clinic, in 1990 a total of 16.186 patients visited the centre. 35% of them came from the Eastern Region, 25% from Greater Accra, 20% from the Ashanti Region, and 2% from Overseas. During the same year the following diseases were treated: Rheumatism and joint pains (36000 cases), Hypertension (2400), other heart disease (2100), malaria (1800), diabetes (1440), sickle cell disease (600), piles (600), asthma (480) and other cases (1200). Cases like hernia, tuberculosis, abscess and eye diseases (approximately 20 a month) were referred to the appropriate hospitals. Apart from the two doctors the clinic has a staff of 20 including nurses (8), registrar (4), dispensing technicians and general purposes staff (2).

2.1.9 Production Unit: This unit functions in close collaboration with the Herbarium and Arboretum, and is also linked to the dispensary. The production section is responsible for the collection of medicinal plant parts from the fields, the preparation of herbal preparations and their dispensing. 17 people work in the production unit. There are four senior staff members. Research officer is a botanist with a MSc degree from the University of Cape Coast. The chief technical officer is an experienced and registered herbalist with a good knowledge of medicinal plants and preparations. The assistant research officer holds a BSc degree. The technical officer has a diploma certificate from the University of Cape Coast. In addition to this staff members there is one herbalist consultant and three senior assistant herbalists. The rest are laborers. The production unit has the following facilities: solar dryer and two hot air electric dryers, two grinders, two stainless steel stirred vessels (48 gallons each) for mixing. Drying and grinding is done in the main building. The dried powdered plant material is then transported to a nearby shed and makeshift building for extraction. They have 5 large (100 L) and three small(50 L) cast iron cauldrons. The dried

and powdered plant parts are weighed and loaded into the cauldrons and appropriate volumes of water is added. The cauldrons are heated using fire wood on open fire and boiled vigorously for one hour. Then the cauldrons are taken into a room, covered with a wooden lid and cooled overnight. The next day the extract is decanted through a wiremesh sieve into 20 L carboys. These are then brought back, labelled and stored in the Dispensary and treated with Spiritus Chloroformi to prevent microbial contamination. Ordinary pottable water is used in the preparation of the extracts. Besides decoctions, powders, balms and ointments are also produced for specific ailments. Palm oil, sheabutter, vaseline and lanolin are used in the preparation of balms and ointments (See Annex 5 for formulations). At present, for quality control there is very little facility. Only total solid content is measured.

2.1.10 Dispensary: The preparations produced by the production unit are dispensed in the containers provided by the patients according to the prescription issued by the clinical department. The containers are labelled with the name of the preparation and instructions for its use. Overall, the dispensing of liquid preparations appears unhygienic and unsatisfactory due to probable contamination of the containers (glass bottles or plastic containers). Patients bringing used wine and liquor bottles seem reluctant to remove the original labels and this may cause some confusion and accidents at home. Some patients bring the container of a previous lot for obtaining a fresh drug preparation and the new label is fixed on top of the old one or near it. This may also cause confusion. It is advisable to dispense them in standard sterile glass bottles.

2.1.11 Planned expansion: CSRPM covers an area of 7650 sq.m in Mampong-Akwapim . The place is on Aburi hills at an altitude of ca. 250 meters. Total area covered by the existing building is 4432 sq. meters. The Centre has planned expansion to accommodate a clinic for in patients, pilot plant, production units, boiler house, animal house, residences and a guest house.

As early as October 1979, Herzog-Hart Corp. (USA), an industrial consulting firm was commissioned to prepare an engineering report for pilot plant and boiler facilities at the Centre. The Company produced the report in February 1979, which included recommendations for (a) boiler room and equipment; (b) bench scale/laboratory pilot plant; (c) main pilot plant comprising (1) preparation department, (2) extraction department, (3) product separation and refining area, (4) tablet production area, (5) liquid pharmaceutical products area. The report recommended two 50 horse power oilfired boilers capable of producing 600kg/hr of steam at 10.5 kg/cm2 hot water heater and air compressor facilities (150 psig) each. it would also have water softener, deionizer. A cooling tower system was also included in the package. An

incinerator was also proposed for the disposal by burning of the rubbish, waste paper, wood sweepings, medical waste, animal etc. and solvent rich waste from the carousel extractor, but it was also pointed out that this would represent a potential explosion hazard. Electrical wiring and controls, sprinkler system and safety equipment, utility piping would also be installed.

Bench scale/laboratory pilot plant included the following: (1) Bench scale rotary dryer: chain driven tube dryer with pressure blower, electric air heater and cyclone dust collector equipped with a solid state variable speed feed system, internal conveying flights and a discharge receiver. Rotating cylinder and cyclone dust collector would be type 316 S/S. Capacity would be 2.25 kg/hr of cellulose acetate. This continuous feed drum dryer was recommended for the drying of plant materials prior to processing; (2) Turbo mill; electrically driven laboratory turbo grinding mill with inside milling chamber of 130 mm , with variable size milling rotors, stators, screens, sleeves and associated equipment. The unit would be suitable for use as a turbo mill, inclined bar mill, cross beater arm mill or pinned disc mill for grinding of dried plant materials; (3) 10 liter cooker with hinged or lift off flanged lid, double jacket for electrical heating, cooling device, mixing systems, all parts of 304 S/S; (4) filter press: plate or frame filter press of 309 S/S on wheels with 11 S/S plates feed pump and motors. (5) Solid /liquid extraction unit: The unit includes semirotary hand pump, reboiler, condenser, conducting vessel, pipes valves, flanges, support frame, etc. This unit is used for extraction of plant material with a solvent. (6) liquid/liquid extraction unit: This continuous type unit (type not specified) with 20 liter capacity consisting of solvent feed and solution feed vessels, semi-rotary hand pump, condenser, contactor and inter-connecting pipe work. This unit is used for purification of liquid extracts; (7) essential oil still: This is not in fact a unit for distillation of essential oils from aromatic plants but a 20 L glass fractionation equipment to work under-vacuum for the fractionation of essential oils. It has a distillation column (dimensions not specified) packed with glass rashig rings with reflux distributors, condenser, reboiler and receivers; (8) Distillation unit: A bubble cap distillation column for continuous operation with 20 L reboiler, condenser, cooler, centrifugal feed pump. This unit can be used for fractional distillation of solvents and essential oils for rectification; (9) climbing film evaporator: This glass unit was intended for the quick evaporation of the solvent under vacuum. It has maximum evaporation capacity of 15 kg/hr at slightly reduced pressure (650 mm Hg); (10) process reactor: 25 liter capacity, 316 S/S Jacketed, stirred reactor. It works under vacuum but the system lacks condensers for reflux; (11) crystallizer: This glass unit is intended for the crystallization of solids from saturated solution by evaporation of the solvent under vacuum. The unit consists of a feed-tank, hand-pump set, liquid container and various types of filter bags. Process capacity

0.2 to 2 kg. Main Pilot Plant would consist of the following five areas: (1) Preparation department; (2) extraction department; (3) separation and refining section; (4) tablet production department; (5) liquid pharmaceutical production department. The building would be fitted with electrical work, sprinklers, pipe racks, building safety equipment, ventilation, utility piping etc. Steam, demineralized water, softened water, hot water cooling tower and air would be provided to all the departments. (1) The preparation department consists of equipment necessary to prepare plant materials for pilot plant processing. This includes chopping, removing moisture by hot air or freeze drying, granulating, flaking, etc. For peeling of plant material an abrasive disc peeler of 10 kg/min. Capacity was recommended. Peeled material would be chopped in a heavy duty vegetable cutter/slicer and the material would be dried either via hot air drying or freeze drying. For cutting and slicing a S/S or aluminium four entry vegetable cutter and slicer of 10 kg/min. capacity was recommended. A universal mill and flaking machine was also included for grinding of roots, barks, etc. Two refrigerated rooms are recommended in the report for drying heat sensitive products. It is understood that this rooms would be used for freeze drying. Each room would have a capacity of 2.5 tons of refrigeration. For grinding 500 kg/hr capacity electrically driven universal mill is proposed with various size cutting blades and screens of stainless steel wire mesh. Flaking stand comprises an electrically driven roller mill with a capacity of 600 kg/hr to produce 0.25 to 0.3 mm thick flakes.

(2) Extraction Department has the following equipment: 250 L S/S pressure cooking stirred vessel for dissolving, mixing, extraction, precipitation, cooling, melting and emulsifying as stated in the report. (b) The extraction marc is pressed via an electrically driven medium pressure hydraulic press which can also be used to extract juice or liquor from fruits, seeds or boiled roots. The capacity of the press is 300 kg/hr with variable compression ratios. (c) Carousel extractor is recommended for solid/liquid extraction. This is a multistage continuous extraction unit with a daily put of 200-600 kg. It comes with 6 counter current and 1 filtration stages. According to the report the unit has no desolventizer. This definitely creates environmental hazard and safety problems. (d) Glass line reactor: This 350 L glass lined reactor with heating jacket and stirrer is understood to be intended for chemical reactions such as derivatization or semi-synthesis.

(3) Production, Separation and Refining Section comprises the following equipment: (a) 250 L glass lined steel reactor with condenser,receiver, impeller type agitator (b) 100 L fractional distillation unit. Glass apparatus with bubble cap column (12 plates) complete with reflux divider automatic controls, feed-storage vessel (2000 L), etc. (c) 115 L Essential oil still for

distillation of essential oils from aromatic plants. The unit consists of a 115 L steam heated still, condenser, separator/receiver and a funnel with a return pipe to the still. In this form the unit can only be used for hydro-distillation. Steam injection facility is not mentioned. (d) centrifugal extractor: One multistage S/S continuous current centrifugal extractor is recommended for liquid/liquid extraction. 1 gpm capacity per operation is indicated. (e) Thin film evaporator is recommended for the rapid evaporation under vacuum of heat sensitive liquids. It is capable of evaporating 50 kg/hr at 50°C. (f) spray drying unit: A standard spray dryer (capacity not mentioned) is recommended for spray drying of liquid extracts. The unit being non-explosion proof is advised to be set up outside the pilot plant area. (g) crystallizer: This rocking cradle crystallization equipment consists of a 270 L agitated steam heated feed tank and a 3 meter long x 30cm wide rocking cradle cystallizer with other necessary accessories, (h) vacuum pot filter: This S/S unit consists of an upper pan (25 L) with perforated plate suitable for use of paper or cloth placed on the support mesh and lid with flanges, and a lower pan (40 L) with a bottom outlet pipe, etc. It works either by gravity drainage or by vacuum. (i) chemical pumps.

(4) Tablet Production Area has the following items: (a) tray oven dryer: Electrically heated dryer with tray capacity to meet all production requirements of 2000 to 4000 tablets per batch (Tablets are max. 22mm in diameter), (b) Drum mixer: Unit handles standard drums of a approx. 61 cm diameter and provides uniform dispersion of dry materials in any standard drum; (c) Mixing machine: 0.6 cubic meter batch mixer with paddles. This horizontal paddle type mixer is fabricated in stainless steel and is of approximately 56 L capacity for the intimate mixing of dry or moist materials; (d) Granulating machine: This S/S equipment is capable of processing 10-15 kg per batch and is suitable for all types of size reduction, pulverizing, blending and dispersion; (e) Sieving machine: Electrically driven sieving machine is constructed with a S/S hopper and interior complete with 20 pieces of various sizes of changeable S/S meshes; (f) Tablet press: Single-motion single-punch compacting machine to produce tablets up to 22 mm with a maximum speed of 85 strokes per minute; (g) Fluid bed dryer: Capable of drying 10 kg of material; (h) Tablet coating machine: The unit is a 40 cm diameter S/S coating pan driven with a variable speed drive and a hot air blower; (i) Tablet counter and filling machine: Capable of counting batches 1-1000 and handles any standard size or shape of tablet or capsule up to 16 mm (Note: The tablet machine recommended is capable of producing tablets up to 22 mm diameter) It can fill 2500 tablets and 2000 capsules per minute.

(5) Liquid Pharmaceutical Production Unit possesses the following equipment: (a) Bottle washing machine: The package consists of a cabinet-type washer and separate cabinet-type dryer with observation windows. (b) Mixing vats: Three mixing kettles with 250 L capacity each are made of 304 stainless steel. Each vessel is equipped with lids, valves, and agitator braces. (c) Vertical leaf filter: 40 cm standard, non-jacketed, horizontal plate, sparkler filter to take cellulose filter media complete with S/S pump and motor; (d) Liquid filling machine with conveyor: Four pump volumetric filler for liquids and syrups. Fully automatic with conveyor, motor and pumps; (e) Scales: Platform type scale to weigh up to 5 kg (2 pieces); (f) planetary mixing machine is a 60 liter mix unit, jacketed with mixer and homogenizer. (g) Ointment filling machine: Consists of two pumps capable of filling 1200 units per hour with a container size range.

In February 1979, cost estimation by the company amounted to US$ 1.908.900 which includes engineering, equipment, installation, shipping, insulation, wiring, piping and fee. Equipment cost was estimated as US$ 934.400. In 1982, cost estimation by the consulting firm reached US$ 6 million.

The range of equipment recommended in the report for the prescribed processes has a variety of shortcomings. (1) The bench scale/laboratory pilot plant and the production pilot plant have no weighing facility and loading/unloading device for the plant material and for the extraction mark, (2) The bench scale/laboratory pilot plant does not include a steam distillation unit for the distillation of essential oils from plant materials, (3) Quite unnecessarily, two fractional distillation units with two different column packings are included. Instead of having two fixed capacity (20 L) fractionation unit, it is more advisable to have one unit with a more effective packing material and variable volume capacity. (4) Drying of chopped fresh material could easily lead to enzymatic degradation, hence spoilage. No detailed specification is given for hot air drying facility. Freeze drying, on the other hand, can be recommended not for the chopped plant materials prior to processing but for heat sensitive aqueous extracts or plant juices. (5) Carousel extractor would allow only one type of extraction, that is continuous percolation. No other manipulation is possible. Moreover, since no desolventizer is included, solvent loss will be considerable. It is suggested in the report that the solvent rich marc can be disposed off by incineration. This is not only uneconomical but would create environmental and safety problems. (6) Several reactors are recommended without explanation for their use. (7) The crystallizer recommended for the production unit is not deemed necessary for the type of unit processes planned in the production area. (8) In the tablet production unit, tablet punches for upto 22 mm dia. tablets are recommended, however the proposed tablet filling machine can only handle tablets of upto 16 mm diameter. (9) All in all the

equipment suggested cannot fully meet the needs of a pilot plant processing unit. A pilot plant of a research laboratory should be capable of carrying out at least a few unit processes, in other words, it should be multifunctional. (10) The pilot plant and other units occupy unnecessarily large space area.

2.2 Ministry of Health

In the Ministry of Health, we first visited Dr. K. Appieh-Kupi, Deputy Director of Health Services (Herbal Medicine). He gave information of his programme and activities. He has been in the office since March 1991. He is keen on uniting all herbal practitioners, numbering about 100.000, to form the Ghana National Council of Herbal medicine. He plans to coordinate the efforts of all research institutions dealing with medicinal plants in the country. He has commenced the registration of herbal practitioners by recording their name, address, age and specialization (only up to 5 diseases). He wants to categorize herbalists into their respective specialization fields. Each herbalist registered is given a certificate by his Department. He plans to organize local workshops, seminars and training programmes to upgrade their skills and to give them simple basic scientific information. He also recognizes the important role of the Centre at Mampong-Akwapim for the promotion of herbal medicine on a scientific footing.

We then visited Dr. A.R. Ababio, the Vice Minister of Health. He expressed the enthusiasm of his Ministry in promoting herbal medicine in Ghana and said that his Government would support all efforts to strengthen the Centre for Scientific Research into Plant Medicine. He reiterated his Government's wish to equip the Centre with appropriate activities for research into herbal medicine in Ghana with the help of international experts.

2.3 Pharmacy Board

The Pharmacy Board was established in 1961 according to "Pharmacy and Drugs Act". The Board consists of nine members. The Chairman is the Director of pharmaceutical Services at the Ministry of Health. Vice-chairman is the Dean of the Faculty of Pharmacy, UST, Kumasi. The other members are as follows: Representative of the Director of Medical Services at the Ministry of Health, Legal Advisor from the Ministry of Justice, representative of the Ghana Medical Association, a Physician appointed by the Minister of Health, Three members of the Pharmaceutical Association of Ghana.

The Board is charged with the task of regulating all issues related to pharmacy practice; control, registration, sale and transport of pharmaceuticals in Ghana. The Board meets once a month.

The Pharmacy Board is planning to divide its function and responsibilities into "Pharmacy Council" and "Drugs, Cosmetics and Poisons Commission". A legislative bill has been drafted to this effect.

According to the information supplied by the Registrar of the Pharmacy Board, no herbal preparation has been registered to date. Registration of generic drugs used in orthodox medicine is affected by submission of a file to the Pharmacy Board. If the Board ratifies it then a certificate for its production is issued to the applicant - The applicant has to re-register the preparation with the Ghana Standards Board.

The Pharmacy Board jointly with the Deputy-Director of Health Services (Herbal Medicine) and CSRPM has established a Technical Committee to draw up regulations for the registration of traditional herbal preparations. In one of their recent meetings, the Committee recommended that priority in registration should be given to dosage forms for oral, rectal and topical preparations. In the long run, the Board expects CSRPM to act as a drug control laboratory for herbal preparations. Registration procedures for herbal preparations is expected to be legalized under the already drafted "Drug, Cosmetics and Poisons Act".

The Board recognizes the importance of traditional herbal preparations in the health-care and takes a positive stand for their registration provided they conform to scientific rationale and scrutiny. The registrar was concerned about the reluctance of many herbalists who want to register their herbal preparation without disclosing the ingredients and the method of production. He does not favour the registration of such preparations. He also pointed out that there was so much disunity among the traditional medical practitioners in Ghana and the newly appointed Deputy-Director of Medical Services has been working towards registering all the TMPs so that some measure of control could be exerted on them by the Ministry of Health.

2.4 Ghana Standards Board

Like in many other countries, the Ghana Standards Board is charged with the function of maintaining standards of products and techniques in the country. The Board consists of an administrative section and a technical section comprising four divisions which looks into the aspects of quality assurance, standards development and metrology. The laboratories have trained personnel and necessary equipment for chemical, physical and microbiological

analysis of foods, drugs, cosmetics, agro-chemicals and other products marketed in the country. The Board has a total staff strength of 330.

A drug approved by the Pharmacy Board has to be analysed at the Ghana Standards Board laboratories before release for consumption. The Board also carries out periodic or random checks on factory premises and on products collected either from the factory or retail outlets.

2.5 Ghana Export Promotion Council

Ghana Export Promotion Council promotes the export of indigenous raw materials and products. The council keeps a record of the total volume and the value of exported goods. As regards medicinal plants there are 12 private companies exporting them. The biggest single consignment exported by any company is about 30 tons and in 1990 the total export value of medicinal plants was US$ 64,000. Major importing countries of Ghanaian medicinal plants are Germany, Belgium, UK, USA, Gambia and Liberia.

Since 1986 onwards, the export values of plant drugs in US$ are as follows: 19.000 (1986), 29.000 (1987), 85.000 (9188), 443.000 (1989), 64.000 (1990).

The Council in recognition of the potential of the medicinal plants of Ghana has compiled a list of Ghanaian plants with export potential. The survey was conducted by the Botany Department of the University of Ghana. A list of 27 plants recommended is given in Annex 6.

At present seeds of Voacanga africana, Griffonia simplicifolia, Gloriosa superba, Azadirachta indica, Physostigma venenosum, roots of Rauvolfia vomitoria, frozen arils of Thaumatococcus daniellii are major export items. These will continue to be in demand and it is expected that the volume of many of the above items and other medicinal plants will increase. During our survey, it was only possible to obtain information on the export volume or value of a few medicinal plants. Griffonia seeds were once exported with and estimated 75-80 tonnes per annum to Germany. A lectin isolated from these seeds is claimed to be useful in blood grouping tests.

The frozen arils of Thaumatococcus daniellii are exported by Forestry Enterprises Ltd to a leading sugar manufacturer in UK for the extraction of a protein-based sweetener called Talin.

2.6 Botany Department, University of Ghana, Legon

The Herbarium of the Botany Department is housed in an air-conditioned building and contains over 80,000 mounted specimens of plants from the West African Region and also from other parts of the World. The Herbarium is arranged in the phylogenetic system of Hutchinson and curation is under the supervision of Mr. D. Abbiw who is the author of the recently published book entitled "Useful Plants of Ghana" (1990). According to his estimate 5 to 6 thousand species of flowering plants representing about 200 families occur in Ghana. 300 of these are woody species with two endemics, namely Talbotiella gentii (Leguminosae) and Pandanus abbiwii, named after him. He also estimates the number of herbaceous plants, shrubs and lianes as ca.4000.

The Botany Department has been involved in two recent projects, namely "Herbs of Ghana project" supported by CSIR and a more recent study of the "Medicinal plants of Export Potential from Ghana". Both the projects have been completed and the manuscripts are awaiting publication. The latter has been presented to the International Trade Centre (ITC), UNCTAD/GATT for review and publishing. In this project, 27 medicinal plants were identified (Annex 6).

2.7 University of Science and Technology, Kumasi

Faculty of Pharmacy

The only Faculty of Pharmacy in Ghana has 270 students and conducts a four year diploma course. The Faculty admits 80 students each year and has 12 post graduate students leading to MSc. degrees. There are 22 teaching staff of which four are professors. The Dean of the Faculty is represented in the Council of CSRPM and the Pharmacy Board. Jointly with CSRPM, the Faculty has recently completed a Herbal Pharmacopoeia which is now being edited for publication.

The Faculty has limited number of analytical instruments which are located at the Central Instrumentation unit, and some pharmacological research facilities including a modest animal house for teaching and research purposes. The central library of the University receives abstracting journals such as Chemical Abstracts and Biological Abstracts and some related scientific journals. Like many higher educational institutions in developing countries, the Faculty has constraints in procuring instruments, chemicals and scientific literature. The Faculty has access to spectroscopic equipment such as UV, IR and NMR (60 MHz) which is out of order and chromatographic techniques such as TLC and GC (broken down).

Main research activities in the faculty are centred around medicinal plants and herbal preparations brought by herbalists. The Faculty maintains good relations with the herbalists and has plans to develop training programmes for herbal practitioners. The Faculty collaborates with CSRPM.

2.8 Ministry of Industry, Science and Technology (MIST)

We had discussions with Dr. A. Ata, Chief Director of Ministry of Industry, Science and Technology (MIST) concerning the development of herbal pharmaceuticals in Ghana. He was very enthusiastic about this project and assured his Ministry's full support for the establishment of a Pilot Plant at CSRPM, Mampong-Akwapim and the provision of quality control facilities to ensure the production of standardised extracts from medicinal and aromatic plants of Ghana.

2.9 Council for Scientific and Industrial Research (CSIR)

The Council for Scientific and Industrial Research (CSIR) was established in its present form in 1968, but it has a history dating back to 1958.

The statutory functions of CSIR include, among others, to advise the Government on scientific and technological advances likely to be of importance for national development. The Council also encourages scientific and industrial research for the development of nationally important sectors such as agriculture, medicine, industry and technology. It coordinates research in all aspects in the country.

Currently, the following research institutes and projects have been controlled and coordinated by CSIR:

(1) Animal Research Institute, Achimota; (2) Building and Road Research Institute, Kumasi; (3) Crop Research Institute, Kumasi; (4) Food Research Institute, Accra; (5) The Institute of Aquatic Biology, Accra; (6) Industrial Research Institute, Accra; (7) Oil Palm Research Centre, Kumasi; (8) Scientific Instrumentation Centre, Accra; (9) Soil Research Institute, Kwadaso, Kumasi; (10) Water Resources Research Institute, Accra; (11) Ghana National Atlas Project, Accra; (12) Herbs of Ghana Project, Legon.

CSIR has a total staff strength of 4500 . Of these about 200 are research workers while over 400 are supporting technical personnel. The rest are administrative staff and supporting labour force. We first payed a courtesy call to the Secretary General's office and met Dr. M.A. Odei, Acting Secretary General and Mr. J.T.G.B. Acquah, Deputy Secretary General, then we visited the following research institutes:

2.9.1 Scientific Instrumentation Centre

This Centre was established with UNDP/UNESCO assistance for the repair, maintenance and calibration of scientific instruments used in schools, Universities, research institutes and hospitals. In the initial phase twelve years ago, Glass Blowing Unit and Calibration Laboratory were established, later Electronics Instrumentation Repair Unit and Mechanical Workshop were added. All these units complement each other. Six graduate scientists and engineers and 35 technicians work in the Centre.

The Glass Blowing Unit has equipment for the repair and manufacture of standard laboratory glassware and small glass apparata. The unit supplies large number of glassware to school laboratories and CSRPM. Glass tubes, ground joints and stopcocks are imported. The unit is capable of producing separating funnels, condensers, flasks, pipettes, burettes, test tubes, etc.

The Mechanical Workshop has turning, welding and carpentry facilities and is capable of producing a range of improvised spare parts for a variety of equipment. The Scientific Instrumentation Centre can supply the necessary laboratory glassware to CSRPM. The Glass Blowing Unit is capable of manufacturing some specialized bench scale glass equipment, such as volatile oil content determination apparatus and distillation units, when designs are provided.

2.9.2 Industrial Research Institute (IRI)

This Institute is also located in the premises of CSIR. It has four major divisions, namely chemistry, engineering, materials and techno-economics which are supported by a general administrative division.

The Chemistry Division conducts research generally in industrial chemistry with the objective of developing appropriate technology for the use of local materials in finding local substitutes for imported raw materials. The Chemistry Division has a laboratory with basic facilities for wet chemistry. The Institute has designed a simple field distillation pilot plants using steel barrels. This wood fired still was used for experimental distillation of citronella grass. If the Division is to expand its activities into the area of essential oils, it has to be equipped with a gas chromatograph for the quality control of essential oils. The Division also conducts research into production and use of biogas from organic waste.

The Engineering Division carries out various activities such as development, design, manufacturing and distribution of appropriate machinery and equipment for the promotion of small scale industries in both urban and rural areas. The Division has metal, turning and foundry workshops and is capable of manufacturing small mild steel and aluminium equipment for processing plant materials if adequate designs are provided. The division lacks stainless steel welding facilities but this capability can be easily created by the provision of stainless steel material and argon welding equipment.

Besides the above-mentioned division, there are two more Divisions conducting research into development of locally available raw materials for metals, ceramics, refractory and plastics. The Techno-economics Division carries out economic surveys, feasibility studies, project evaluation and costing of prototypes. The Division organizes training programmes and workshops for local craftsmen and small scale industrialists.

2.9.3 Food Research Institute (FRI)

The Food Research Institute was established in 1963 and started operations in 1965 with the assistance of UNDP/FAO. This project lasted for five years. After 1970, the Institute became a part of CSIR and is managed by a Board.

The major objective of this Institute is to carry out and coordinate programmes of applied research into the storage, processing, preservation, marketing and utilization of food.

FRI has a staff strength of 186 including 35 scientists and engineers comprising four PhDs and 28 MScs, 40 technical staff, and supporting administrative personnel and laborers.

FRI has basic facilities for carrying out laboratory and pilot scale processing of food materials. Except for thin layer chromatography and ultraviolet spectroscopy no other chromatographic or spectroscopic facilities are available. The library has about 3000 volumes of books and a wide range of back issues of international journals dealing with food science. In recent years, subscription to journals has not been realized.

FRI offers consultancies and training services to local food industries. The Institute has a pilot plant facility close to the University of Ghana at Legon and has started marketing a range of processed foods for local consumption, such as Gari, Cassava flour, Soybean meal, etc. One of the paramount successes of the Institute has been an improved fish smoking kiln, FRI-Chorkor smoker rated as the best fish smoking oven in Africa.

The Institute is not at present engaged in research into food flavouring and colouring. It has developed a simple and easily fabricated solar drier. This dryer has also been used by CSRPM for drying harvested plant drugs at the arboretum and the Ayikuma farm.

2.9.4 Forestry Research Institute of Ghana (FORIG), Kumasi

Main function of this research Institute is in the areas of timber utilization, silviculture and management of natural forests. Recently, an agro-forestry department has been established. The Director in charge is in the process of drawing up a programme of activities. We were interested to hear if it was possible to incorporate the cultivation of medicinal plants in the different forest zones of Ghana. It is also possible to encourage the harvesting of barks and other plant parts during logging operations with local people's participation. This again would augment the supply of raw materials for herbal preparations and would also generate employment in remote areas. It is recommended that CSRPM should explore the possibility of obtaining raw materials from the Forestry Department and to encourage them to cultivate medicinal plant species as an intercrop. This will ensure a steady supply of plant materials when the production of extracts is scaled up.

2.9.5 TECHNOLOGY TRANSFER CENTRE (TTC)

The above Centre was established in 1981 as a policy research Centre and was under the Ministry of Science and Technology. In 1982 it was brought under the Council for Scientific and Industrial Research (CSIR) which is the statutory institution which co-ordinates R & D activities in Ghana. The Centre became fully operational in July 1988 when UNDP decided to strengthen this Centre.

The staff of TTC consists of a multi-disciplinary team drawn from various disciplines such as law, economics, engineering and sociology. Supporting staff assist the centre's activities and has in addition a computing unit and will have a technology information database.

The Centre's main functions are gathering of information and co-ordination of technology transfer activities. The Centre advises the Government on the technologies appropriate for national needs without causing major environmental problems. It catalyses the adoption of imported technologies to harness the available natural and human resources. Some of the Centre's current programmes include appropriate technology in important areas such as Food Processing, Energy, Capital Goods, Pharmaceutical and Small and Medium Scale Enterprises (SME). The Centre has recently organized a workshop on strategies towards commercialisation of traditional drug preparations and contracted a consultant to prepare project documents concerning the establishment to produce

drugs from plants and for strengthening of CSRPM, Mampong-Akwapim. These have been reviewed by us in this report under the heading "Previous Studies on Plant Medicine related to this Mission".

The Director of TTC. Dr. M.N.B. Ayiku has expressed concern regarding the establishment of a pilot plant and considered it as a proper means of technology transfer.

2.10 GIHOC Pharmaceutical Company Limited

GIHOC Pharmaceutical Company Limited is the only state owned and the biggest pharmaceutical company in Ghana. After an initial period of uncertainty, the factory became operational in early 1970s. Recently with technical and financial assistance amounting to 26 million DM from the Republic of Germany a modern tablet and capsule production plant was installed and commissioned in the Dome district of Accra. This new facility conforms to GMP regulations fully and is the only pharmaceutical plant of its kind in Ghana. The Company employs 500 staff in two production plants. GIHOC produces 46 different generic drugs in 73 pharmaceutical forms. The Company imports all the raw materials including the packaging materials. It produces finished products in retail and hospital size packages. The Ministry of Health is the single largest customer of GIHOC and takes up 65-70% of the total output of the factory.

In recognition of the important role of herbal medicines in the health care, GIHOC is interested in developing herbal medicines in collaboration with CSRPM. The General Manager of GIHOC, Ms. J.R. Onny indicated her willingness to undertake industrial production of herbal preparations tested and developed by CSRPM through pilot scale operations. The Company envisages the manufacturing of herbal products in appropriate dosage forms for use at the Centre and within the country. GIHOC also plans to cultivate medicinal plants with industrial potential in herbal farms to be established in suitable bioclimatic zones of the country.

2.11 Forestry Enterprises Limited

Mr. A.A. Enti who worked for many years as a chief Herbarium technician and a plant collector at the Botany Department of the University of Ghana is a very knowledgeable and enterprising person. After retirement, he set up his own private exporting company called Forestry Enterprises Ltd. He supplies on request the following: (a) Pressed herbarium specimens complete with flowers/fruits and labels to researchers and international Herbaria. (b) Dried medicinal plant materials for phytochemical and pharmacological research. (c) seeds of wild plants or living plants such as orchids, lilies and begonias for horticultural

establishments. (d) Timber samples of tropical forest trees for research institutions. According to his account, he has so far exported ca.800 samples of medicinal plant species. In 1984, he exported Pound Sterling 180.000 worth of medicinal plants. His main business is with Tate and Lyle (UK) for the last 12 years exporting the frozen arils of Thaumatococcus daniellii. He exports 6000kg of frozen arils each year. For 1991, he expects an export volume of 4000 kg. In 1987 he exported 110 tonnes of various medicinal plants including seeds of Abrus precatorius, Azadirachta indica, Gloriosa superba and G.simplex, Physostigma venenosum.

2.12 The Complex Hospital of Research Institute of Tropical Diseases and Herbal Medicine, Nsawam

This clinic was established 30 years ago by Mr. J.A. Nartey, herbal Practitioner with Governmental support and finance. After 1966, it continued as a private herbal clinic and five years ago it moved from the town centre to its present premises on the Nsawam - Accra highway. The clinic is managed by Mr. C.B. Nartey, the son of Mr. J.A. Nartey. He studied homeopathy and naturopathy at Sussex, U.K. The clinic consists of a reception and registration office where cards are issued for each patient, clinical laboratory, diagnosis room, herbal preparation unit, dispensing unit. The in-patient wards have forty beds but are not at present functional.

According to Mr. C. Nartey, 30 patients a day visit clinic and he estimates the annual figure as 5000 new cares. After registration, the patient undergoes some examination and analysis such as pulse, blood pressure and urine tests. Based on case history and the tests, if necessary, or physical examination is carried out. After diagnosis, a suitable preparation is dispensed. In the clinic only chronic cases are treated. Mr. Nartey claimed that malaria, typhoid, diphteria, whooping cough, skin diseases snake bite, scorpion bite, etc. were successfully treated. According to his explanation, he prescribes herbal medicine to accelerate the healing power of the body. About 10 herbs are used in the preparation of decoctions, infusions, macerates, tinctures, ointments, powders, ovules, suppositories and enema. Aqueous preparations are recommended to use for up to seven days. Animal preparations and minerals such as white clay and alum are also used at times. The plant materials are either collected by Mr. Nartey from the vicinity of the Clinic or supplied by collectors from other regions.

3. CONCLUSIONS AND RECOMMENDATIONS

The terms of reference of the chemical technologist/pharmacist (Team leader) and of the agro-technologist/botanist for this fact-finding and preparatory assistance mission to assess the potential for the processing of herbal pharmaceuticals based on the Traditional Ghanaian therapies indicated in the job description are as follows:

1) To assess the potential of medicinal and aromatic plants indigenous to Ghana for industrial utilization.
2) To assess the progress in cultivation and post harvest treatment of medicinal and aromatic plants.
3) To assess the progress in the current production of herbal pharmaceuticals and the specific needs for improvement of these.
4) To assess industrial and institutional infrastructure related to medicinal and aromatic plants in the country, and the development of pharmaceuticals based on traditional preparations.
5) To assess the current research capability at CSIR and status of equipment, for natural product based drug development.
6) To prepare a comprehensive report containing the findings, conclusions and recommendations on the basis of the above and to recommend therein the mechanisms and modalities of a technical assistance project including the inputs in terms of equipment, training, expertise and other infrastructural requirements.

The above points shall be dealt with under separate headings based on the findings reported in the previous chapter.

1) To assess the potential of medicinal and aromatic plants indigenous to Ghana for industrial utilization.

Ghana has humid, moist and dry tropical climates supporting a rich flora of over 6000 species. Many of them are used by the rural population and herbalists. It has not been possible to get a quantitative estimate of the extent of exploitation of especially the wild species, however the estimated number of herbalists as 100.000 may give some indication to the widespread use of indigenous medicinal and aromatic plants.

Irvine enumerated 752 plants with medicinal and veterinary uses in 1961 in his book of "Woody Plants of Ghana"(1).

More recently, Abbiw gave a comprehensive list of medicinal plants used in indigenous medicinal practices for a wide range of diseases in his publication entitled "Useful Plants of Ghana" (1990) (2).

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1. Irvine ,F.R., Woody Plants of Ghana, Oxford Univ. Press (1961)
2. Abbiw, D., Useful Plants of Ghana, ITP and RBG-Kew (1990)

Xiao Pei-Gen listed 50 commonly used herbal drugs in Ghana and suggested 20 medicinal plants for the development of commercialized herbal preparations(3).

"Herbs of Ghana "Project identified more than 500 species with therapeutic uses (4).

The survey of medicinal plants of export potential from Ghana has resulted in the recommendation of 27 species (5). In 1989, Ghana exported US$ 443.000 worth of medicinal plants (6)

It has also been brought to our attention that Lever Brothers Company is encouraging the cultivation of Cymbopogon nardus (citronella) and hiring out stills to farmers for the distillation of its essential oil. The Company purchases all the oil produced and uses it in its own manufacture of soaps and other toiletries.

CSRPM and Danafco Company are currently producing herbal preparations for general dispensing and sale.

The above findings clearly indicate that there is considerable potential for the industrial utilization of medicinal and aromatic plants of Ghana. However, there is an urgent need to improve the technological capabilities for the processing of medicinal and aromatic plants. At present, none of the herbal medicines is manufactured on an industrial scale despite the availability of raw materials and the apparent popularity of herbal medicines.

Provision of a multipurpose pilot plant for extraction and distillation is seen as a right step to promote industrial processing.

It will be the most appropriate way of transferring technology into the country and will help the achievement of the programme of industrial development. The pilot plant should be supported by a well established phytochemical laboratory with modern analytical equipment to ensure the production of standardized herbal materials.

Pilot plant is the necessary step between the bench scale findings and industrial production. Process parameters for commercial production are tested in a pilot plant before scaling up to the industry. At every stage of the development, analytical instruments are heavily used to monitor process parameters and eventually ensure the quality of the product.

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3. Xiao Pei-Gen, Strategy Towards Commercialization of Traditional Drug Preparations(TDP) in Ghana. UNDP/TTC(1990)
4. Agbettor, E.O.and Tackie, A.N., Report on Phaceutical Industry with Emphasis on Traditional Medicine, TTC/CSIR (1990).
5. Odamtten, G.T.,Laing, E. and Abbiw, D.K.,Survey of Medicinal Plants of Export Potential from Ghana, ITC,UNCTAD/GATT (1989). (Manuscript).
6. Statistical Information supplied by GEPC (1991).

GIHOC, the largest pharmaceutical company in Ghana has expressed its willingness to undertake the formulation and commercial production of herbal medicines once it has been shown to be technically feasible and economically viable after pilot plant experiments.

2) To assess the progress in cultivation and post harvest treatment of medicinal and aromatic plants.

Cultivation is of paramount importance for the healthy development of plant based industries. Annual and perennial plants are being utilized for herbal preparations and for the distillation of essential oils. At present, only citronella grass is being cultivated to some extent but most of the other raw materials are harvested from the wild. CSRPM, however, has embarked on a programme of cultivating 35 different species in the Arboretum at Mampong-Akwapim in an area of 25 acres. The estimated yield of drugs from three of the species are as follows:

Name of plant	Acreage	Yield per year (kg)
Indigofera arrecta	4	1400
Xylopia aethiopica	3	720
Aframomum melegueta	0.5	80

The Ayikuma farm is cultivating 16 species. The names, acreage and estimated annual yields are given in Annex 4.

These figures are indicative of the potential for cultivation at the Centre. The Centre is, at present, producing plant materials sufficient to support pilot plant studies. The plants selected for industrial processing following the pilot plant evaluation will have to be cultivated on a larger scale. GIHOC pharmaceuticals have indicated their willingness to establish herbal farms for large scale cultivation of plant species with industrial potential.

Indiscriminate collection from wild habitats would lead to severe depletion of the natural resources of the country. Conservation measures should be adopted to protect rare and vulnerable species. In the case of plants with great export potential, exporters of such commodities should be encouraged to invest in cultivation.

Since most plant drugs used in Ghana are gathered from forest trees, the Forestry Department must embark on silvicultural and agroforestry programmes that would maintain a steady source of supply of raw materials to sustain a plant based pharmaceutical industry. During logging operations of trees with medicinal use barks, roots, leaves, seeds, branches, etc. may be collected. This collection could be done by rural people living in forest villages,

thus adding to their income. This is a practice that has been widely advocated by international conservation bodies such as IUCN, WWF, etc. This is a sustainable system of managing ecologically sensitive and species-rich tropical forests.

Appropriate post harvest handling and storage to prevent deterioration and infestation should be followed. Field solar dryers will be appropriate and cost effective for general purpose drying. Succulent and special-care needing materials such as the arils of Thaumatococcus may demand special handling.

3) To assess the progress in the current production of herbal pharmaceuticals and the specific needs for improvement of these

At present none of the pharmaceutical companies produces herbal pharmaceuticals for commercial use. Some herbal practitioners prepare and market their preparations without specifying ingredients contained therein. These preparations do not undergo usual procedures for registration with the Pharmacy Board and the Ghana Standards Board. Therefore, their safety and efficacy are questionable. Furthermore, such preparations can be hazardous to the health of the people. Although, the Medicines Advertisement and Sales Ordinance 1965 prohibits both western and indigenous practitioners from advertising their skills or services, herbal practitioners freely advertise their skills and preparations.

CSRPM produces 20 Water-based liquid preparations, 6 balms and ointments and 8 powders of herbal origin. These are dispensed at the Centre upon prescription from the out-patients clinic of the Centre. The production follows traditional procedures indicated to them by herbalists. Since correctly identified plant materials in weighed quantities are used and preservatives are added, some degree of standardization is maintained. However, the preparations need to be freshly prepared.

A pilot plant to undertake the production of standardized dry or liquid extracts from the plants used in herbal preparations will greatly improve the existing production procedures at the Centre. It will facilitate the preparation of herbal remedies as and when needed and in larger quantities. Relatively large volumes of extracts can be sealed and stored for future use or dispatched to other clinics or pharmaceutical companies.

4) To assess industrial and institutional infrastructure related to medicinal and aromatic plants in the country and the development of pharmaceuticals based on traditional preparations.

There are more than 20 pharmaceutical manufacturing enterprises in Ghana. They produce only 32 items out of a list of 211 national essential drugs in the form of liquid and solid preparations, and injectables. The pharmaceutical industry in

Ghana is dependant on imported chemicals, pharmaceutical machinery and packaging materials. Between 1982 and 1985 the total consumption of imported and locally manufactured pharmaceuticals in Ghana amounted to more than US$ 100 million.

Recently, it has been suggested that in order to strengthen the pharmaceutical industry, action should be taken to (a) establish a pilot plant to produce a selection of the most widely used extracts; (b) development and commercialization of herbal medicines in an appropriate research establishment in collaboration with regulatory bodies; (c) encourage cultivation and post-harvest treatment of medicinal trees and herbs; (d) some of the herbs can be used as raw materials for the preparation of spices, flavour and fragrances and essential oils. This helps promote the development of related industries (7).

Although some institutions such as CSRPM, chemistry department of Universities, Faculty of Pharmacy of UST have been engaged in research into the chemistry of medicinal plants, the existing overall infrastructure for research and development is inadequate. Their studies cannot, in its present form, meet the needs of developing a plant based pharmaceutical industry.

Among the institutions visited, CSRPM seems to be the only institution with integrated laboratories and clear commitment for the development of herbal medicines. Therefore, it is imperative that this Centre should be strengthened to perform bench-scale and pilot-scale processing of herbal extracts and essential oils. Phytochemical laboratories of the Centre should also be equipped with modern analytical and other facilities. The library should be strengthened in such a way for the Centre to operate as a national focal point for the development of herbal preparations. The Centre should collaborate with other research institutions and pharmaceutical companies for expediting the transition from bench-scale to pilot-scale and to industrial operations.

The development of the Centre should be realized in phases. The first phase should cover the above-mentioned immediate needs. Strengthening of the pharmacology/toxicology, microbiology and pharmaceuticals manufacturing laboratories can be carried out during the second phase.

This Centre should have a separate building(s) to house the pilot plant and boiler. The pilot plant building (approx. 20m x 10m, height at least 6m) should have access to the main building through a corridor passage. The building should be equipped with ex-proof electrical outfit and basic infrastructural requirements such as water, ventilation, drainage, water cooling, etc. should be provided.

The Centre should also establish boarding and lodging facilities for international and local experts. Otherwise, it may be extremely difficult to get the required expertise into Mampong-Akwapim. The Centre should have international telephone, telefax and telex, and if available, computer communication facilities. -

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7. Ugbor, F., Personal Communication (1991)

In order to maintain a steady power supply, a generator needs to be installed. A voltage stabilizer and an uninterrupted power source (ups) should be made available for the protection of sensitive and sophisticated equipment and for their reliable performance. Laboratories should be fully air-conditioned. Adequate amount of clean running water should be supplied to the laboratories and the pilot plant. A boiler should be installed to generate at least 250 kg/hr of steam for the operation of the pilot plant. A cooling tower with chilling provision will also be a necessary prerequisite for satisfactory operation of the pilot plant. Lighting and switches in the pilot plant area must be ex-proof and ventilation and fire-fighting facilities must be available. A modest metal and glass workshop should be established for minor modifications and repairs.

The multipurpose pilot plant should be capable of performing solid/liquid extraction (eg. hot and cold stirred or static maceration, percolation, forced percolation, Soxhlet extraction), evaporation under reduced or atmospheric pressure, water and steam distillation, fractional distillation, and should consist of the following major parts: (1) reboiler (500L) with steam jacket complete with a changeable lid containing stirrer attachment, condenser, centrifugal pump and an oil separator. (2) evaporator (500 L) with a column packed with stainless steel wire mesh (knitmesh) material complete with reflux distributor and controls, condenser, cooler, decanter, filter, a water-ring vacuum pump and a storage tank of 600 L capacity. All parts should be made of stainless steel and the pumps and switches must be ex-proof.

Additionally, a filter press, a basket centrifuge, storage tanks of several sizes, cold room (preferably -18°C and or at least 15°C) of at least 5 cubic meters, large scale rotary evaporators, a tray dryer, a hammer mill grinder (50 kg/hr) will be required with two scales weighing up to 200 kgs.

The Phytochemistry Laboratory will need the following facilities:

1. Laboratory glassware
2. Chemicals, solvents, adsorbents, etc.
3. Vacuum pumps (3 pcs)
4. Rotary evaporators with vacuum and temperature controllers and waterjet vacuum attachment (2 pieces)
5. Glass Soxhlet extractors (250 ml - 10 sets, 500 ml - 5 sets) 1 liter (3 sets), 2 liters (2 sets).
6. Glass Clevenger apparatus for essential oil/determination content (5 pieces for oil-rich material, 3 pieces for oil-poor material)
7. Volumetric moisture determination apparatus (10 pieces)
8. Chromatography columns

9. TLC plate spreader with already out 5x20, 10x20, 20x20, 40x20 cm glass plates(50 pcs each).
10. Chromatography tanks to develop the above-mentioned plate sizes (10 pieces each).
11. UV lamps (2 pieces) (one hand-lamp, the other mounted in a cabinet)
12. Buchner filtration set up (a range of all available sizes)
13. Moisture balance
14. Micro-processor controlled UV-VIS double beam scanning spectrophotometer with recorder.
15. Micro-processor controlled IR spectrophotometer complete with recorder, cells, cell holders and a-hand operated press to make KBr discs.
16. Bench-top electronic balances. (toploading-2 pieces; analytical - 2 pieces).
17. Distilled water still (10 liters per hour cap.)
18. Water deionizer (300 liter per hour cap.)
19. Electronic digital polarimeter with a range of cells to measure down to 0.1 ml of material.
20. Abbe type refractometer
21. Muffle furnace for ash value determination
22. Laboratory centrifuge (up to 10.000 rpm) with tubes and various size changeable rotors.
23. Ultrasonic bath
24. Gas liquid chromatograph complete with integrator, ECD and FID detectors, various fused silica capillary columns, chart papers, diskettes, injectors,two each of hydrogen, oxygen and nitrogen cylinders complete with gauges and regulators and spare parts.
25. High pressure liquid chromatograph complete with integrator, two pumps, detectors (UV/VIS, refractive index, conductivity and fluorescence), packed columns, automatic injectors, integrator, column oven, diskettes, chart paper, range of HPLC-grade solvents and spare parts.
26. TLC scanner complete with UV and Tungsten Lamps, integrator, chart paper, uniform spraying device, spare parts and other accessories.
27. Bench top freeze drier with chamber trays with heating attachment and manifold.
28. Binocular and stereo microscopes (2 pieces each)
29. Laboratory scale spray dryers.
30. Drying ovens (2 pieces)
31. Vacuum oven
32. Hot plate/magnetic stirrers (5 pieces)
33. Heating mantles with thermostats (for various size flasks, 3 pieces each)
34. Water baths with thermostats to take up to six flasks at a time (3 pieces)
35. Circulating thermostalic water bath
36. Flask shakers (5 pieces)

37. PH meter/conductimeter with electrodes and spares
38. Automatic titrator
39. Photocopier
40. Slide projector
41. Overhead projector
42. Fax machine
43. Books, journals, chemicals, solvents, other expendables.
44. Word processors (3 pieces) with laser printer
45. Computers for data collection, storage and processing complete with necessary software (3 pieces) and printer.

3.1 SUMMARY OF RECOMMENDATIONS

Identification of the problem	Action to be taken	Responsible party
1. Indigenous plant preparations are widely used by herbal practitioners for the treatment of various illnesses in Ghana. In order to put their practices into a scientific perspective the Government of Ghana established a research centre at Mampong-Akwapim and appointed a high ranking Government official within the Ministry of Health. The problem is the lack of appropriate technology for the production of standardized herbal remedies in Ghana.	A multipurpose pilot extraction / distillation plant should be established at CSRPM together with modern analytical facilities for quality control in order to ensure the production of standardized herbal extract which in turn can be used for the formulation of herbal preparations. An important prerequisite is the completion of a pilot plant building with necessary infrastructure and the provision of national personnel. Strengthening of CSRPM should be realized in phases. The first phase should take care of the above and the second phase should concentrate on the strengthening of pharmacology / toxicology and formulations units.	Project staff, building(s) to accommodate the pilot plant, boiler, laboratories, with necessary infrastructure, raw material(s) running cost of the pilot plant and other locally incurring costs should be born by the Government; Acquisition of pilot plant, analytical instruments and other necessary equipment, international and local experts, international training and study tours should be covered by UNDP/UNIDO.
2. Steady supply of adequate amount of plant materials to support industrial operations.	Cultivation and/or systematic collection from the wild of medicinal and aromatic plants on a sustained yield basis should be programmed and executed. Farmers should be encouraged to cultivate potential medicinal and	The Government/CSRPM

	aromatic plants as intercrops and on marginal lands. CSRPM should continue its planned cultivation of selected medicinal and aromatic plants.	
3. Pharmaceutical and related industries are not at present interested in investing in the production of plant based pharmaceuticals or raw materials.	CSRPM should identify some potential entrepreneurs to commercialize research findings as a result of bench and pilot scale studies. GIHOC could be a suitable partner. The Government should encourage industries to process locally available natural resources.	The Government/CSRPM
4. Due to suitable climate, the country has a wide range of essential oil bearing plants. This area has not been sufficiently explored.	Essential oil production from aromatic plants is suitable for small and medium scale industries for it does not require enormous capital investment. Farmers can be encouraged to cultivate aromatic plants and to produce the essential oil in the field. This can easily be realized if buy-back is guaranteed. CSRPM can conduct the bench and pilot scale processing studies and can give analytical and consultancy services to such industries.	CSRPM/private sector

5. The mission had difficulty in obtaining exacts figures, names and parts of medicinal plants exported from Ghana. If this information is not available, no adequate measures can be taken for the conversation of rare and vulnerable species and no planning for the industrial utilization potential of medicinal plants of Ghana can be accurately made.	Information on export of invidual medicinal plants should be correctly recorded and monitored. When necessary, conservation measures should be considered.	Ghana Export Promotion Council/Forestry Dept.
6. At present, there is none or very limited stainless steel working facility and capability, and commonly used solvents for industrial extractions are not sufficiently produced in the country.	Since the country has metal working capability, stainless steel working capacity can easily be created. This would result in big savings in foreign exchange if some of the processing equipment could be locally fabricated. Some of the most commonly used solvents such as ethanol, methanol, hexane, etc. should be locally produced in sufficient quantities.	The Government / Industrial Res.Ins.

4. PEOPLE CONTACTED

4.1 Ministry of Health

Dr. A.R. Ababio, Deputy Secretary for Health
Dr. K. Appiehkupi, Deputy Director of Health Services (Herbal Medicine)

4.2 Pharmacy Board

Mr. T.C. Ccrquaye, Registrar
Mr. G.K. Acheampong, Deputy-Registrar

4.3 CSRPM

Dr. G.L. Boye, Director
Prof. A. N. Tackie, Consultant, Phytochemistry
Prof. Oku Ampofo, Founding-Director, Consultant, Clinic
Mr. O.K. Gyapong, Administrative Secretary
Mr. E.C.O. Ansah, Herbalist, Head, Production Unit
Mr. D. Ofosuhene, Botanist, Research Officer, Production Unit
Mr. H. Blagawgee, Assistant Research Officer, Production Unit
Mr. A. Ankrah, Technician, Production Unit
Mr. A.A. Nkrumah, Herbalist Consultant, Production Unit
Mr. E.O. Lartey, Curator, Herbarium
Mr. B.O. Adjei, Librarian
Mr. J.E. Yankey, Medical Technician, Clinical Laboratory
Dr. A. Asabre, Principal Medical Officer, Clinic
Mr. A. Nkansah, Senior Laboratory Technician, Pharmacology/Toxicology.
Mr. G.A. Mensah, Laboratory Technician, Pharmacology/Toxicology
Mr. R.L.K. Glover, Research Officer, Microbiology
Mr. I. Odoi, Research Officer, Microbiology
Mr. Y.O. Boahen, Head, Research Officer, Phytochemistry
Mr. F.A. Aboagye, Assistant Research Officer, Phytochemistry
Mr. V.R. Biaku, Horticulturist, Ayikuma farm

4.4 Ghana Standards Board

Dr. E.K. Marfo, Director
Mr. S. Boateng, Deputy Director (Tech.)

4.5 Ghana Export Promotion Council

Mr. K. Ahwoi, Director
Mr. K.B. Owusu-Sekyere, Senior Export Development Officer
Mr. G. Nyarko-Mensah, Export Development Officer

4.6 Ministry of Industry, Science and Technology

Dr. A. Ata, Chief Director
Mr. I. Nikabs, Senior Officer

4.7 Ministry of Finance and Economic Planning

Ms. Margaret Clarke-Kwesie, Principal Economic Planning Officer
Mr. Charles Abakah, Head, Multilaterals

4.8 University of Ghana, Legon

Prof. Dr. G.T. Odamtten, Head, Botany Department
Prof. Dr. E. Laing, Botany Department
Mr. D. Abbiw, Chief Technician, Herbarium, Botany Department

4.9 University of Science and Technology (U.S.T.), Kumasi

Prof. K. Sarpong, Dean, Faculty of Pharmacy
Dr. J.S.K. Ayim, Vice-Dean, Faculty of Pharmacy
Dr. M. Mensah, Assistant-professor, Pharmacognosy, Faculty of Pharmacy

4.10 C.S.I.R.

Dr. M.A. Odei, Acting Secretary
Mr. J.T.G.B. Acquah, Deputy Secretary
Mr. V. Mills, Director, Scientific Instrumentation Centre
Ms. A. Amoako-Mensah, Director, Industrial Research Institute
Mr. F. Djokoto, Mechanical Engineer, Industrial Research Institute
Mr. H.A. Obiri, Metalurgical Engineer, Industrial Research Institute
Dr. K.K. Eyeson, Director, Food Research Institute
Mr. B.L. Lartey, Chief Research Officer; Head, Engineering Division, Food Research Institute
Dr. J. Cobbina, Senior Research Officer (Agroforestry), Forestry Research Institute of Ghana, Kumasi.
Dr. M.N.B. Ayiku, Director, Technology Transfer Centre

4.11 GIHOC Pharmaceuticals Division

Ms. J.R. Onny, General Manager

4.12 Forestry Enterprises Limited

Mr. A.A. Enti, Managing Director

4.13 The Complex Hospital, Nsawam

Mr. C.B. Nartey, Director

4.14 Engineering and Industrial Consultants

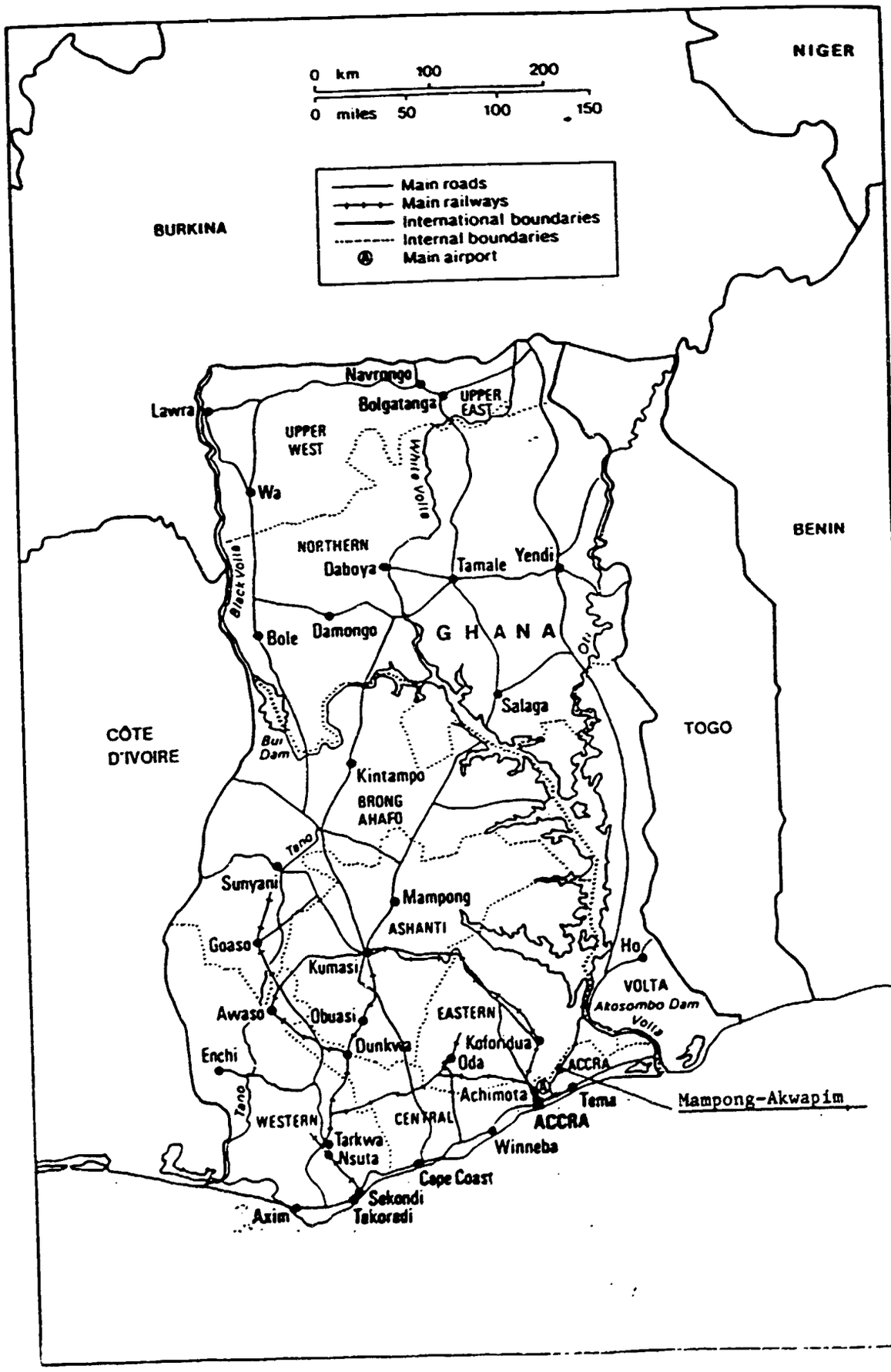
Mr. M.O. Agbettor, Mechanical Engineer
Mr. F.S. Okwnaning, Electrical Engineer.

4.15 UNDP/UNIDO

Mr. Thomas Bernklau, J.P.O., Accra

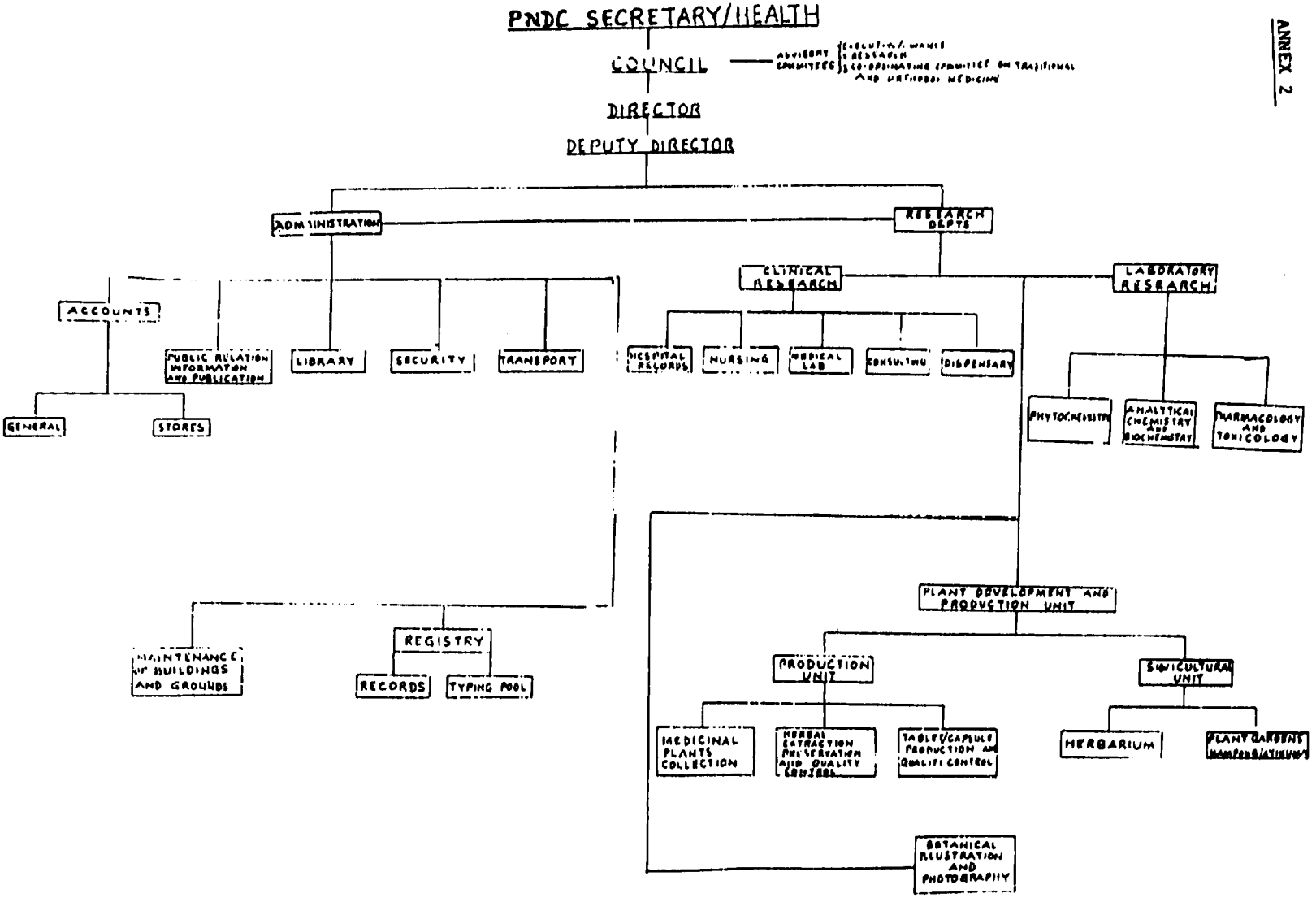
Annex 1

MAP OF GHANA



ANNEX 2

ORGANISATIONAL STRUCTURE
CENTRE FOR SCIENTIFIC RESEARCH INTO PLANT MEDICINE
MAMPONG-AKWAPIM



ANNEX 3

MAMPONG ARBORETUM/HERBAL GARDEN

TOTAL ACREAGE: 25 acres

LIST OF PLANTS IN THE ARBORETUM

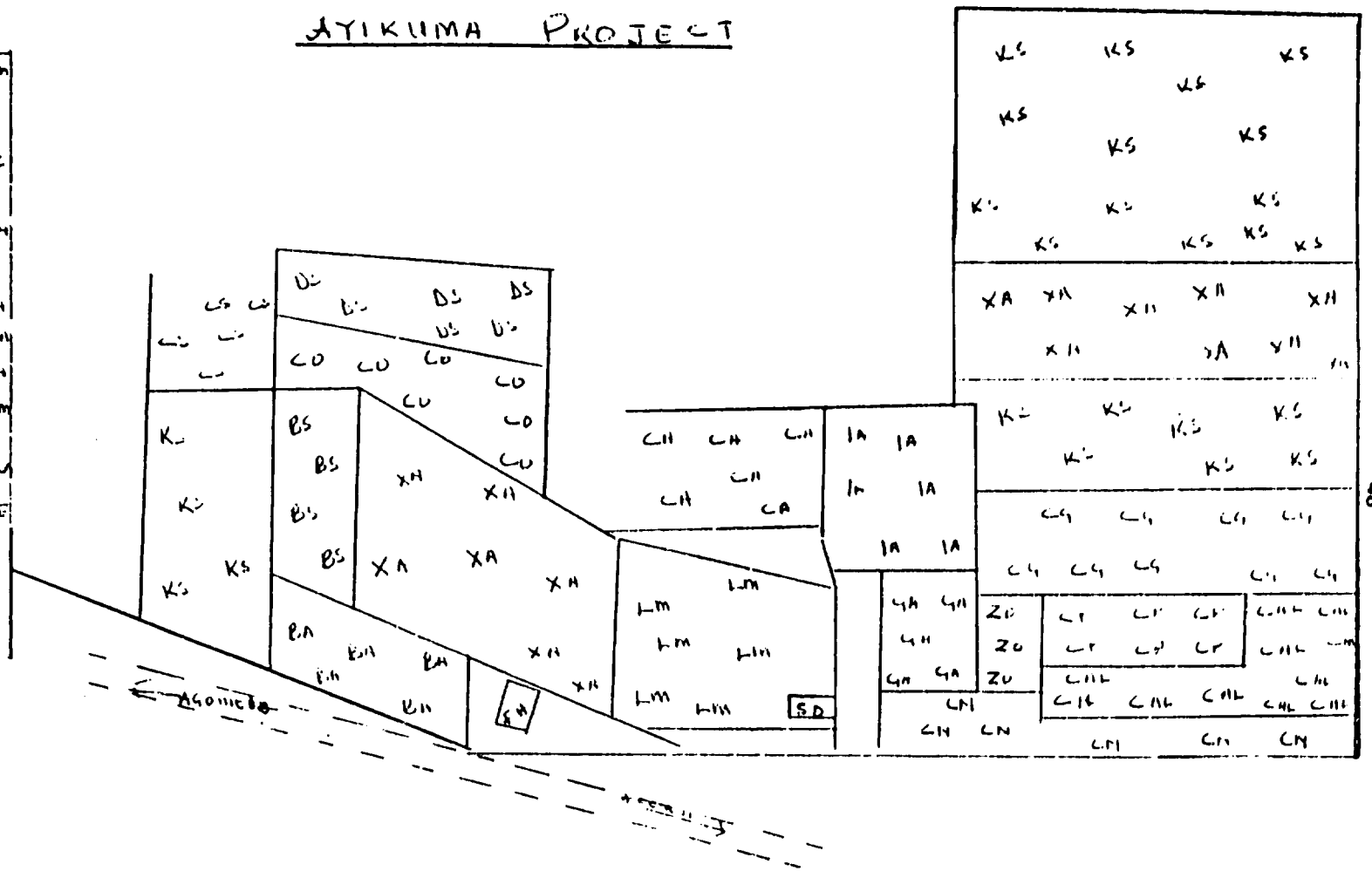
NO	NAME OF PLANT	FAMILY
1.	Baphia nitida	Papilionaceae
2.	Chlorophora excelsa	Moraceae
3	Synsepalum dulcificum	Sapotaceae
4.	Albizia zygia	Mimosaceae
5.	Anthocleista nobilis	Loganiaceae
6.	Monodora myristica	Annonaceae
7.	Monodora tenuifolia	Annonaceae
8.	Bridelia micrantha	Euphorbiaceae
9.	Cnestis ferruginea	Connaraceae
10.	Carapa procera	Meliaceae
11	Tetrapleura tetraptera	Mimosaceae
12.	Olax subscorpioides	Olacaceae
13.	Cola millenii	Sterculiaceae
14.	Vitex grandifolia	Verbenaceae
15.	Elaeophorbia drupifera	Euphorbiaceae
16.	Trichilia heudelotii	Meliaceae
17.	Bombax buonopozense	Bombacaceae
18.	Blighia sapida	Sapindaceae
19.	Alstonia boonei	Apocynaceae
20.	Newbouldia laevis	Bigoniaceae
21.	Antiaris africana	Moraceae
22.	Khaya grandifoliola	Meliaceae
23.	Okoubaka aubrevillei	Octchknemataceae
24.	Tabernaemontana pachysiphon	Apocynaceae
25.	Morinda lucida	Rubiaceae
26.	Rauvolfia vomitoria	Apocynaceae
27.	Lecaniodiscus cupanioides	Sapindaceae
28.	Xylopia aethiopica	Annonaceae
29.	Aframomum melegueta	Zingiberaceae
30.	Ouratea flava	Ochnaceae
31.	Indigofera arrecta	Papilionaceae
32.	Discoglypremna caloneura	Euphorbiaceae
33.	Alchornea cordifolia	Euphorbiaceae
34.	Mareya micrantha	Euphorbiaceae
35.	Hoslundia opposita	Labiatae

AYIKUMA PROJECT

ANNEX 4

LEGEND

CL	-	CATHARANTHUS LANCEOLATUS
KS	-	KHAYA SENEGALENSIS
DS	-	DATURA STRAMONIUM
CO	-	CASSIA OCCIDENTALIS
BS	-	BRUCHIA SPHAERA
BA	-	BALANITES AEGYPTIACA
XA	-	XYLOPIA AETHIOPICA
CA	-	CLAUSENA ANISATA
LM	-	LIPPIA MULTIFLORA
IA	-	INDIGOFERA ARRECTA
GA	-	GOSSYPIUM ARBOREUM
CN	-	CYMBOPOGON NARDUS
CG	-	CANTHIUM GLABRIFLORA
ZO	-	ZINGIBER OFFICINALE
CP	-	CASSIA PODOCARPA
CAL	-	CASSIA ALATA
FH	-	FARM HOUSE
SD	-	SOLAR DRYER



ANNEX 5

Some Decoctions Produced at CSRPM

1. MIST TONICA - A (BLOOD TONIC)
a) Mitragyna stipulosa (stem bark)
b) Kigelia africana (stem bark)
c) Khaya ivorensis/senegalensis (stem bark)
d) Xylopia aethiopica - as adjuvant
e) Monodora myristica - as adjuvant
f) Natron (local sodium carbonate)
g) Water

2. MIST TONICA - B (BLOOD TONIC)
a) Nauclea latifolia (root)
b) Mitragyna stipulosa (stem bark)
c) Pycnanthus angolensis (stem bark)
d) Xylopia aethiopica - as adjuvant
e) Monodora myristica - as adjuvant
f) Natron
g) Water

3. COUGH MIXTURE
a) Pachypodanthium staudtii (stem bark)
b) Cnestis ferruginea (roots)
c) Paulinia pinnata (roots)
d) Zingiber officinale - as adjuvant
e) Water

4. ARTHRITIS MIXTURE - C
a) Piliostigma thonningii (stem bark)
b) Nauclea latifolia (roots)
c) Kigelia africana (stem bark)
d) Clausena anisata (roots)
e) Trichilia heudelotii (stem bark)
f) Khaya ivorensis/senegalensis (stem bark)
g) Strophanthus hispidus (roots)
h) Xylopia aethiopica - as adjuvant
i) Monodora myristica - as adjuvant
j) Natron
k) Water

5. PILE MIXTURE
a) Treculia africana (stem bark)
b) Dialium guineense (roots
c) Anthocleista nobilis (roots)
d) Lecaniodiscus cupanioides (roots)
e) Zingiber officinale - as adjuvant
f) Xylopia aethiopica - as adjuvant
j) Monodora myristica - as adjuvant
h) Natron
i) Water

6. MIST NIBIMA

a) Cryptolepis sanguinolenta (root powder)
b) Water

7. ANTI-SICKLING I
a) Morinda lucida (roots)
b) Albizzia ferruginea (stem bark)
c) Water

8. ANTI-SICKLING II
a) Morinda lucida (roots)
b) Albizia ferruginea (stem bark)
c) Carissa edulis (roots)
d) Bosqueia anqolensis (stem bark)
e) Terminalia glaucescens (roots)
f) Water

9. DYSPEPSIA MIXTURE CM
a) Spathodea campanulata (stem bark)
b) Trichilia heudelotii (stem bark)
c) Carapa procera (stem bark)
d) Maytenus senegalensis (roots)
e) Piper guineensis - a adjuvant
f) Zingiber officinale - as adjuvant
g) Natron
h) Water

10. MIST ADENIA
a) Adenia cissampeloides(stem vine)
b) Water

11. MIST ADENIA/SODA MEDICINE
a) Adenia cissampeloides (stem vine)
b) Pseudocedrela kotschyi (root bark powder)
c) Monodora myristica - as adjuvant
d) Xylopia myristica - as adjuvant
e) Aframomum melegueta - as adjuvant
f) Natron
g) Water

12. MIST DIODIA - A
a) Diodia scandens (whole plant)
b) Aframomum melegueta
c) Water

13. ANTI JAUNDICE MIXTURE
a) Bidens pilosa (whole plant)
b) Citrus aurantifolia (leaves or green fruits)
c) Unripe pineapple (fruit peels)

d) Trema guineensis
e) Water

14. HYPERTENSION MIXTURE - C
a) Canthium glabrifolium (stem bark)
b) Zingiber officinale (Rhizome)
c) Water

15. ANTIARIS MIXTURE
a) Antiaris africana (stem bark)
b) Zingiber officinale (Rhizome)
c) Xylopia aethiopica
d) Water

16. HERBAL LAXATIVE
a) Cassia podocarpa (leaves)
b) Anthocleista nobilis (roots)
c) Kigelia africana (fruit powder)
d) Pycnocoma macrophylla (root bark)
e) Water

17. ASTHMATIC MIST - D
a) Desmodium adscendens (leaves)
b) Water

18. MIST AGERATUM
a) Ageratum conyzoides (whole plant)
b) Water

19. DIABETIC MIST - A
a) Indigofera arrecta (leaves) dried
b) Water

20. DIABETIC MIST - D
a) Bridelia ferruginea (leaves) dried
b) Water

21. MIST PROSTATIV (MEMBRANACEOUS)
a) Croton membranaceous (rough root powder)
b) Ethanol
Alcoholic macerate

* MIST stands for mixture.

ANNEX 6

CENTRE FOR SCIENTIFIC RESEARCH INTO PLANT MEDICINE

HERBAL PREPARATIONS PRODUCED BY THE CENTRE

	Name	Indications
1.	Mist Adenia	For Mild Hypertension
2.	Mist Tonica	Blood Tonic
3.	Arthritis Mixture- C	Muscular & Joint Pains
4.	Dyspepsia Mixture -C	Heartburn, Nausae and Dyspeptic Complaint
5.	Dyspesia Mixture- M	Stomach Pains
6.	Cough Mixture	For Cough
7.	Pile Mixture	For Piles
8.	Herbal Laxative	A General Purgative
9.	Mist Nibima	For Malaria Fever
10.	Mist Anti-Sickling	For Sickle-Cell Diseases
11.	Diodia-A	Diuretic
12.	Mist Antiaris	For Epilepsy
13.	Jaundice Mixture	For Jaundice
14.	Hypertension Mixture-C	High Blood Pressure
15.	Dysmenorrhoea Mist-T	Painful Menstruation
16.	Mist Membraneceous	For Retention of Urine in Men
17.	Asthma powder-T	For Asthma
18.	Asthma Powder-D	For Asthma
19.	Kenken Powder (CS)	For Abdominal Colic
20.	Anti-Diarrhoea Powder	For Diarrhoea
21.	Soda Medicine	For Numbness in Extremities
22.	Cissus Powder	Aphrodisiac
23.	Lumbago Powder-Olax	For Waist Pains
24.	Lippia Tea	Sedative and Mild Hypertensions
25.	Diabetic Mixture-A	For Diabetes Mellitus
26.	Diabetic Mixture-B	For Diabetes Mellitus
27.	Asthmatic Mixture-D	For Asthma
28.	Mist Ageratum-C	For Infertility in women
29.	Rheubalm-A	For Rheumatic Pains and Bacterial Skin Infections
30.	Rheubalm-J	For Joint Pains
31.	Garibe Ointment	For Skin Infections, Herpes zoster

32.	Pile-C-Ointment	For Piles (Haemorroid)
33.	Akane Ointment	For painful and swollen Limps, etc.
34.	Wound Ointment	For Topical wounds.

ANNEX 7

Medicinal Plants of Export Potential From Ghana

Medicinal Plants

A. Catharanthus roseus ... ...

B. Calotropis procera ... ...

C. Carica papaya ... ...

D. Clausena anisata ... ...

E. Datura metel ... ...

F. Datura stramonium ... ...

G. Dennettia tripetala ... ...

H. Ehretia cymosa ... ...

I. Ehretia trachyphylla ... ...

J. Griffonia simplicifolia ... ...

K. Heliotropium indicum ... ...

L. Penianthus zenkeri ... ...

M. Physostigma venenosum ... ...

N. Rauvolfia vomitoria ... ...

O. Sphenocentrum jollyanum ... ...

P. Xylopia acutiflora ... ...

Q. Xylopia aethiopica ... ...

R. Xylopia parviflora ... ...

S. Xylopia quintasii ... ...

T. Xylopia staudtii ... ...

U. Xylopia villosa ... ...

V. Zanthoxylum (macrophylla) gillettii ... ...

W. Zanthoxylum xanthoxyloides ... ...

Sweeteners

A. Synsepalum dulcificum ... ...

B. Dioscoreophyllum cumminsii ... ...

C. Thaumatococcus daniellii ... ...

ANNEX 8

United Nations Development Programme
Project of the Government of Ghana
PROJECT DOCUMENT
(Draft)

Title: Processing of Herbal Pharmaceutical Materials Based On Traditional Ghanaian Therapies.

Number: DP/GHA/92/..... Planned Duration: 3 Years.

Project Site: Mampong-Akwapim, Ghana.

Primary function: Institution building

Secondary function: Experimental and Research

Sector (Govt. class): Industry UNDP class and code: Industrial Development Support Service (0510)

Subsector (Govt. class): Pharmaceutical Industry UNDP class and code Development and Transfer of Technology (1620)

Estimated Starting date: 1992

Government Implementing agency: Centre for scientific Research into Plant Medicine (CSRPM)

Executing Agency: United Nations Industrial Development Organization (UNIDO)

Total UNDP budget (excl. support cost): US$1,496,301.00

Government inputs: In Cedis (To be decided later)
(in kind):
(in cash):

Brief Description: The project intends to strengthen production and phytochemical research and development facilities of CSRPM by the provision of a multipurpose pilot plant for the extraction of pharmaceutical materials from medicinal plants, and standardization and quality assurance of these products by modern analytical techniques. Establishment of a technological and scientific base in the country is expected to expedite development of herbal preparations and their commercialization. project will contribute to rural development by encouraging the collection from the wild and cultivation of selected medicinal plants.

A. CONTEXT

A.1: Description of Subsector: Medicinal plants have been used by man for the treatment of and prevention from diseases since time immemorial. Even today 80 percent of the world population is estimated to rely on plants to meet the health care needs. In some African countries this figure is estimated to go up to 95%. 33% of the drugs produced in developed countries come from higher plans and 25% of these owe their origin to the tropical rain forests of Africa, Asia and South America. In otherwords, the developing countries possess the majority of natural raw material sources for the pharmaceutical industry. These products have an estimated retail value of 20 to over 40 billion dollars out of the estimated drug market of 150 billion dollars.

Medicinal plants exert their therapeutic action through their active ingredients contained in the tissues of various organs. These chemicals are metabolic products produced by the plant through biosynthetic pathways. Since each plant species is capable of synthesizing active chemical constituents according to their genetic make up, different plants may possess different medicinal properties. When these attributes are discovered, the plant is regarded as medicinal and useful.

Although many plants are claimed to have medicinal properties, it requires extensive scientific research to verify these claims and to develop a commercially available standardized dosage form. Extensive bench scale work should be scaled up to pilot process stage before the realization or even planning of an industrial production. Pilot plants are necessary to bridge the gap between the bench scale work and industrial processing. A research institute cannot establish an industrial research base without having a multifunctional pilot plant. The pilot plant should be supported by a well developed instrumental laboratory having modern chromatographic, spectroscopic and other instruments to determine physicochemical characteristics of the raw material and the product, and to assist in the development of processing techniques.

A.1.2 Situation in Ghana

Like in most developing countries 70% of the population especially in rural areas in Ghana, rely on traditional systems of healing and do not have access to orthodox pharmaceutical preparations. About 100.000 traditional herbal practitioners are estimated to be practicing in the country to treat various illnesses with their special plant based preparations. However, they operate in a rather primitive way both on treatment and remedies. They are illiterate and without any kind of formal training. They practice under unhygienic conditions and their preparations are far from any kind of standardization or

stabilization. According to a recent survey in Ghana, there is one traditional doctor to approximately 400 people, as opposed to one orthodox doctor to 12.000 people. However, in remote rural areas, the ratio is 1:70.000 (orthodox doctor). In urban areas like Accra, it is 1:4000.

Flowering plant species of Ghana are estimated to be around 6000. Apart from the 11 percent cultivated land, 34 percent of Ghana is forest and the rest is bushland. As traditional herbal medicines are cheap and readily available in Ghana, they are used and accepted by the majority of the population. it would be the most appropriate strategy to investigate their suitability for new formulations and to improve their quality by the introduction of better technology, scientific methods of quality assessment and good manufacturing practices.

A.2 Host Country Strategy

As with many developing countries, constraints of foreign exchange does not enable Ghana to acquire in sufficient measure a wide range of basic requirements. These include pharmaceuticals which cannot be imported to meet fully the local demand. The Ghanaian Government, mindful of this situation established a Centre for Scientific Research into Plant Medicine (CSRPM) in Mampong-Akwapim in 1973 and has recently appointed a Deputy Director at the Ministry of Health to take responsibility for the healty development of herbal medicine. This step is expected to accelerate the fusion of traditional herbal treatments with scientific medical practices.

The Government has showed its willingness to support research efforts into rationalization of herbal practices in the country and to explore the potential of medicinal plants for domestic use and for export. The research centre at Mampong-Akwapim has been recognized by the Government as the main focal point in this field and is charged with developing scientific basis for herbal medical practices. The Council for Scientific and Industrial Research (CSIR) has recently supported the realization of the "Herbs of Ghana Project" with the help of the Botany Department of the University of Ghana.

The same Department has recently compiled a report covering "Medicinal Plants with Export Potential from Ghana". Both books are being published. These two most recent studies clearly indicate that there is a potential in the country for industrial development of plant based pharmaceutical materials. Chemistry Departments of the University of Ghana, University of Cape Coast, University of Science and Technology, Kumasi and the Faculty of Pharmacy of the latter have also been carrying out some phytochemical analyses on Ghanaian Medicinal Plants. Furthermore, the Ghana Medical School of the University of Ghana, Korle Bu

Teaching Hospital and the Pharmaceutical Division of Ghana Industrial Holding Corporation (GIHOC) are engaged in research into traditional herbal medicines.

The Government is also drafting legislations for the registration of herbal preparations and the herbalists.

A.3 Prior and on-going assistance: Apart from an earlier UNDP Mission which resulted in the preparation of two project drafts that did not materialize, on the request of the Government of Ghana, a fact-finding and a preparatory assistance project to sent two experts to Ghana to assess the potential for the processing of herbal pharmaceuticals based on the traditional Ghanaian Therapies has been realized. This project is developed based on their findings and recommendations.

A.4 Institutional Framework of Subsector: The Centre for Scientific Research into Plant Medicine (CSRPM) was established by the Ministry of Health on November 2, 1973 and given legal recognition on July 10, 1975 by National Redemption Council (NRC) Decree 344. The Centre is governed by a Council whose members are appointed by the Minister of Health. The Centre is charged with the following responsibilities: (1) to conduct and promote scientific research relating to the improvement of plant medicine; (2) to ensure the purity of drugs extracted from plants; (3) to cooperate and liase with herbalists association and commercial organizations in any part of the world in the matters of plant medicine; (4) to publish and disseminate the research results and other useful information; (5) to establish botanic gardens for medicinal plants; and (6) to perform other functions as may be assigned by the Government. The Centre has an arboretum and a farm for the cultivation of medicinal plants, herbarium out-patients clinic, production and dispensary unit, phytochemistry, pharmacology/toxicology, microbiology and clinical analysis laboratories.

Part B. PROJECT JUSTIFICATION

B.1 Problem to be addressed

Production of standardized extracts from medicinal plants is the first step of commercialization of herbal preparations. These extracts can then be easily formulated into appropriate dosage forms. These extracts can be further purified if necessary to increase the quantity of active constituents to enhance their potency.

Standardized plant extracts can be produced from plant parts collected at the right time and have good keeping qualities. Their use in herbal medicines is independent of seasonal variations, hence guaranteeing steady supply and constant efficacy.

Despite rich untapped medicinal plant resources, Ghana does not produce extracts from indigenous plants at industrial scale. Development of industrial processing techniques shall not only create an industrial base in the country, but also generate new sources of income through import substitution or export. An immediate benefit of the exercise shall be the development of standardized herbal preparations. The largest pharmaceutical company in Ghana, GIHOC has expressed its willingness to scale up extraction processes developed by CSRPM at pilot scale from medicinal plants, and to formulate them into pharmaceutical dosage forms for commercial sales.

B.2 Expected end of the project situation

The following capabilities would be established at the Centre at the completion of the project.

a) Development of laboratory techniques for the production of extracts and essential oils.

b) Establishment of pilot plant facilities for the scaling up of techniques developed at bench scale.

c) Quality assurance at raw material, processing and finished product stages.

d) Setting up of a phytochemistry laboratory with modern spectoscopic, chromatographic and other instruments for physicochemical analyses, training of appropriate technical personnel.

e) Modernization of the library, establishment of information storage, retrieval and dissemination facilities.

B.3 Target beneficiaries

The primary target beneficiary would be the CSRPM which will have facilities for the development of process technology, quality control techniques and research in the area of medicinal and aromatic plants. In addition to transfer of technology, the technical capabilities and scientific knowhow of the scientific staff of the centre would be enhanced. The country will benefit from import substitution and export of medicinal plant extracts and essential oils. The technologies developed would be transferred to the private or public sector for the industrial production of crude and purified extracts and essential oils and their isolates. The people of Ghana would be the ultimate beneficiaries as consumers of good quality and low cost pharmaceuticals. The country's health care system would have reached larger portion of the population.

B.4 Project strategy and institutional arrangement

The Centre has been operational since 1973 with poor facilities for the research and development of plant based pharmaceuticals. Being the only research Centre of its kind, it needs strengthening of its phytochemistry laboratories and setting up of a multipurpose pilot plant in order to develop processing technologies for standardized extracts and essential oils from medicinal and aromatic plants. This is the basic strategy of the project. It will upgrade the competence and capabilities offered by the Centre.

Ghana exports plant raw materials and imports the total requirement of chemicals, solvents and pharmaceutical raw materials. As a result of the project, plant raw materials exported as such will be converted to value added products. This in turn will create a local industry which will result in the export of value added plant product and will also reduce the size of the import of pharmaceutical raw materials. The Centre will be equipped with the latest techniques for the development of process and quality assurance in the area of plant based pharmaceutical materials. International expertise will provide on the job training of scientists and interaction with local industries. Wherever appropriate the technical staff of the Centre will be trained abroad in specific areas. The Centre has planned expansion of the existing building to accommodate pilot plant facilities and new laboratories.

B.5 Reasons for assistance from UNDP/UNIDO

The Government has been interested for some time to establish a research base for the development of plant based pharmaceuticals within the country. Due to scarcity of expertise and concerted efforts in the country, it has not been possible for any project to this effect to take off the ground. Therefore the Government of Ghana decided to seek UNDP/UNIDO assistance to realize the fulfilment of its objective.

UNIDO's experience in this field including consultants and established contacts with other similar centres in the developed and developing countries could be highly valuable in executing the project.

B.6 Special considerations

In Ghana, most plant drugs used in herbal preparations are gathered from forest trees. If the Forestry Department embarks upon silvicultural and agroforestry programmes, maintaining a steady source of supply of raw materials to sustain a plant based pharmaceutical industry can be achieved and even an export

potential can be created. During logging operations of trees with medicinal use barks and other parts of the tree may be collected. This collection could be done by rural people living in forest villages, thus generating an extra source of income. Farmers could be encouraged to cultivate promising medicinal and aromatic plants and they could be supplied with field distillation stills to produce essential oils in their farms. They would do so if buying back is guaranteed. Many women would be employed in cultivation and harvesting of these crops.

The country's import bill of pharmaceutical raw materials could be considerably reduced.

B. 7 Coordination Arrangements

The project is to be managed by a Chief Technical Adviser who will work in close collaboration with the Director of the Centre. CTA will be responsible for the coordination of project objectives. He will also liase between the Government and UNDP/UNIDO for the healthy execution of the project. The Director of the Centre will be responsible for the fulfillment of infrastructural requirements and the provision of manpower and raw materials. He will work in accord with the CTA for a successful implementation.

B. 8 Counterpart Support Capability

The counterpart Centre CSRPM has been charged by the Government to undertake necessary steps for the standardized herbal preparations. The Centre has developed a certain degree of capability for the cultivation and post harvest treatment of plants and the production and dispensing of herbal preparations. The Centre has the capability of providing enough raw materials to sustain steady operation of a pilot plant. Moreover, the Centre works in harmony with Chemistry and Botany Departments of the University of Ghana, Faculty of Pharmacy of the University of Science and Technology, Council for Scientific and Industrial Research and GIHOC Pharmaceuticals Branch. Therefore, it may call upon their professional assistance, as required.

C. DEVELOPMENT OBJECTIVE

Production of pharmaceutical materials from the indigenous plant resources leading towards improved health conditions and industrial development.

D. IMMEDIATE OBJECTIVES

D.1 Strengthening of the existing facilities at CSRPM for the production and quality control of pharmaceutical materials based on indigenous medicinal and aromatic plants.

D.1.1 Output 1

Establishment of a multipurpose pilot plant and related facilities for the production of extracts and essential oils from medicinal and aromatic plants.

	Activities (24 months)	Responsible party
D.1.1.1	Construction of pilot plant building complete with all necessary infrastructure	CSRPM
D.1.1.2	Acquisition of pilot plant equipment and materials	UNIDO
D.1.1.3	Installation of equipment	UNIDO/CSRPM
D.1.1.4	Commissioning of the pilot plant	UNIDO/CSRPM
D.1.1.5	On the job training of staff by chemical technology expert	UNIDO
D.1.1.6	Training of staff abroad	UNIDO

D.1.2 Output 2

Laboratory and pilot plant processing of ten potential medicinal and aromatic plants for the production of standardized extracts and essential oils.

	Activities (36 months)	Responsible party
D.1.2.1	Selection and processing trials on ten already cultivated medicinal and aromatic plants	UNIDO/CSRPM
D.1.2.2	Acquision of laboratory scale equipment	UNIDO
D.1.2.3	Installation and commissioning of equipment and production of extracts and essential oils	UNIDO/CSRPM
D.1.2.4	Training of staff on site by phytochemistry expert	UNIDO
D.1.2.5	Training of staff abroad	UNIDO
D.1.2.6	Production of project profiles of ten selected plant materials	CSRPM

D.1.3 Output 3

Establishment of analytical procedures for the quality control of raw materials and products using modern analytical techniques.

	Activities (36 months)	Responsible party
D.1.3.1	Acquisition of equipment	UNIDO
D.1.3.2	Installation and commissioning of equipment	UNIDO/CSRPM
D.1.3.3	Training of staff on site by quality control expert	UNIDO
D.1.3.4	Training of staff abroad	UNIDO
D.1.3.5	Drawing up of standard analytical procedures for the raw materials and products produced in pilot plant	UNIDO/CSRPM

D.1.4 Output 4

Strengthening of library and documentation facilities

	Activities (36 months)	Responsible party
D.1.4.1	Acquisition of books and subscription to journals	UNIDO
D.1.4.2	Acquition of word processors, computers, software and printers	UNIDO
D.1.4.3	Installation and commissioning of equipment	UNIDO/CSRPM
D.1.4.4	Training of staff on the use of equipment	CSRPM/local consultants
D.1.4.5	Creation of a database with information on herbalists and their preparations with plant parts used therein.	CSRPM
D.1.4.6	Creation of a database on the botany, chemistry, pharmacology and ethnopharmacological aspects of the ten selected plants for processing.	CSRPM

E. INPUTS

E.1. Government inputs

E.1.1 Assignment of national staff

In addition to the national counterpart director a total of 15 scientific staff will be made available to the project. Furthermore, adequate support staff will be provided.

E.1.2 Building and facilities

Building for the pilot plant and laboratories with full infrastructure including water, electricity, steam, gas, watercooling, air-conditioning wiill be provided. All additional services such as telephone, telex, fax, photocopying, computer communication (if available), etc. and operational costs will be borne by the Government. Adequate quest house facilities at the project site for the experts will be provided by the Government.

E.1.3 Materials and supplies

Locally available glassware, equipment, raw materials and other consumables will be provided.

E.1.4 Office accommodation, transport and secretarial assistance needed for international experts will be provided.

E.1.5 Training services

Organization of programmes, photocopying of papers, typing of reports will be done by the Centre.

E.2. UNDP/UNIDO Inputs

E.2.1 Experts

Post	Title	Duration	US Dollars
11-01	Chief Technical Adviser	36 m/m	324,000
11-02	Chemical Technologist	9 m/m (3x3 m/m split missions)	75,150
11-03	Phytochemist	9 m/m (3x3 m/m split missions)	75,150
11-04	Quality Control Chemist	9 m/m (3x3 m/m split missions)	75,150
11-50	Short term consultant	3 m/m	25,050
13-00	Administrative support		
13-01	Secretary	36 m/m	12,600
13-02	Driver	36 m/m	7,200
17-00	National experts	6 m/m	6,000

E.2.2 Training

E.2.2.1 Fellowships

Post	Field	Duration	US Dollars
31-01	Pilot plant processing	4 m/m (2x2 m/m)	
31-02	Phytochemical techniques	4 m/m (2x2 m/m)	
31-03	Quality control techniques	4 m/m (2x2 m/m)	
		12 m/m	44,001
	E.2.2.2 Study tours (32-00)		15,000
	E.2.2.3 In-service training (33-00)		5,000
	E.2.3 Equipment (41-00 and 42-00)		785,000
	E.2.4 Other inputs		
15-00	Project travel		12,000
16-00	UNIDO Missions including TPR meetings		15,000
51-00	Sundries		20,000
		PROJECT TOTAL	1,496,301

F. RISKS

		Measures envisaged to deal with risks
F.1	Achievement of the outputs heavily depends on the timely completion of the pilot plant building with necessary infrastructure, together with an adequate guest house facility, at the project site, for international experts.	CSRPM should take necessary measures for the provision of budgetary funds and for the completion of the buildings before the start of project activities.

G. PRIOR OBLIGATIONS AND PREREQUISITES

None

H. PROJECT REVIEWS, REPORTING AND EVALUATION

H.1 The project will be subject to Tripartite Review (Government, UNDP and UNIDO) at least once every 12 months, the first such meeting to be held within the first 12 months of the start of full implementation. The Chief Technical Adviser, with the assistance of the senior project officer of the United Nations Executing Agency, shall prepare and submit to each tripartite review meeting a Project Performance Evaluation Report (PPER). Additional PPERs may be required, if necessary, during the project.

H.2 A project terminal report will be prepared for consideration at the terminal tripartite review meeting. It shall be prepared in draft sufficiently in advance to allow review and technical clearance by the executing agency at least four months prior to the terminal tripartite review.

H.3 The executing agency will conduct technical evaluation of the Project at appropriate stages, approximately at intervals of 12 months, the first one concurrently with the first Tripartite Review Meeting.

I. LEGAL CONTEXT

I.1 This project document shall be the instrument referred to as such in Article 1 of the Standard Basic Assistance Agreement between the Government of Ghana and the United Nations Development Programme, signed by the parties on 27 November 1978. The host country implementing agency shall, for the purpose of the Standard Basic Assistance Agreement, refer to the Government Co-operating Agency described in that Agreement.

I.2 The following type of revisions may be made to this project document with the signature of the UNDP resident representative only provided he/she is assured that the other signatories of the Project Document have no objections to the proposed changes.

a) Revision in, or addition of, any of the annexes of the project document
b) Revisions which do not involve significant changes in the immediate objectives, outputs, or activities of the project but are caused by the rearrangement of inputs already agreed to or by cost increases due to inflation and
c) Mandatory annual revisions which rephase the delivery of agreed project inputs or increased expert or other costs due to inflation or take into account agency expenditure flexibility.

Annexes:

1. UNIDO budget
2. Provisional list of equipment.

ANNEX 1

PROJECT BUDGET

Country: Ghana
Project number: DP/GHA/92/
Project name: PROCESSING OF HERBAL PHARMACEUTICAL MATERIALS BASED ON THE TRADITIONAL GHANAIAN THERAPIES

Code description	total		1992		1993		1994	
	m/m	$	m/m	$	m/m	$	m/m	$
10. Project personnel								
11 International Experts								
11.01 Chief Technical Adviser	36	324000	12	108000	12	108000	12	108000
11.02 Chemical technologist	9	75150	3	25050	3	25050	3	25050
11.03 Phytochemist	9	75150	3	25050	3	25050	3	25050
11.04 Quality Control Chemist	9	75150	3	25050	3	25050	3	25050
11.50 Short term Consultants	3	25050	1	8350	1	8350	1	8350
11.99 Sub Total	66	574500	22	191500	22	191500	22	191500
15.09 Admin support	72	19800	24	6600	24	6600	24	6600
15.00 Official travel	0	12000		4000		4000		4000
16.00 Mission Costs	0	15000		5000		5000		5000
17. National Experts								
17.01 Counter documentation	6	6000	2	2000	2	2000	2	2000
17.99 Sub Total	6	6000	2	2000	2	2000	2	2000
19.99 Component total	144	627300	49	209100	49	209100	49	209100
30. Training								
31.00 Individual fellowships		44001		14667		14667		14667
32.00 Group training		15000		5000		5000		5000
33.00 In-service training		5000		2000		2000		1000
39. Component total		64001		21667		21667		20667
40. Equipment								
41. Expendable		50000		25000		7500		7500
42. Non-expendable		735000		685000		25000		25000
49. Component total		785000		710000		27500		27501
50. Miscellaneous								
51. Survey		20000		6000		7000		8000
59. Component total		20000		6000		7000		8000
99. Budget tree total		1496301		953767		275267		267116

ANNEX 2

Provisional list of Equipment

A.	Pilot Processing Equipment	Estimated cost (US$)
1.	Multipurpose pilot plant and spareparts	290,000
2.	Steam generator	20,000
3.	Water cooling system	20,000
4.	Filter press	3,000
5.	Basket centrifuge	2,000
6.	Cold room (2 pieces)	10,000
7.	S/S storage tanks	10,000
8.	Large scale rotary evaporator	5,000
9.	Tray dryer	1,000
10.	Grinder	10,000
11.	Scales (2 pieces)	1,000
12.	Vacuum filter	2,000
13.	Mechanical tools set	1,000
14.	Metal working and welding equipment	5,000
15.	Glass blowing equipment for simple repairs	5,000
16.	S/S tubes, sheets, flanges, gaskets, etc.	5,000
17.	Expendables	10,000
		400,000

B.	Equipment for Phytochemistry/QC Laboratory	
1.	Laboratory glassware	5,000
2.	Vacuum pumps (3 pieces)	6,000
3.	Rotary evaporators (2 pieces)	5,000
4.	Glass Soxhlet extractors (various sizes, total 20 pieces)	500
5.	Glass Clevenger apparatus (8 pieces)	500
6.	Volumetric moisture content determination apparatus (10 pieces)	200
7.	Chromatography columns	300
8.	TLC Spreader + cut glass plates + developing tanks	1,000
9.	UV lamps (2 pieces)	750
10.	Hot air blower	50
11.	Buchner filtration setup	200
12.	Moisture balance	2,000
13.	UV/VIS spectrophotometer	20,000
14.	IR Spectrophotometer	35,000
15.	Electronic balances (Toploading: 2 pieces Analytical 2 pieces)	9,000
16.	Distilled water still (10L/h cap.)	1,500
17.	Water deionizer (300L/h cap.)	800
18.	Electronic polarimeter	3,500
19.	Abbe type refractometer	5,000
20.	Muffle furnace	3,000

21.	Laboratory centrifuge (10.000 rpm with tubes and rotors)	800
22.	Ultrasonic baths (2 pieces)	600
23.	Gas liquid chromatograph with FSC columns, ECD, FID detectors, integrator, chart paper, injectors, diskettes, split splitless injectors, spares	30,000
24.	High pressure liquid chromatograph with column oven, automatic injectors, detectors (RI, UV/VIS, conductivity, fluorescence), integrator, chart paper, diskettes, packed columns, spares	47,500
25.	TLC scanner	20,000
26.	Freeze dryer	30,000
27.	Fraction collector	2,000
28.	Microscopes (Binocular and stereo: 2 pieces each)	5,000
29.	Laboratory spray drier	25,000
30.	Drying ovens (2 pieces)	1,000
31.	Vacuum oven with vacuum pump	1,600
32.	pH meter/conductimeter (2 sets)	1,300
33.	Hot plate/magnetic stirrer (5 pieces)	500
34.	Heating mantles (9 pieces)	1,000
35.	Water baths (3 pieces)	500
36.	Circulating water bath	2,500
37.	Flask shakers (5 pieces)	500
38.	Automatic titrator	10,000
39.	Uninterrupted power supply (UPS)	10,000
40.	Voltage stabilizer	5,000
41.	Chemicals, solvents and other expendables	20,000
		314,100

C.	Office equipment	
1.	Word processors (3 pieces) + laser printer	12,000
2.	Computers (3 pieces) + printer	15,000
3.	Photocopier	5,000
4.	Fax machine	2,000
5.	Slide projector	1,500
6.	Overhead projector	1,000
		37,500
D.	Books and journals	15,000
E.	Project vehicle	20,000
	Total equipment budget	786,600

Backstopping Officer's Technical Comments based on the Fact-finding mission report of K.H.C Baser and S. Balasubramaniam

The consultants have submitted a very comprehensive report and a draft project document for technical assistance in the processing of herbal pharmaceutical materials based on Ghanian therapies.

The report has reviewed the past activities in this area and critically evaluated the earlier reports on the subject. The consultants have visited the relevant institutes to gather the required information and made a very realistic assessment in making their final recommendations.

The proposal has also been discussed in detail with the counterparts, the government authorities and the Resident Representative of the UNDP. It is hoped that the project will be approved for IPF funding. The project will develop tl.. technological capabilities and support the health care delivery system of Ghana.