

FINAL TECHNICAL REPORT

PROJECT R6087 (A0363)

Improving small-scale extraction of coconut oil

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EXECUTIVE SUMMARY

This project provided co-financing for a Common Fund for Commodities (CFC) contract aimed at developing, field testing, and promoting improved techniques for extracting coconut oil at the small rural and domestic scale, for which traditional methods are arduous, time consuming and inefficient.

Five coconut processes were researched investigated:

- aqueous processing
- hot oil immersion drying
- waste heat recovery technology
- ram press, and
- the intermediate moisture method.

Country collaborators were

- **Tanzania** - National Coconut Development Programme, (now the Mikocheni Agricultural Research Institute), Dar es Salaam.
- **Côte d'Ivoire** - Marc Delorme Coconut Research Station (DPO/IDEFOR), Port Bouët.
- **Ghana** - Technology Consultancy Centre, University of Kumasi.
- **India** - Coconut Development Board, Kochi.
- **Sri Lanka** - Coconut Development Authority, Colombo.
- **Indonesia** - Institute for Research and Development of Agro-based Industry, Bogor.

Dissemination was provided by both the African Oil Palm Development Association (AFOPDA) and the Asian and Pacific Coconut Community (APCC).

Final Technical Reports have been prepared for each of the five processes and these are attached to this report as Annexes 1-5 respectively. A summary of the main findings is presented below.

Aqueous Process

(Annex 1 contains a comprehensive technical report for this process)

Experimental programmes were undertaken by collaborators in Tanzania, Côte d'Ivoire, Ghana, and India. A review of the aqueous processing system was carried out in these countries as well as in Brazil and Guyana. Field trials in Africa have demonstrated that the extraction efficiency of the Aqueous Process could be significantly increased by avoiding losses (eg spillages) during processing. A sequential washing process used in Ghana was found to be highly efficient compared with the Côte d'Ivoire process. The India collaborators have developed and tested the aqueous method using a mechanised screw press and they sell the dried pressed cake for inclusion in curry preparations.

All the African collaborators examined the effect of commonly available additives such as salt and citrus juices on cream formation in order to speed up separation by breaking the oil/water emulsion thus allowing the process to be completed in a single day instead of the two days normally taken. Of the additives examined both salt and citric acid (in the form of lemon/lime juice) had some effect but not sufficient to warrant their routine use. However, citric acid was shown to act as a preservative and this can be used to advantage if it is known that cream skimming is likely to be delayed beyond the normal overnight period.

The introduction of a rotary grater, as part of project activities in Tanzania, clearly represents an important process improvement. The grater can provide an increase in oil yield in excess of 30% over that given by the traditional grater. The mean oil extraction efficiency (OEE) was found to average 62%. The grater also reduces grating time and is less arduous to use than the traditional grater. The positive correlation between oil and protein transfer into coconut milk (an intermediate step in oil production as well as being a foodstuff consumed in its own right) has the wider implication that milk produced from fine particles (ie from a rotary grater as opposed to the traditional scraper) has improved nutritional value over milk obtained from coarse gratings.

This project has highlighted the diverse nature of what is still a very important process in many coconut producing countries. The process has a reputation for producing poor quality oil in low yield. The work carried out within this project has shown that this poor reputation is totally unjustified.

Hot oil immersion drying (HOID)

(Annex 2 contains a comprehensive technical report for this process)

Hot oil immersion drying (HOID) is an indigenous method of producing coconut oil by drying the chopped meat (kernel) of the coconut in a pan of hot coconut oil. As part of the extraction process, the dried products are subsequently screw pressed to extract the coconut oil. This “fry-dried” oil is known locally as *kilang oil*, and has a distinctive flavour favoured in some parts of Indonesia. *Kilang oil* can be consumed locally without further refining, or sent to a refinery, where refining costs are significantly lower than for normal oil from copra.

The market for coconut oil is being squeezed by growing sales of cheaper palm oil, especially in the rural areas. Consumer taste trials showed that although *kilang oil* was liked in preference to palm oil or aqueous extracted coconut oil, refined oil was preferred to *kilang oil*. Factors mitigating against *kilang oil*, were the variability in its quality and the short shelf-life - not more than 6 months.

Research was conducted by Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement (CIRAD) in Montpellier on the shelf-life of *kilang oil*, which indicated great variability depending on the conditions of production and storage. Laboratory trials were conducted to determine an optimal mix of temperature, coconut particle size, stirring required and drying times. Tests were carried out to determine the number of times the same oil can be used to dry fresh

batches of coconut meat. It was found that oil could be used up to 18 times without deterioration in quality.

To determine the efficiency under actual operating conditions, two factories using the HOID system were selected - one at Gorontalo, N. Sulawesi and one at Padan Pariaman, West Sumatra. The former had a throughput of 1,250 nuts per day or 250 kg of copra equivalent, the latter had a capacity of 5,000 nuts per day or 1,000 kg of copra equivalent. It was concluded that the “fry-dry” process was a financially attractive proposition, although the 5,000 nuts per day operation had a higher rate of return due to economies of scale.

A commercial collaborator was identified in Pontianak, West Kalimantan, and a furnace and frying pans (designed by NRI in conjunction with the Indonesian collaborators - the Institute for Research and Development of Agro-based Industry - IRDABI), were installed, commissioned and monitored. Technical data as well as financial data on costs and sales were recorded for a period of four months, when the factory was running at full capacity.

To see how the HOID compared with more traditional methods of coconut oil extraction on the same scale, three models were developed using data from the Pontianak area. The three models were:

- HOID system, using fresh coconut kernel as feedstock
- A copra manufacturing and milling operation, using whole nuts as feedstock
- A copra mill, buying variable quality copra from farmers as feedstock

All three systems were rated at 1 tonne of copra equivalent per day. For the purposes of the model, it was assumed that all the equipment would result in a similar oil yield. The results showed that the HOID gave an internal rate of return (IRR) of 32%, whereas the copra processor and mill obtained an IRR of 37%, and the mill alone, 41%. However the price of fresh meat that the HOID was paying was higher, in equivalent terms, to that of whole nuts and copra being bought by the traditional systems. Additionally, it was not likely that the copra mill buying-in copra would be able to achieve the same out-turn of oil as the HOID based on the survey of current practices. The oil yields obtained for the HOID process and that of the copra mill only systems were 57% and 55% respectively. Based on these yields and a plant with a throughput of 5000 nuts per day, the IRR for the HOID was 40% and that of the copra mill only was 32%.

Although the HOID did not show itself to be commercially superior to the traditional copra system for the same oil extraction efficiency, it nevertheless showed itself to be a promising technology. In particular, it is technically a more efficient system, it allows better operating conditions for workers as it has a markedly lower dust and smoke levels, and produces a better quality oil for direct consumption or for further refining.

The deciding factor from the investors point of view on whether to establish a HOID system will be:

- The premium that can be obtained for HOID oil over copra oil on the local market, and / or in the refinery market;
- The price at which nuts can be obtained, and the ability to secure a regular supply;
- The ability to sell by-products from the coconut - notably the shell, which will effect the form the feedstock should be purchased - as dehusked nuts or fresh meat.

This study has built up an understanding of design criteria for HOID and the commercial factors to be considered in operating a HOID system.

Waste Heat Recovery Technology

(Annex 3 contains a comprehensive technical report for this process)

Charcoal produced from coconut shell is traditionally made using the pit or drum methods produce large volumes of noxious smoke and variable quality charcoal often contaminated with extraneous matter such as earth, leaves and twigs. The traditional systems can be inefficient and pollute the surrounding areas. Consequently charcoal-making is banned in urban areas and near to village residences.

A coconut shell carbonization with waste heat recovery unit has been developed to virtually eliminate the evolution of noxious smoke evolved during the charcoal-making operation and simultaneously enable the heat generated during the process - heat normally lost to the surroundings - to be used in the production of copra.

This Waste Heat Unit (WHU) is produced in two sizes : 8 m³ and 16 m³. The standard kiln with a capacity of 8 m³ is designed to produce approximately 0.45 - 0.5 tonnes of charcoal from 1.5 tonnes of shell per 10 to 12 hour operation. The WHU system consist of two WHUs, a heat exchanger/furnace system, a dryer fan and tunnel copra dryer capable of a producing approximately 0.9 tonnes of good quality charcoal and 3 tonnes of copra per day; provided the two WHU kilns are operated alternately on a semi-continuous basis. The system was installed, commissioned and monitored at a site in Palembang, Sumatera.

To operate the copra factory with twin WHU for 250 days operation with throughput of 3 tonnes copra per day requires minimally 1,250 Ha of coconut area. It is assumed that 1 Ha coconut plantation can produce 5,000 nuts/year. The capacity of twin kiln WHU is 15,000 whole coconut shells/day. The system has been shown to be financially viable with internal rates of return of around 33%; but these will vary with each case as labour, prices of the feedstock and raw material costs and markets vary with the site of the operation.

The system could be adapted and used for the provision of process heat in associated coconut production operations, such as dual-firing (kiln gas plus solid fuel) boilers for

raising steam; for providing heat for hot oil immersion drying (fry-drying kernels); for providing drying air to dry other products and crops.

The economic viability of the WH technology depends largely on obtaining a premium for the copra produced and a ready market for the charcoal. The quality of the copra from the system is superior to traditional copra but does not always command a premium price. It may have greater potential elsewhere in Indonesia as an energy source for the HOID.

Ram press

(Annex 4 contains a comprehensive technical report for this process)

Experimental programmes were undertaken by collaborators in Tanzania, Côte d'Ivoire, and Ghana to examine the performance of the ram press on copra, dried coconut gratings, and the residue from the traditional aqueous process. The press was found to be able to extract between 4.5 and 5.5 litres of oil from 10 kg of copra or dried coconut gratings, whilst from 10 kg of aqueous processing residue between 3 and 4 litres could be recovered. Both yields represent oil extraction efficiencies of over 60%. Ghana additionally examined the performance of the press on the residues from the Intermediate Moisture Content, with similar results. Throughputs were, in general, higher in Tanzania than in the other collaborating countries, reflecting their familiarity with the operation of the equipment gained from its extensive use in rural sunflower seed oil extraction.

Field trials of the ram press using residues were initiated by all collaborators at Women's Groups in rural areas. In Tanzania, where batch sizes for the aqueous process are relatively small (10 to 20 coconuts), the press proved extremely popular, and several Women's Groups, other than those initially selected for the trials, acquired a press and were trained in its use by the collaborator. The care taken with drying the residue before pressing determines whether the oil is suitable for edible use or can only be used as a raw material for soap manufacture, and both options were taken up. In Tanzania trials of the ram press showed a mean throughput of 4.6kg/hr of dried residue from the aqueous process producing an oil extraction efficiency of 70%. A financial appraisal in Tanzania showed that viable ventures could be based on the technology.

In contrast, the field trials in Ghana and Côte d'Ivoire proved short lived at all the sites selected, with the Women's Groups showing little interest in the press, finding it too arduous to use and of too low a throughput in comparison with the quantities of residue available. The rural coconut processing industry in these two countries operates on a scale much larger than that in Tanzania, typical batch sizes being 2,000 to 3,000 coconuts. The financial appraisal also concluded that the Ram Press ventures in these countries would not be viable at the throughputs obtained during the field trials.

Intermediate moisture content

(Annex 5 contains a comprehensive technical report for this process)

Experimental programmes were undertaken by collaborators in Tanzania, Côte d'Ivoire, Ghana, and Sri Lanka and confirmed the basic concept that at a 12% moisture content, between 60% and 70% of the available oil can be extracted from

coconut kernel using an inexpensive manual low pressure system. Mixing fresh and dried gratings appeared to give the most reliable outcome of attaining the required moisture content of coconut gratings. The drying of gratings in a field situation has posed problems for many collaborators (disturbance by livestock, birds and wind). To overcome this, solar dryers have been examined in Côte d'Ivoire and Ghana, and drying by frying in Ghana and Tanzania.

The yields of oil produced by a simple manual bridge press during field trials carried out with Women's Groups in rural areas have consistently given between 4 and 5 litres per 10 kg of kernel, which represents an oil extraction efficiency of over 60%. The oil produced is distinct from that from the traditional aqueous process and comments on its superior colour and flavour have been common, but only in Ghana and Sri Lanka does this appear to be reflected in a higher market price. Financial appraisals of the method have produced a range of outcomes depending on the assumptions, but ventures were found to be viable under certain circumstances in all collaborating countries.

The advantages of the method, when compared with the traditional aqueous process, have been recognised by all collaborators and participants:

- no water or firewood are needed for the process,
- oil extraction can be completed in one day; and,
- the oil yield is comparable or higher and oil quality is generally superior.

Disadvantages of the method as a practical procedure include:

- the difficulties of drying the gratings in the field, and,
- the capital cost of the press.

Financial appraisals of the method have produced a range of outcomes depending on the assumptions, but ventures were found to be viable under certain circumstances in all collaborating countries.

Dissemination

As a result of the research carried out on the five processes outlined above, numerous reports were produced (see list of outputs on pages 15-22) on both research and development activities as well as field trials of processing methods. NRI and the APCC organised an international workshop held in Indonesia to disseminate research outputs and provide a forum for developing strategies for technology transfer of appropriate processing methods both within and between collaborating countries as well as to other coconut producing countries. Separate country seminars and workshops were held in Tanzania, Ghana, Cote d'Ivoire, India and Sri Lanka. These workshops resulted in collaborators producing project concepts that may result in the commercialisation of suitable technologies within countries or enable transfer of a technology to another country.

Processing manuals have been produced on each of the processes. These outputs provide comprehensive guidance on all of the five coconut processing methods researched. The documents are aimed at organisations active in carrying out coconut processing development projects and are intended to provide sufficient detail to decide whether a process is likely to have potential in a particular environment.

BACKGROUND

The Inter-Governmental Group for Oilseeds, Oils, and Fats (IGG/OOF) is recognised by the Common Fund for Commodities (CFC) as an International Commodity Body for the purposes of identifying suitable projects for financing under its Second Account. At its 24th meeting, at the Headquarters of the Food and Agriculture Organization (FAO), Rome, in June 1991, the IGG/OOF, selected a project concept entitled "**Improving the small-scale extraction of coconut oil**" as a priority for submission for CFC financing.

The Natural Resources Institute (NRI) was invited to prepare a detailed Project Proposal in the format required by the CFC which was submitted to the CFC by the IGG/OOF Secretariat (FAO) in March 1992 with the UK Government's Overseas Development Administration providing the co-funding for NRI's inputs.

The project received final approval in September 1993, with NRI as Project Executing Agency (PEA) and FAO as the Supervisory Body (SB), and commenced with the signing of the Project Agreement between NRI and CFC in March 1994, with the following technical collaborators:

- **Tanzania** - National Coconut Development Programme, (now the Mikocheni Agricultural Research Institute), Dar es Salaam.
- **Côte d'Ivoire** - Marc Delorme Coconut Research Station (DPO/IDEFOR), Port Bouët.
- **Ghana** - Technology Consultancy Centre, University of Kumasi.
- **India** - Coconut Development Board, Kochi.
- **Sri Lanka** - Coconut Development Authority, Colombo.
- **Indonesia** - Institute for Research and Development of Agro-based Industry, Bogor.

and two international agencies who participated in the dissemination and promotion activities:

- **The Asian and Pacific Coconut Community**, Jakarta, Indonesia.
- **The African Oil Palm Development Association**, Abidjan, Côte d'Ivoire.

PROJECT PURPOSE

This Project aimed at developing, field testing, and promoting improved techniques for extracting coconut oil at the small rural and domestic scale and consisted of five sub-objectives. Each processing technique was defined in the project memorandum as a **sub-objective** within which several **activities** were carried out as explained below. The countries involved in researching each technique are given in brackets.

Sub-objective 1.1: Improving Aqueous Processing Techniques (Ghana, Tanzania, Côte d'Ivoire, India)

Sub-objective 1.2: Development of Hot Oil Immersion Drying Technology (Indonesia)

Sub-objective 1.3: Development of Waste Heat Recovery Technology (Indonesia)

Sub-objective 2.1: Use of the Ram Press (Ghana, Tanzania, Côte d'Ivoire)

Sub-objective 2.2: Development of the Intermediate Moisture Content Method (Ghana, Tanzania, Côte d'Ivoire)

The activities carried out within each sub-objective were as follows:

Activity 1.1.1.1 - Survey

Activity 1.1.1.2 - Report

Activity 1.1.1.3 - Meeting

Activity 1.1.2.1 - Experimental Programme

Activity 1.1.2.2 - Field trials

Activity 1.1.2.3 - Report and Promotion

In summary, the project purpose was to develop and field test small-scale coconut oil extraction methods and disseminate information on techniques developed.

OUTPUTS

- Improved knowledge of five coconut processing systems (aqueous processing, hot oil immersion drying, waste heat technology, ram press, and the intermediate moisture method) in collaborating countries and, additionally, of aqueous processing systems in Brazil and Guyana.
- A comprehensive and detailed technical examination of the aqueous coconut process which has provided new information on the efficiency of a process carried out in various forms in most coconut producing countries, in particular the factors affecting oil recovery.
- Experimental research, field trial demonstrations, training and techno-socio-economic evaluations carried out on five small-scale coconut processing methods in collaborating countries.
- Country processing manuals (produced by each country collaborator) for each method as applied in that collaborating country.
- Processing manuals amalgamating all country processing approaches for each process. These manuals have been produced by the Project Executing Agency (NRI) and have been disseminated to coconut producer countries by both the

Asian and Pacific Coconut Community and the African Oil Palm Development Organisation.

- Proceedings of the end-of-project seminar (disseminated to delegates representing coconut producer countries in Asia, the Pacific, and Africa) containing results of research and field trials of coconut processing methods as well as recommendations for using results in future coconut processing activities.

CONTRIBUTION OF OUTPUTS

This research and development project was aimed at evaluating those technologies with potential for commercialization and/or transfer to other countries.

In their respective country strategy papers presented at the International Workshop held in Indonesia in September 1997, each collaborating country provided details on how further to pursue suitable technologies developed under the Project. The government representatives of the APCC countries present at the Workshop were invited to provide a personal perspective on the scope for the application of the technologies developed within the CFC Project. In a closed session the PEA and APCC invited the project collaborators to provide a summary of those projects they considered would be suitable for introduction and uptake within their respective countries after considering the Workshop presentations.

This project has developed both the knowledge and skills of the collaborating teams. Technological innovations, to be sustainable, require a combination of technical, social and financial/economic factors. The findings articulated by the collaborators reflected their perceptions of the sustainability of the various technologies within their own country contexts. The application of all the procedures and equipment developed under the project is site-specific. For example the ram press was found to be highly appropriate and successful in Tanzania whereas it was not considered suitable for Côte d'Ivoire nor Ghana since the scale of operations which could involve its use is much larger. Selection of a site will also require a market for the products of the technology as well as ready access to suitably-priced inputs.

This Project has successfully completed the initial research, development and technology evaluation stages. Sound strategies have been proposed by all the collaborators, and the PEA has identified certain technologies which it considers could be transferred into the commercial arena. The transfer of technology by its very nature can be a long term and expensive process. However, the projects which have been identified by the PEA for consideration are seen as a means of providing an impetus for the continued adaptation and proliferation of the technologies both within countries and regionally.

Table 1, summarizing the proposals, is based on the summary statements made by the individual collaborators and also takes into account the individual country representative's individual statements.

Drawing on the information collected during the Project, the PEA recommend that the CFC (via the IGGEOF) give consideration to two categories of project: those based on a solely in-country basis; and those with a regional and/or inter-regional dimension.

The regional and inter-regional projects prepared after the International Workshop were presented at the APCC Session held in November 1997 in Western Samoa. All proposals were accepted by the delegates.

These proposals are presented below under the appropriate CFC Project sub-objectives and are those which are considered by the PEA to be worthy of special attention by the CFC.

- **Sub-Objective 1.1 - Aqueous processing.**

TANZANIA'S recommendations for in-country technology transfer for the commercialization of the improved grater should involve the transfer of the technology using existing institutions within Tanzania so that it is self-sustaining. The aim is to enable purchasers of the grater to buy from any local market at a reasonable price and assured product quality. This project will a suitable strategy to be formulated and, as a first step, the CFC should consider funding the preparation of the project document.

INDIA has recommended the commercial application of both screw and bridge presses for the extraction of coconut milk. However at the country level, there is need to provide the CDB with a project grant to carry out a market evaluation on the scope for the application of these technologies as part of a small industries project. The aim would also be to draw up business plans for the establishment of one or two commercial enterprises. This grant would help establish further transfer of the technology.

- **Sub-Objective 1.2 - Hot Oil Immersion Drying**

INDONESIA'S recommendations for propagation of the HOID technology are:

(1) At the country level priority should now be given to a market study on the application of the technology as a separate initiative and in combination with Waste Heat Recovery Technology to provide a firm base on which to pursue the comprehensive strategy proposed by them. Support funding to augment this study including the design of the larger scaled unit of 5 tonnes per day should be sought.

(2) The proposal to evaluate the suitability of lower temperature HOID processing at the pilot/laboratory scale for application at the larger scale operations is also recommended; but as part of a longer term national programme for which funds could be sought from organizations such as the EU under the DG VIII Programme and UNIDO for identification of suitable funding agencies.

(3) Of particular interest is the application of the HOID at the small- to medium-scale industry level for application in countries such as Sri Lanka, Ghana, Côte d'Ivoire and

the Philippines. See project concept entitled “Hot Oil Immersion Drying on small- to medium-scale” given in the section on “Selected Regional and Inter-Regional project concepts for submission to the APCC and AFOPDA Sessions

Table 1: Summary of interest shown in technologies by delegates to the Workshop

| Collaborator / sub-objective | 1.1 Aqueous | 1.2 HOID | 1.3 WHU | 2.1 Ram | 2.2 IMC |
|---|-----------------------|-----------------------|-----------------------|------------------------|-----------------------|
| INDIA | X ** Project proposed | | | | |
| SRI LANKA | | X ** Project proposed | X ** Project proposed | | X ** Project proposed |
| INDONESIA | | | | | |
| TANZANIA | X ** Project proposed | | | X ** Project proposed | X ** Project proposed |
| GHANA | X ** Project proposed | | | X | X ** Project proposed |
| CÔTE D'IVOIRE | X ** Project proposed | | | X | X * |
| Intercollaborator | | | | | |
| INDIA | | | ** Project proposed | | |
| SRI LANKA | * interest (scale) | ** Project proposed | | * also speciality oils | |
| INDONESIA | *dissemination | | | *assessment | *Cottage and domestic |
| TANZANIA | | | | | |
| GHANA | | ** Project proposed | ** Project proposed | | |
| CÔTE D'IVOIRE | | ** Project proposed | ** Project proposed | | |
| Countries not collaborating in CFC project | | | | | |
| MALAYSIA | | | ** Project proposed | | |
| PHILIPPINES | * | ** Project proposed | | | |
| SAMOA | | | | | Established |
| FIJI | | | | | Established |
| THAILAND | | | | | |
| SOLOMON ISLANDS | | | ** Project proposed | | |

X indicates country collaborator; HOID=Hot Oil Immersion Drying; WHU=Waste Heat Unit; RP=Ram Press; IMC=Intermediate Moisture Content;

* Interest expressed

- **Sub-Objective 1.3 - Coconut Shell Carbonization with Waste Heat Recovery Unit (WHU)Technology**

INDONESIA'S recommendations for follow-up action on the WHU technology are:

(1) At the country level there is a need for the IRDABI to carry out a market study on the application of the technology separately and in combination with the HOID technology to provide a firm basis on which to pursue the comprehensive strategy proposed by them.

(2) The exchange of information for the transfer of the technology should be carried out on a country-to-country basis with IRDABI as the providers of the technology - see project concept entitled "Coconut Shell Carbonization with Waste Heat Recovery Unit (WHU)Technology at the small- to medium-scale" given in the section on "Selected Regional and Inter-Regional project concepts for submission to the APCC and AFOPDA Sessions"

- **Sub-Objective 2.1 Ram Press**

TANZANIA

The oil extraction efficiency (OEE) of the aqueous process is around 65%. That of the ram press operation when using the dried residue from the aqueous process - *chicha* - is about 70%. The overall OEE is approximately 75%. This is a high figure and approaches that of a small-scale powered expeller when processing copra. The benefit of the aqueous/ram press approach is that the process involves low-cost equipment and no external power thereby making it suitable for the remote village situation. The added value of processing the *chicha* is substantial, since little value is normally attached to it although the oil which can be produced from it is of high value.

It is essential that the message of the benefits to be gained from processing *chicha* should be broadcast widely. The Tanzanian collaborators will seek funding to disseminate the results of the CFC project in areas such as Mtwara and Lindi in southern Tanzania where communication links are few and difficult. Coupled with this work will be a market study to ensure that locally produced oil has a suitable outlet near to the production site.

- **Sub-Objective 2.2 Intermediate Moisture Content Method (IMC)**

SRI LANKA

The Coconut Development Authority will identify and assist in the establishment of 3-4 self-employment projects based on the IMC method and the use of a bridge press. These will function as demonstration units. It is envisaged that a second stage of the project would establish a further 100 units.

Selected regional and inter-regional project concepts for submission to the APCC and AFOPDA Sessions

- **Hot Oil Immersion Drying Technology on small- to medium-scale**

Of particular interest is the application of the HOID at the small- to medium-scale industry level for application in countries such as Sri Lanka, Ghana, Cote d'Ivoire and the Philippines. Whilst the CDB of India was not present at the Workshop, its interest in the HOID has been expressed earlier during the Project. It is recommended that an evaluation of the suitability of the technology in Côte d'Ivoire be undertaken involving a preliminary financial and market analysis. The technology could be transferred - with suitable adaptation to meet the local requirements. The Philippines could carry out discrete work on the small-scale refining of the oil - an area in which they have expressed interest in view of the market demand for refined bland tasting oil. Sri Lanka (and India) could also play a role in local application of the technology based on the findings of the Project. However this regional/inter-regional project idea would need to be developed and a proposal formulated as part of a follow-up to the CFC Project.

Countries interested: Ghana, India, Indonesia, Philippines, Cote d'Ivoire, and Sri Lanka. Extent of interest to be identified at APCC and AFOPDA Session. The scope for widescale application albeit after adaptation to fit within a local context was evident.

- **Aqueous processing with improved grating coupled with ram press technology.**

The benefit of the aqueous process coupled with ram pressing is that this combination involves low-cost equipment and is independent of power thereby making it suitable for the remote village situation. The added value of processing the *chicha* is substantial since little value is normally attached to it although the oil that can be produced is of high value.

It is essential that the message of the benefits to be gained from processing *chicha* should be broadcast widely. The Tanzanian collaborators will seek funding to disseminate the results of the CFC project in areas such as Mtwara and Lindi in southern Tanzania where communication links are few and difficult. Coupled with this work will be a market study to ensure that locally produced oil has a suitable outlet near to the production site.

The coconut belt extends both north and south of Tanzania into Kenya and Mozambique respectively where the aqueous coconut process is indigenous. There is considerable scope to transfer this technology regionally. Additionally, these technologies have wider potential in other coconut growing countries not represented at this meeting.

Countries interested: Tanzania and Indonesia. Also scope for transfer to many other coconut producer countries.

- **Coconut Shell Carbonization with Waste Heat Recovery Unit (WHU) Technology at the small- to medium-scale**

The exchange of information for the transfer of the technology should be carried out on a country-to-country basis with IRDABI as the providers of the technology.

However especial interest has been expressed by Ghana on the WHU-technology including a general opinion that there would be scope for the development of a smaller unit where emphasis is placed on the operation of a WHU which produced principally charcoal with minimal smoke pollution; but operated independent of power. A general view was expressed that interest in the technology would increase if a unit approximately a third or half the scale of the standard 8 m³ unit were developed. The heat generated could also be used but without the same degree of thermal efficiency obtained at the larger scale. This regional/inter-regional project would essentially be a R&D programme developing smaller units.

Countries interested: Ghana, India, Indonesia, Cote d'Ivoire, Pacific Islands and others. Extent of interest to be identified at APCC and AFOPDA Session. At the smaller scale the WHU technology has scope for application in all coconut producing countries.

List of outputs

Project Proposal to the Common Fund for Commodities for a Project entitled "Improving the Small-Scale Extraction of Coconut Oil"; NRI, July 1993.

Project Agreement between the Common Fund for Commodities, the InterGovernmental Group for Oilseeds, Oils and Fats, and the Natural Resources Institute; February 1994.

- 1. G R Breag;** Common Fund for Commodities Project "Improving the Small-Scale Extraction of Coconut Oil": Report on the "Pre-Commencement" visit to agree Proposals and Contract with Asian Collaborators: 5 to 20 November 1993; NRI Report R 2044 (C).
- 2. R V Harris;** Common Fund for Commodities Project "Improving the Small-Scale Extraction of Coconut Oil": Report on the "Pre-Commencement" visit to African Collaborators; 28 November to 15 December 1993; NRI Report R 2064 (C).
- 3. G R Breag;** Meeting with the Coconut Development Board, Cochin, India, to discuss progress with the Common Fund for Commodities Project "Improving the Small-Scale Extraction of Coconut Oil": 10/11 October 1994; NRI Report R 2165(S).
- 4. A A Swetman and A Gordon;** Report on a visit to Brazil and Guyana to survey small-scale Aqueous Processing methods: 16 September to 8 October 1994; NRI Report R 2191 (S)
- 5. S W Head;** Report on a Meeting of Representatives of Collaborating Countries working on the Aqueous Processing component of the Common Fund for Commodities Project; "Improving the Small-Scale extraction of Coconut Oil": Held in Abidjan, Côte d'Ivoire, February 1995.
- 6. G R Breag, Y Y Setiawan, R Simmons;** Report on a visit to Indonesia to evaluate the Coconut Hot Oil Immersion Drying Technology: 17 April to 8 May 1994; NRI Report R 2123 (S).
- 7. S W Head and A A Swetman;** Analyses of samples collected during the visit to Indonesia to evaluate the Coconut Hot Oil Immersion Drying Technology. Annexe to NRI Report R 2123 (S).
- 8. André Rouziere, CIRAD, Montpellier;** Technical Summary of the Work undertaken on Coconut Hot Oil Immersion Drying - Methodology and Results - February 1995.
- 9. André Rouziere, CIRAD, Montpellier;** Technical Summary of the Work undertaken on Coconut Hot Oil Immersion Drying - Tables and Figures - February 1995.
- 10. G R Breag and J Croyley;** Report on a visit to Indonesia to assess the viability and scope for WHU Technology: 20 February to 19 March 1993.

11. **G R Breag**; Report on a visit to Indonesia to monitor progress with the transfer of WHU Technology: 11 to 19 November 1994 - NRI Report 2041 (S).
12. **G R Breag**; Progress Report on WHU Technology in Indonesia: 1 March to 30 May 1994 - NRI Report R 2124 (S).
13. **Workshop on Coconut Shell Carbonization with Waste Heat Recovery Technology**; Palembang, Indonesia: 23 to 27 January 1995
14. **Robert Simmons**; Financial Appraisal and Preliminary Evaluation of WHU Technology in Indonesia: 4 to 11 March 1995 NRI Report No 2217 (S).
15. **Summary of Progress**: First Year Report, April 1995.
16. **P Donker, TCC, UST, Kumasi, Ghana**; Small-scale Coconut Oil Extraction: Report on Trials of Improved Technologies; April 1995.
17. **A A Swetman**; Report on a visit to African Collaborators (Ghana, Côte d'Ivoire, and Tanzania) to monitor progress on the Small-Scale Coconut Oil Extraction Project; 2 to 24 June 1995. NRI Report R 2270.
18. **G R Breag, A Hone and Y Y Setiawan**; Report on a visit to the Coconut Development Board, Kochi, India, to monitor progress on the Small-Scale Coconut Oil Extraction Project; 24 to 27 July and 13 to 18 August 1995.
19. **G R Breag and D M Baker**; Report on a visit to Indonesia to monitor progress on the Small-Scale Coconut Oil Extraction Project; 27 July to 18 August 1995.
20. **Progress Report**; First Half of Year Two - April to September 1995.
21. **R V Harris**; Report on a visit to Tanzania, Côte d'Ivoire, and Ghana, to review progress with the Common Fund for Commodities Project, "Improving the Small-Scale Extraction of Coconut Oil"; 3 October to 3 November 1995.
22. **G R Breag**; Summary of a visit to Indonesia to monitor progress on the small-scale coconut oil extraction project; 7 to 12 December 1995.
23. **G R Breag, J Copley, and A Marter**; "Energy Consumption in Coconut Processing: Two Case Studies"; Paper presented at the APCC XXXII Cocotech Meeting held in Kochi, Kerala, India: 17 to 21 July 1995.
24. **G R Breag, A Marder, A Marter, and A A Swetman**; "Small-Scale Agroprocessing: Three Case Studies": Paper presented at the DSE/ATSAP Workshop on Small-scale Food Processing and its contribution to Food Security, held in Bonn, Germany; October 1995.
25. **G R Breag and D M Baker**; "A synopsis of Developments on the Introduction of Waste Heat Recovery Technology in Southern and South East Asia"; Paper

presented at the UNIDO Workshop on Coconut as a Source of Energy: Bali, Indonesia: November 1995.

26. V T Markose and S Poduval; Review of Work by the Coconut Development Board, Cochin, India, for the CFC Project Mid-Term Evaluation: Jakarta, Indonesia: 21 - 24 January 1996.

27. H A Tillekeratne; Review of Work by the Coconut Development Authority, Colombo, Sri Lanka, for the CFC Project Mid-Term Evaluation: Jakarta, Indonesia: 21 - 24 January 1996.

28. IRDABI Team; Review of Work by the Institute for Research and Development of Agro-Based Industry, Bogor, Indonesia, for the CFC Project Mid-Term Evaluation: Jakarta, Indonesia: 21 - 24 January 1996.

29A. S.W.Head and V. Papadopulos; An Assessment of Small-Scale Coconut Oil Extraction Technologies in African Collaborating Countries. Common Fund for Commodities Project, "Improving the Small-Scale Extraction of Coconut Oil"; 24 January to 1 March 1996. Part A Technical Evaluation.

29B. V. Papadopulos and S.W.Head; An Assessment of Small-Scale Coconut Oil Extraction Technologies in African Collaborating Countries. Common Fund for Commodities Project, "Improving the Small-Scale Extraction of Coconut Oil"; 24 January to 1 March 1996. Part B Socio-economic Evaluation.

30 S. W. Head; Recommended Equipment and Costs for a Laboratory Designed to Evaluate Coconut Processing.

31. J. J. Mpagalile; Report on Small-Scale Coconut Processing Project for the Evaluation Team.

32. P. N'Cho; Mid-term review Côte d'Ivoire

33. P. Donkor; Activity Report Presented at a Mid Term Evaluation Meeting in Abidjan (8-12th May, 1996)

34. Progress Report; Second Half of Year Two - October 1995 to March 1996.

35. Y.Y. Setiawan, L Junaidi, D. Supriato, G.R.Breag and A. S. Tariq; Testing and performance of an experimental energy efficient furnace for hot oil immersion processing for the production of coconut oil. Jan. to March 1996.

36. L Junaidi and Y.Y. Setiawan; Report on a Visit to Palembang to Select the Field Testing for Establishing Fry Dry Oil Factory - September 1995.

37. A A Swetman; Proposed Future Project Schedule. 24 June 1996

- 38. Y Y Setiawan, A Bashra Enie, G Breag and A S Tariq;** The Prospect of Hot Oil Drying Technology in Indonesia. Presented at the APCC Cocotech in Kuala Lumpur (July 1996).
- 39. Tony Swetman, Stafford Head and Lynda Hammond;** Use of the Ram Press to Extract Oil from Dried Coconut. Presented at APCC Cocotech in Kuala Lumpur (July 1996).
- 40. A A Swetman;** Interim Progress Report by the Project Executing Agency Prepared for the Review Team meeting 2 - 5 September 1996.
- 41. A A Swetman;** Proposed Future Work Programme for the Completion of Objectives 1 & 2. 4 October 1996
- 42. Peter Donkor;** Report on the Survey of Aqueous Processing Methods(Sub-Objective 1.1) in Ghana. Activity 1.1.1.2 September 1994.
- 43. Alassane Sangare;** Report on the Survey of Aqueous Processing Methods (Sub-Objective 1.1) in Côte d'Ivoire. Activity 1.1.1.2, February 1995.
- 44. J J Mpagalile;** Report on the Survey of Aqueous Processing Methods (Sub-Objective 1.1) in Tanzania. Activity 1.1.1.2 , February 1995.
- 45. V T Marcose;** Report on the Survey of Aqueous Processing Methods (Sub-Objective 1.1) in India. Activity 1.1.1.2 , February 1995.
- 46. Tony Swetman;** Report on the Survey of Aqueous Processing Methods (Sub-Objective 1.1). Part Output Activity 1.1.1.2 , February 1995.
- 47. J J Mpagalile and Ron Harris;** Report on the Experimental Programme related to the Aqueous Processing component (Sub-Objective 1.1) in Tanzania, October 1995.
- 48. Mawuena Aggey;** An Investigation of the Traditional Ghanaian Aqueous Extraction Technology for Coconut Oil, Industrial Research Institute of CSIR, Ghana. November 1995
- 49. Joseph Mpagalile and Ron Harris;** Report on the Experimental Programme related to the Ram Press component (Sub-Objective 2.1) in Tanzania, October 1995.
- 50. Peter Donkor and Ron Harris;** Report on the Experimental Programme related to the Ram Press component (Sub-Objective 2.1) in Ghana, October 1995.
- 51. Joseph Mpagalile and Ron Harris;** Report on the Experimental Programme related to the Intermediate Moisture Content Method component (Sub-Objective 2.2) in Tanzania, October 1995.

52. Peter Donkor and Ron Harris: Report on the Experimental Programme related to the Intermediate Moisture Content Method component (Sub-Objective 2.2) in Ghana, October 1995.

53. Stafford Head, Tony Swetman and Ron Harris: Report on Experimental Work carried out by the Project Executing Agency on the Aqueous Processing of Coconut, September 1996.

53A. Summary of Report No 53

54. George Breag et al: Application of coconut carbonisation with waste heat recovery technology for copra drying at Palembang: detailed evaluation of local heat exchanger and furnace system including design recommendations for safe operation.

55. Tony Swetman: Progress Report: First Half of Year Three - April to September 1996, November 1996

56. Tony Swetman: Proposed Future Work Programme for the Completion of Objectives 1 and 2, November 1996.

57. Stafford Head: Notes on the Analysis of Coconut Products and Experimental Techniques for the Evaluation of Small-Scale Coconut Processing Methods, February 1997.

58. George Breag: Report on a Visit to India to review progress with the Common Fund for Commodities Project, "Improving Small-Scale Coconut Oil extraction" 4 to 9 January 1997.

59. George Breag: Report on a Visit to Sri Lanka to review progress with the Common Fund for Commodities Project, "Improving Small-Scale Coconut Oil extraction" 9 to 10 January 1997.

60. George Breag: Report on a Visit to Indonesia to review progress with the Common Fund for Commodities Project, "Improving Small-Scale Coconut Oil extraction" Sub-Objective 1.2 Development of the Hot oil Immersion Drying Technique, 11 to 30 January 1997.

61. George Breag: Report on a Visit to Indonesia to review progress with the Common Fund for Commodities Project, "Improving Small-Scale Coconut Oil extraction" Sub-Objective 1.3 Development of Waste heat Recovery Technology, 11 to 30 January 1997.

62. George Breag: Report on a Visit to Indonesia to review progress with the Common Fund for Commodities Project, "Improving Small-Scale Coconut Oil extraction" Discussions with the Asian and Pacific Coconut Community (APCC) 11 to 30 January 1997.

- 63. Tony Swetman:** Report on a Visit to Ghana, Tanzania (13 November-December 1996) and Côte d'Ivoire (11-18 January 1997) to monitor progress on the CFC Coconut Oil Project, April 1997.
- 64. Tony Swetman et al:** Comparison of Small-Scale Coconut Processing Technologies used in Tanzania. Presented at the International Cashew and Coconut Conference, Dar es Salaam, Tanzania, 17-21 1997, February 1997.
- 65. Stafford Head:** Provision of Laboratory Equipment and Training Personnel at the Technology Consultancy Centre, Kumasi, Ghana, 23/02/97 to 08/03/97, April 1997.
- 66. Stafford Head:** Provision of Laboratory Equipment and Training Personnel at the Mikocheni Agricultural Research Institute, Dar es Salaam, 11/03/97 to 24/03/97, April 1997.
- 67. Tony Swetman:** Progress Report: Second Half of Year Three - October 1996 to March 1997, April 1997.
- 68. George Breag et al:** Final Technical Report on Sub-Objective 1.2 - Hot Oil Immersion Drying, May 1997
- 69. George Breag et al:** Economic and Commercial Evaluation of Waste Heat Recovery Technology, May 1997.
- 70. Tony Swetman:** Proposed Programme for Objective 3, May 1997
- 71. Peter Donkor:** Report on Field Trials Related to the Ram Press Method Component of the CFC Project (Activity 2.1.2.1), April 1997.
- 72. Peter Donkor:** Report on Field Trials Related to the Intermediate Moisture Content Method Component of the CFC Project (Activity 2.2.2.2), April 1997.
- 73. Newton Temu:** Use of the Ram Press in the Extraction of Coconut Oil in Tanzania. Progress Report related to Activity 2.1.2.1 October 1996
- 74. Newton Temu:** Improving Aqueous Processing Techniques for Coconut Oil in Tanzania. Progress Report related to Activity 1.1.2.2, October 1996
- 75. Newton Temu:** Final Technical Report of Tanzanian Work on Sub-Objective 1.1 - Aqueous Processing of Coconuts June 1997
- 76. Newton Temu:** Final Technical Report of Tanzanian Work on Sub-Objective 2.1 - Use of the ram press June 1997
- 77. Newton Temu:** Final Technical Report of Tanzanian Work on Sub-Objective 2.2 - Development of the Intermediate Moisture content Method June 1997

- 78. Peter Donkor:** Final Technical Report of Ghanaian Work on Sub-Objective 1.1 - Aqueous Processing of Coconuts June 1997
- 79. Peter Donkor:** Final Technical Report of Ghanaian Work on Sub-Objective 2.1 - Use of the Ram press June 1997
- 80. Peter Donkor:** Final Technical Report of Ghanaian Work on Sub-Objective 2.2 - Development of the Intermediate Moisture content Method June 1997
- 81. V T Marcose et al:** Final Technical Report of Indian Work on Sub-Objective 1.1 - Aqueous Processing of Coconuts June 1997
- 82. H E Tillekeratne et al:** Final Technical Report of Sri Lankan Work on Sub-Objective 2.2 - Development of the Intermediate Moisture content Method June 1997
- 83. Stafford Head:** Final Technical Report on Sub-Objective 1.1 - Aqueous Processing of Coconuts July 1997
- 84. Ron Harris:** Final Technical Report on Sub-Objective 2.1 - Use of the Ram press July 1997
- 85. Ron Harris:** Final Technical Report on Sub-Objective 2.2 - Development of the Intermediate Moisture content Method July 1997
- 86. George Breag et al:** Final Technical Report on Sub-Objective 1.3 - Waste Heat Recovery Technology July 1997
- 87. P N'Cho:** Final Technical Report from Côte d'Ivoire on Sub-Objective 1.1 - Aqueous Processing of Coconuts July 1997
- 88. P N'Cho:** Final Technical Report from Côte d'Ivoire on Sub-Objective 2.1 - Use of the Ram press July 1997
- 89. P N'Cho:** Final Technical Report from Côte d'Ivoire on Sub-Objective 2.2 - Development of the Intermediate Moisture content Method July 1997
- 90. Peter Donkor:** Supplementary Report on aqueous Extraction of Coconut Oil extraction. August 1997.
- 91.** Proceedings of the CFC Workshop on "Improving the Small-Scale Extraction of Coconut Oil" held in Bali, Indonesia, 8 to 11th September 1997.
- 92. Tony Swetman:** Progress Report: First Half of Year Four - April 1997 to September 1997, October 1997.
- 93. Domestic Coconut Oil Production using the Aqueous Method, Country Manual - Tanzania.** (Versions in English and Swahili)

- 94.** Coconut Oil Production using the Aqueous Method, Country Manual - **Côte d'Ivoire**. (Versions in English and French)
- 95.** Coconut Oil Production using the Aqueous Method, Country Manual - **Ghana**.
- 96.** Coconut Oil Production using the Aqueous Method, Country Manual - **India**.
- 97.** Coconut Oil Production using the Intermediate Moisture Content Method, Country Manual - **Tanzania**. (Versions in English and Swahili)
- 98.** Coconut Oil Production using the Intermediate Moisture Content Method, Country Manual - **Côte d'Ivoire**. (Versions in English and French)
- 99.** Coconut Oil Production using the Intermediate Moisture Content Method, Country Manual - **Ghana**.
- 100.** Coconut Oil Production using the Intermediate Moisture Content Method, Country Manual - **Sri Lanka**. (Versions in English and Sinhala)
- 101.** Coconut Oil Production using the Ram Press, Country Manual - **Tanzania**. (Versions in English and Swahili)
- 102.** Hot Oil Immersion Drying (HOID) Technology for Producing Coconut Oil (Small-Scale), Project/Country Manual - **Indonesia**. (Versions in English and Bahasa)
- 103.** Hot Oil Immersion Drying (HOID) Technology for Producing Coconut Oil (Medium-Scale), Project/Country Manual - **Indonesia**. (Versions in English and Bahasa)
- 104.** WHU Technology for Copra Production, Project/Country Manual - **Indonesia**. (Versions in English and Bahasa)
- 105. Project Processing Manual:** Coconut Oil Production using the Aqueous Method.
- 106. Project Processing Manual:** Coconut Oil Production using the Intermediate Moisture Content Method.
- 107. Project Processing Manual:** Coconut Oil Production using the Ram Press.
- 108A.** Outline Information on Country Workshops, December 1997.
- 108B. Mpagalile J.J.& Mwinjaka S.R.** Proceedings of the In-Country Workshops on the Dissemination of the Findings on Small-Scale Coconut Oil Processing Project 17-22 November 1997.
- 109. Mpagalile J.J.** Report on Grater distribution in Tanzania, February 1998.