CHEMONICS INTERNATIONAL INC.

REPORT ON A VISIT TO THE CONTROL LABORATORY AT THE PYRETHRUM PROCESSING PLANT (SOPYRWA) RUHENGERI, RWANDA

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1. SUMMARY

The report describes an examination of the facilities of the control laboratory of the pyrethrum processing factory owned by SOPYRWA (Société de Pyrèthre au Rwanda), sited at Ruhengeri, in order to re-establish its operation. The fabric of the laboratory was found to be in good order and its size and design suitable for the purpose in mind. There is also a considerable amount of useful equipment and chemicals. However, many of the chemicals are not required for pyrethrum analysis and it is suggested that these be relocated in suitable locations. Some simple modifications to the structure of the laboratory are proposed and the additional equipment required for basic pyrethrum analysis identified. Staffing requirements and related job descriptions are outlined. The timing of the second visit, in which the laboratory is to be commissioned and staff trained, was discussed and is likely to be during the four week period July 22nd to August 17th.

2. INTRODUCTION

The purpose of this mission was to examine the existing facilities of the control laboratory of the pyrethrum processing factory owned by SOPYRWA (Société de Pyrèthre au Rwanda) in order to re-establish its operation to enable:

1. control of the operation of the flower extraction plant,
2. control of the refining operation;
3. provide assistance in a crop improvement programme.

The programme of work is divided into two parts, a preliminary visit to establish just what is required by way of staff, equipment and chemicals and a second, to install any additional equipment, set up control analyses and train staff. This report describes the findings of the initial visit and details the work to be carried out by both SOPYRWA and the consultant prior to the second visit. The full "Scope of Work" is presented in Appendix 1 while the visit itinerary and a list of the "persons met" are recorded in Appendix 2 and 3 respectively.

3. EXISTING LABORATORY FACILITIES AND SUPPLIES

The laboratory was found to be in a good state of repair and has a very adequate working area combined with an office and a small sample grinding room. The well designed building has a high ceiling which, in addition to providing a sense of space (see Figure 1), greatly reduces the risk of fire that is associated with the use of highly inflammable solvents in confined areas.

Although the laboratory has not been in active use for a number of years it has an excellent selection of basic equipment, much of which is unused. Most of the equipment required for performing the chemical (AOAC) analysis is in place. However, the volumetric flasks and spectrophotometer required for the plant screening assay and the general control of the processing plants are absent and will have to be purchased. There is also a plentiful supply of solvents and chemicals. The latter have been carefully stored and indexed which greatly assists in the work in hand (see Figure 2).

There are three balances including an old four-place analytical balance (mechanical, 1950's technology) which is presently slightly under-weighing. It is highly likely that when cleaned its performance will prove to be satisfactory. The two place electronic balance will be satisfactory for the spectrophotometric flower analysis. An indication of the range of major items of equipment on site, together with an approximate catalogue value is presented in Appendix 4.

4. SUGGESTED MODIFICATIONS TO THE LABORATORY.

Although several of the laboratory benches have sinks they are small and unsuited to washing glassware. The laboratory is equipped with two fume cupboards but the operations envisaged only require the use of one. The fume cupboard located immediately to the right hand side of the entrance door is not operational and the glass in the front window is broken. It is suggested that this is dismantled and replaced by a large sink supplied with both hot and cold water. The base unit of the cupboard could remain and be adapted for this purpose.

Spare laboratory equipment and laboratory chemicals are presently kept in three storage areas remote from the laboratory. It is suggested that these be kept in a newly created storage area adjacent to the laboratory. This could be achieved by partitioning off an area in the store, which is adjacent to the laboratory, and linking it by making a door to the grinding room.

Presently some of the drawers from laboratory benches are in the stores. These should be returned to the laboratory. Many of the drawers and cupboard doors in the laboratory do not open and close smoothly and require suitable adjustment. All the drawers should be lined with "bubble wrap" which should then be fixed with drawing pins (preferably ones covered in plastic). The bubble wrap will serve to protect stored glassware.

All the electrical supplies in the laboratory should be tested and the wall fixings of switches and sockets checked.

The Manesty still, which produces distilled water required for the AOAC analysis, requires servicing. It may be necessary to replace the heating elements which should be standard kettle elements.

5. ADDITIONAL EQUIPMENT REQUIREMENTS

5.1. Spectophotometric Analysis

The spectrophotometric method for the analysis of fresh pyrethrum flowers requires a dryer, a knife mill for grinding the dried flowers, equipment in which the "pyrethrins" are extracted into a solvent, volumetric flasks & pipettes (for sample dilution) and a spectrophotometer for measurement. The spectrophotometer measures the ability of the "pyrethrins" to absorb UV light.

A small oven was found in the laboratory and it is understood that this is not working and will require replacement. However this is not suitable for drying the fresh flowers. A large fan ventilated used oven has been found in the UK but at a cost of £500 (excluding what would probably be a very high transportation cost) this has been excluded. It is proposed that a dryer be constructed locally using domestic fan heaters as the heat source. Two such heaters, each having variable fan speed and a choice of one or two kW. heat output were taken to Rwanda on the present visit. A suggestion for constructing the dryer is given in the Action List.

The knife mill presently available is suitable for large flower samples i.e. flowers from the factory. The crop improvement programme could well require the analysis of flowers taken from a single plant and while the present mill can handle such samples a smaller mill would be more appropriate.
A broken small mill was seen in one of the stores and this will be examined in the hope that it can be repaired.

The traditional method for extracting the "pyrethrins" from the dried flowers is through the use of a Soxhlet Extractor. It is clear from the nature of the equipment presently in the laboratory that this is the method that was previously employed. It is proposed to introduce a simple cold extraction method that involves weighing the ground flowers into a volumetric flask adding solvent and shaking. Suggestions have been made to enable the modification of the existing shaker for this purpose. This will allow the analysis of 25 samples in duplicate or 50 samples if the equipment is used twice daily.

A small number of volumetric flasks were found but insufficient for the number of analyses predicted (50 per day). The following will have to be ordered new:

- 100ml volumetric flasks (class B) x 60
- 50ml volumetric flasks (classB) x 60
- 1 ml pipettes
- 2 ml pipettes
- 5 ml pipettes

This equipment will allow for the analysis of 25 samples a day in duplicate or 50 single analyses. Depending on the level of agreement found in the duplicate analyses it may be possible to use single analyses for the crop improvement analyses. Note - the above purchase includes ten additional flasks to allow for breakage.

Four old spectrophotometers were found but unfortunately these were all judged to be beyond repair. New instruments cost around £3,500 but a used one has been located at a cost of £1,000 (£1,450 inclusive of packing and delivery by air). This has been tested and found to be suitable for the purpose required.

The spectrophotometer requires calibration against the AOAC analysis and a separate calibration is required for each type of extract (direct from flowers, pyrethrum marc, crude extract and refined extract). It is understood that we may be able enlist the aid of the Pyrethrum Board of Kenya (PBK) in Nakuru for at least part of this calibration procedure. However, although direct calibration is highly desirable approximate conversion factors are known and can be used if necessary.

The spectrophotometric analysis consumes large volumes of petroleum solvents. It is to be hoped that the solvent presently employed in the primary extraction plant will prove to be suitable for this purpose. It is fortunate that the equipment required for solvent recovery is already in place.

5.2. Chemical (AOAC) Analysis

This is the basic method of "pyrethrins" analysis against which all other methods are calibrated. The method has a reputation among analysts as being one of the most difficult in the AOAC methods book. The major items of glassware required are to hand and it will be possible to run the method and time will reveal the level of success to be achieved.

5.3. Other Analyses

Other analyses to be carried out include sieve analysis for the ground flowers and moisture determination. The basic equipment for the sieve analysis is available although additional sieves may be required at a later stage. Moisture content will require the use of an oven set at 101°C. A new oven has been identified for this purpose at a cost of £580 including delivery by air. The purchase of an infra-red lamp and holder will be given consideration as this allows a rapid estimation of the moisture content of flowers.

5.4. Additional Items of Equipment

Two major additional items of equipment are

a. a fridge/freezer and

b. a computer (loaded with "word" and "excel") and printer

Some minor items of equipment required include, timers, rubber gloves, safety spectacles, wash bottles and moisture content dishes.

6. LABORATORY CHEMICALS

The laboratory has a very large stock of chemicals many of which are not required for pyrethrum analysis. For example there is a large stock of nitric acid. It is recommended that this stock be carefully examined with the aim of reducing it to that required for pyrethrum assay together with a small stock of materials that might prove to be of use at some future date. Some of the chemicals might find a good home in the chemistry department of a technical college. Sulphuric acid which is excess to requirements might possibly be sold to a battery manufacturer.

It is estimated that the essential tasks of sorting these chemicals and generally organising the laboratory and stores will take at least 3 days at the initial part of the second visit.

Two chemicals that have been identified for purchase are sodium hydroxide pellets and potassium hydroxide pellets. Factory management has been requested to see if these are available locally (see ACTION LIST). A small quantity of potassium hydrogen phthalate is also required as a primary standard.

7. STAFF REQUIREMENTS AND BRIEF JOB DESCRIPTIONS

It is envisaged that the laboratory will initially operate with a staff of eight made up as follows:

1. A Chief Chemist - a chemistry graduate preferably with some laboratory experience.
2. Five Assistant Chemists - with qualifications in chemistry.
3. Two Laboratory Attendants.

Chief Chemist

The chief chemist will be responsible for ensuring that

a. All analytical procedures are carried out safely and as described in the analytical methods.
b. Equipment such as balances and the spectrophotometer are functioning within specification.
c. The strength of reagents used in the AOAC analysis are correct.
d. Extract sampling is carried out correctly.
e. Analytical results are reported promptly to management.

In addition the chief chemist will, at least initially, personally start and complete the AOAC analysis and take a keen interest, working with factory management, in monitoring and possibly improving the performance of the extraction and refining plants.
It is understood that the person appointed may be able to spend some two weeks training at the PBK laboratories in Nakuru. **Such training would be highly valuable and, if available, is highly recommended.**

Assistant Chemists

The assistant chemists will carry out the whole of the spectrophotometric analysis, including grinding when necessary, and also the numerous intermediate steps in the AOAC analysis. To allow flexibility, it is important that they can all participate in both analyses. They may also be required to undertake the duties of the laboratory attendants as the situation demands.

Laboratory Attendants

The laboratory attendants will be responsible for maintaining the cleanliness of the laboratory including the washing of glassware. Additional duties will include, grinding flowers, carrying out sieve analyses and solvent recovery.

Sampling

The decision on what routine samples are taken, how they are taken and who takes them will be made during the second visit.

8. PYRETHRINS CONTENT OF FOUR FLOWER SAMPLES

Four flower samples have been analysed for "pyrethrins" content using the spectrophotometric method. The results were as follows:

Source	Pyrethrins content (%)
Bisate	1.27
Musanze	1.31
Kora	1.37
Susa	1.37

Although only approximate these results offer a fair indication of the content of these particular samples and, as such, are somewhat disappointing.

9. ACTION LIST

This Action List was sent on May 9th to:Paul Muvunyi, Gideon Kayinamura, Maurice Weiner and Damtien Tchintchibidja (J E Austin Associates)

9.1. Actions by SOPYRWA

1. As discussed, remove upper section of fume cupboard (RHS of entry door); install a large sink with the provision of hot and cold water supplies. Tap outlets should be sited at least 30cm above the edge of the sink to allow large items of glassware to be rinsed.
2. Purchase fridge/freezer
3. Section off ¼ of the store area (behind the grinding room) – include a door to allow entry from the remaining part of the store. In the grinding room, remove a section of the bench (as discussed) and brickwork to create an entrance from the laboratory to the newly created store. Install lighting in new store with switch close to the new door from the laboratory.
4. Ensure that all the drawers ex laboratory that are presently in two stores are returned to the laboratory. Ensure that all the drawers and cupboard doors open and close smoothly. Line all the drawers with "bubble wrap" and fix with drawing pins (preferably ones covered in plastic). The bubble wrap will serve to protect stored glassware.
5. Examine the availability and cost of "analytical grade " sodium hydroxide pellets and potassium hydroxide pellets in Rwanda. We need to decide whether to purchase these in the UK and ship with equipment. URGENT
6. Modify shaker as instructed (ref Ildephonse Bukarani) so as to accommodate fifty 100ml volumetric flasks.
7. Locate a cabinet that can be used, together with the fan heaters, to make dryer for the fresh flowers. If one can be found, an old soft drink cooler would do the job well - insulated sides and lots of shelves (contact Coca Cola!). I will do the modification during my next visit.
8. Check all electrical supplies in laboratory and ensure that the wall fixings are secure.
9. Clean and service Manesty still (produces distilled water required for the AOAC analysis). If necessary replace heating elements which should be standard kettle elements.

9.2. Actions by the consultant

1. Prepare report on initial visit.
2. Analyse 4 samples of flowers (brought from Rwanda) for approximate "pyrethrins" content
3. Purchase spectrophotometer and oven as discussed and arrange for transport by DHL.
4. Organise payment for the above (required prior to despatch) with SOPYRWA. URGENT
5. Organise the collection of additional equipment required (as identified during the visit) and ensure availability at the laboratory at the time of the second visit.

9.3. Timing of the second visit

The date of the second visit was discussed and is likely to be during the four week period July 22nd to August 17th.

APPENDICES

APPENDIX 1: SCOPE OF WORK

Pyrethrum Laboratory Training and Technical Assistance

Background

USAID/Rwanda's Strategic Objective Number Three (SO3) seeks to increase the ability of rural families in targeted commodities to improve household food security by positioning agribusiness operators and their entire commodity sectors on sustainable and expandable growth.

To facilitate the agribusiness private sector revitalization in Rwanda the USAlD mission has under a RAlSE lQC designated Chemonics lnternational lnc., a Washington DC-based consulting firm with agribusiness experience in over 100 countries, to implement the mission's Agribusiness Development Assistance in Rwanda (ADAR) project. The ADAR project seeks to:

- Add value to key commodities targeted for export
- Build efficiency and expand employment within commodity chains
- Upgrade managerial and technical capability in agribusiness enterprises
- Improve product quality and expand access to markets
- Develop financing options to support agribusiness growth

Special Features and Benefits in the ADAR program include the following:

Agribusiness Centre (ABC) to serve as the "Information Central" for Rwanda's agribusiness community offering current market information, expanded commercial contacts, and technical assistance, all to keep motivated agribusiness operators informed. Special Initiatives to break through operational, market, technical and financing obstacles which may confront enterprises seeking to accelerate sales and export. Training through carefully prepared modules to sharpen production, marketing, planning and financial management skills, and through less formal workshops and seminars, both on a continuing basis to improve client enterprise performance Financial Access through a program of orientation and training for bankers and for professionals offering agribusiness support services to individual enterprises and associations that need to apply for credit.

Objective and Nature of Services Required

During the second quarter of 2001, ADAR provided strategic planning to SOPYRWA (Société de Pyrèthre au Rwanda) management, assisting with the development of the company's business plan. Although the market for pyrethrin, as the extract is known, is cyclical in nature, with periods of under supply and over supply, the opportunity to create significant value added is substantial, prompting ADAR, from project outset, to develop a close working relationship with factory management.

In response to a request by factory management, ADAR consultants conducted in September 2001 a detailed technical analysis of the factor. As a result of advisory services provided by the project, SOPYRWA greatly expanded the area under flower production and increased the price paid to producers from 250 FRW to 400 FRW.

The consultants identified several initiatives required to improve product quality and company profitability. These especially included the establishment of a quality control laboratory to monitor what is going on in the factory and in the production fields, it has to be done with good laboratory control.

SOPYRWA needs to keep a very tight control over their agricultural production and maximize the output of pyrethrins (not just flowers) without increasing costs. Factory efficiencies must improve also. To find the suitable planting materials that probably exist in the present cultivated areas, large numbers of samples will have to be screened. The laboratory will need to analyze large number of samples on a daily basis, certainly upward of 50 per day.

Specific Tasks to Be Performed

The objective of this consultancy is to provide advisory services to help SOPYRWA get the laboratories working again and train technical staff in analytical methods, specifically the spectrophotometric method and, if possible, the AOAC method. This will entail new equipment selection and installation as well as re-establishing a laboratory to analyse the level of both raw and processed material.

The consultant, working with factory management, will establish a system of sampling and analysis to assist in the assessment of factory performance.

First visit

After having secured the right additional equipment required for the Laboratory and located a quantity of used equipment that could be obtained at low cost, the Consultant will come for a short initial visit to judge whether any additional equipment is required and to prepare the training program for his second visit.

Second visit

The Consultant will need a break of at least three weeks between the visits so that any work related the laboratory could be carried out. The second visit will be mainly focused on training for the staff to master the technique on methods related to the spectrophotometer and also in the AOAC analysis. The length of the second visit will depend on the skills of the laboratory technicians.

It should be noted that the AOAC method of analysis is challenging, even for experienced analysts, and if the laboratory staff have limited experience it may not be possible to train them fully within three weeks.

APPENDIX 2 : PERSONS MET

SOPYRWA Staff

- Paul Muvunyi, Chairman.
- Gideon Kayinamura, General Manager.
- Augustin Nsengimana, Personnel Manager.
- Ibrahim Nizigiyimana, Stock Manager.
- Alphonse Ruhan, Laboratory Technician.
- Ildephonse Bukarini, Maintenance Technician.
- Janetti Ingabire, Candidate for the position of Chief Chemist.

ADAR Project Staff

- Geoffrey Livingston, Chief of Party.
- Maurice Wiener, Deputy Chief of Party.
- Anastase Murekezi, Senior Technical Cadre.
- Jean-Pierre Ruvuzandekwe, Office Manager.

APPENDIX 3: AN INDICATION OF THE RANGE OF EQUIPMENT PRESENTLY AVAILABLE AT THE LABORATORY TOGETHER WITH AN APPROXIMATE VALUE

Item	**Quantity**	**Value in £**
Knife mill	1	500
Sieve shaker and a set of seives	1	200
Top pan balance (Kern) capacity 3,100g, resolution 0.1g.	1	350
Top pan balance (Kern) capacity 2,600g, resolution 0.01g.	1	1,000
Six place Soxhlet heaters for 500m; flasks	2	1,600
Six place Soxhlet heaters for 250m; flasks	2	1,500
Complete sets of glass Soxhlet extractors	12	1,200
Buchi R300 Rotary Evaporator	1	1,000
Mechanical vacuum pump	1	500
Refrigerator unit with circulating pump (for cooling condenser wat	1	900
Six litre heating mantles	2	500
Heidolf equipment shaker	1	400
Large single place water bath (electrically heated)	1	300
Six place (8cm diameter holes) water bath	1	300
Large hot plate	1	300
Electrical heat controllers (energy regulators)	2	150
Glass distillation columns (for solvent recovery)	2	100
Sets of glass separating funnels for the AOAC analysis (more in sto	2	700
Total estimated value (excluding freight) -		**£13,300 ($19,00**

APPENDIX 4: ITEMS OF EQUIPMENT TO BE PURCHASED

1.Spectrophotometer: Refurbished Cecil 599 double beam instrument with a range from 200nm to 800nm.
Supplier Spectro-Service Ltd of Brackley UK NN13 7UG

- Cost of instrument £1,000
- Cost of packing £200
- Estimated cost of freight £250 (see note 1)

Total estimated cost **£1,450**

2. Oven New Memmert model UM200, range 30 to 220°C, gravity convection with mechanical temperature controller with fixed safety cut out. 32 litre capacity.

Supplier VWR INTERNATIONAL , Merke House Poole, BH15 1TD

- Cost of oven £380 (see note 2)
- Estimated cost of freight £200 (see note 1)

Total estimated cost **£580**

3. Fan Heaters Estimated cost £16 each, two required.

Total estimated cost **£32.**

4. Glassware for the Spectrophotometric Analysis

- 60 x 100ml volumetric flasks @ £6.40 £384.00
- 60 x 50ml volumetric flasks @ £5.65 £339.00
- Pipettes (1ml) pack of 12 £21.86
- Pipettes (2ml) pack of 12 £26.83
- Pipettes(5ml) pack of 6 £16.21

Total **£787.90**

Estimated total cost including freight **£1,000**

Supplier VWR INTERNATIONAL , Merke House Poole, BH15 1TD. It should be possible to obtain a discount on these items.

5. **Sundries**

Item	**Quantity**	**Value in £**
Safety visor 1@10.75	1	10.75
Safety Glasses 4@£5.24	4	20.96
Protective gloves (disposable)	-	30.00
Eyewash station	-	19.33
Countdown timers mechanical 2@£11.43	2	22.86
Electronic timers 3@£9.90	3	29.70
Potassium hydrogen phthalate 2 x 100g		21.64
Wash Bottles (500ml) for hexane (x5)		18.43
Wash bottles (500ml) for water (x5)		12.83
Wash bottles (500ml) plain (x5)		9.77
Total		**196.27**

Supplier VWR INTERNATIONAL, Merck House Poole, BH15 1TD. It should be possible to obtain a discount on these items.

SUMMARY

1.	Spectrophotometer	£1,450
2.	Oven	£ 580
3.	Fan heaters	£ 32
4.	Glassware	£ 1,000
5.	Sundries	£ 196
Total (rounded)		**£3,260**

Notes:

1. The freight cost is estimated because we do not have the exact equipment weights. The equipment will be shipped by DHL using a special rate obtained through the group for whom the consultant is working (RSSL) thus obtaining considerable saving.

2. This is a new oven chosen for its simplicity. It should be possible to keep this serviced in Rwanda. The cost includes a 12.5% discount obtained by ordering through RSSL who are a very large customer of Merke.