Publication No. 47

Malawi Agroforestry Extension Project
Marketing & Enterprise Program
Main Report

J.H. Pratt, E.M.T. Henry, H.F. Mbeza, E. Mlaka and L.B. Satali

July 2002

"This publication was funded by the United States Agency for International Development and produced by Washington State University. The opinions expressed are the views of the authors and not necessarily those of USAID."

Companion documents:

1. ***MAFE Dossier on Mechanical Oil Extraction Systems - November 2001***
H.F. Mbeza, M. Chawala & K. Nyirenda
University of Malawi Bunda College of Agriculture (BCA)
Agricultural Engineering Department Reports:

- ***Design Modifications to Sundhara Sayari Oil Expeller for Moringa Oleifera and other Agroforestry Tree Seeds***
- ***Oil Extraction ….. using Tinytech Expeller***
- ***Optimization of Oil Extraction from Moringa Oleifera, Trichilia Emetica and Jatropha curcas using Ram and Spindle Presses.***

2. Qualitative/Quantitative Assessment of Potential of Plant Oils (MAFE) - July 2001. R.P. Banda. Malawi Bureau of Standards (MBS).

3. Chemical Analysis and Recommended Uses of Tree Seed Oils - July 2002. E.M.T. Henry, PhD. University of Malawi Chancellor College Chemistry Department (CCCD).

4. ***Summary report for MAFE:*** **Major Secondary Metobolites in Plant Tissues from Malawi, Nicaragua and Senegal - July 2002. R. Bennett, Ph D. Institute of Food Research (IFR), Norwich, UK.**

5. Tree Seed Production Areas in Malawi II: The Lower Shire - June 2001. S.F.D. Chomanika, M. Likoswe & C.Z. Chilima, PhD. Forestry Research Institute of Malawi Seed and Tree Improvement Strategy Area.

a Malawi Government, USAID, Washington State University Collaborative Project

Table of Contents

Useful Contacts, Maps, Illustrations &Tables

ANNEXES (Volume 2: 381pp)

ANNEX 1: SCOPE OF WORK/TERMS OF REFERENCE &
ANNUAL WORKPLANS 2000 - 01 and 2001- 02

ANNEX 2: COLLABORATION AGREEMENTS (not included in Companion Documents)
EDETA 21/02/01 - 31/12/01
EDETA ADDENDUM 01/03/02 – 31/05/02 & WSU report on medicinal plants investigation
CHANCELLOR COLLEGE CHEMISTRY DEPARTMENT

AGREEMENTS WITH BUNDA COLLEGE OF AGRICULTURE DEPARTMENT OF AGRICULTURAL ENGINEERING

LEATHERHEAD FOOD RESEARCH ASSOCIATION (LFRA) OFFER OF SERVICES;
MAFE-COMMISSIONED LFRA CHEMICAL ANALYSIS;
SCHEDULE OF MATERIALS SUPPLIED;
LFRA RESULTS OF ANALYSIS

INSTITUTE OF FOOD RESEARCH (IFR) : LETTER OF UNDERSTANDING;
SCHEDULE OF MATERIALS FOR ASSAY;
IFR PRELIMINARY RESULTS OF ANALYSIS

SCOTTISH CROP RESEARCH INSTITUTE (SCRI) – LIPID ANALYSIS UNIT/
MYLNEFIELD RESEARCH SERVICES LTD: SCHEDULES OF MATERIALS SUPPLIED;
SCRI RESULTS OF ANALYSIS

Other analysis received by MAFE/contacts

Fact sheets from other organizations: SANProTA; Marula Net; Optima of Africa: Moringa; University of Botswana: Tephrosia; Eduardo Mondlane University, Maputo: Natal Mahogany

ANNEX 3: INSTITUTIONAL SUPPORT AVAILABLE
Trade associations
NGOs (Formal and informal)
Government
Financial institutions

ANNEX 4: LOWER SHIRE SURVEY OF TRADITIONAL USES OF ON-FARM TREES:
Sites, Interviewees and Map

ANNEX 5: NATURAL PLANT PRODUCTS COMMERCIAL INVESTIGATIONS IN MALAWI
INFORMATION FROM PROFESSIONAL ASSOCIATION, COMMERCIAL TRADERS& PROCESSORS

ANNEX 6: SUMMARIES AND MATRIX OF 140 POTENTIAL USES OF STRATEGIC SPECIES

ANNEX 7: PLANT OILS STAGE 1 NARRATIVE OF ACTIVITIES AND DIARY OF EVENTS

ANNEX 8: ECONOMIC ANALYSIS SUMMARIES;
ECONOMIC ANALYSIS SCHEDULES

ANNEX 9: ENVIRONMENTAL IMPACT ASSESSMENT

ANNEX 10: MID-PHASE STAKEHOLDERS MEETING:
CONCLUSIONS DRAWN
Table: MAFE Marketing & Enterprise Program (MEP) *SWOT session results*

ANNEX11: DOSSIER ON PILOT COMMERCIAL PRODUCTION PROGRAM Nov. 2001 – April 2002

ANNEX 12: BCMMORA IMPLEMENTATION PLAN AND RELATED CORRESPONDENCE

ANNEX 13: MIRTDC QUOTATION FOR BRIQUETTE PRESSES

Other:
MAFE Organogram
MAFE Publications
Agroforestry Research Policy correspondence

ACKNOWLEDGEMENTS

Malawi Agroforestry Extension Project (MAFE) was established in 1992 and is implemented through a Cooperative Grant between USAID and Washington State University under the Department of Land Resources Conservation in the Ministry of Agriculture and Irrigation.

John H. Pratt is Marketing & Enterprise Specialist, MAFE.
Dr Elizabeth M.T. Henry is Leader of Chancellor College Chemistry Department Tree Oilseeds Program, University of Malawi.
Henry F. Mbeza is Head of Engineering, Bunda College of Agriculture, University of Malawi.
Emmanuel Mlaka is Executive Director of Enterprise Development & Training Agency (EDETA) and Leonard B. Satali was Training Manager of EDETA up to February 2002.

Introduction to international traders and other guidance were kindly provided by Armelle de Saint Sauveur of PROPAGE (Association for the Promotion and Propagation of Arid and Semi-Arid Plant Resources), France and Brian Pavey and Yvonne de Lange of Avroy Shlain Cosmetics (Pty.) Ltd, South Africa.

A wide variety of information, including some trade leads, was given by Richard Hartley of the Lower Shire Protected Areas Project (World Bank), Lars Moeller of Optima Environnement S.A., Switzerland and Tanzania, Susie Burgess in Zambia, Dr Nikolaus Foidl of the BIOMASA Project in Nicaragua, Lowell Fuglie of Church World Service in Senegal, Dr Clinton Green - UK Consultant, Reinhard Henning - German Consultant (formerly in Zambia), Keith Machell of Harmony Foods Ltd in Zimbabwe, Charles Mwamba of Zambia's National Institute for Scientific and Industrial Research and Drs Jan and Titia Warndorff of Binga Trees Trust, Zimbabwe.

Our report quotes key information gathered by MAFE and a team of regional consultants in a USDA/USAID-sponsored regional investigation of current knowledge (2002) of selected natural plant products, their uses and markets. The investigation was managed by Dr Peter Wyeth of Washington State University (WSU) – International Programs. He has also provided extensive oversight of the MEP. Numerous contributors kindly assisted our international literature searches and included Jo Bonner of WSU, Utta Gottschalk (GTZ-GATE), Dr David Odee, Jo Chamberlain, Duncan Macqueen, Patrick Hardcastle and Dr Andrew Watson and his colleagues at COMPASS (DAI-USAID).

Sander Donker and colleagues at Cheetah (Malawi) Ltd generously provided copies of the Company's reports on investigations into tree oilseeds which we can now reciprocate. This was matched by helpful guidance to literature from the region from Dr Augustin Chikuni of the National Herbarium, Arthur Schwarz of SHOGA, June Walker and Stacia Nordin, Prof John Tsaknis in Greece, Cyril Lombard of the Southern Africa Marula Oil Producers' Network in Namibia and Gus Le Breton of the Southern Africa Natural Products Trade Association, headquartered in Zimbabwe. His contribution to the regional investigation is extensively quoted. Alois Sander of Nyika-Vwaza Border Zone Development Project kindly drew our attention to the similarity of the Nkamanga Plain ecosystem to an ecosystem in Namibia and organized and supported respective research in the field. With the kind approval of Mr Komakoma of Chikwawa RDP, Francis Margareta provided excellent assistance to field investigations in Lower Shire, addressing the challenge of communication in Sena.

We are grateful for collaboration in investigation of pharmacological applications of targeted plant species by Linda Robison of WSU and Juliet Chiluwe of EDETA, and Prof. Susan Fairweather-Tait and Dr Richard Bennett of the Institute of Food Research, Norwich, UK with Dr Nikolaus Foidl, Prof Berhanu Abegaz of University of Botswana and Dr John Rositor of Imperial College London at Wye.

Professional analytical services were provided by the following organizations:

Malawi Bureau of Standards (MBS)
Leatherhead Food Research Association, UK
Scottish Crop Research Institute – Lipid Analysis Unit/
Mylnefield Research Services Ltd, UK

We would like to thank Dr Austin Khulumula for the use of the MBS Boardroom for key partner meetings in Blantyre and acknowledge the ongoing efforts of Fred Sikuesi to secure Tanzania Bureau of Standards support to planning for joint development of *tree oils Standards* across the Region.

Dr Irmgard Hoeschle-Zeledon of the Malawi-German Plant Protection Project and Drs Richard Steketee and Dwight Mount of the Centers for Diseases Control and Prevention (CDC) assisted our investigations of the pesticide and anti-feedent applications of target species; Dr Antonia Calafat of CDC Air Toxicants Branch conducted related further research.

We acknowledge advice received in 2000 from Moringa water-treatment scientists Dr John Sutherland and Prof Geoff Folkard of Leicester University and from water engineer Prof Victor Chipofya of Blantyre Polytechnic (now at University of Strathclyde). We likewise thank Wells Kumwenda, Ernest Kunkwesu and Brandi Mbale at Chitedze Agricultural Research Station for the opportunity to follow-up their previous work on investigation of the commercial feasibility of tree seed oils extraction.

Similar recommendations were received from Dr Christine Witte and Lovemore Mvula of the International Eye Foundation, and mechanical engineers Kenneth Gondwe and John Taulo of Malawi Industrial Research and Technology Development Centre and Cosmas Chigwe of Blantyre Polytechnic. Subsequent adaptive research was kindly facilitated by material support from Valmore Paints Ltd, VYAHUMU Oil Seed Project with Intermech Engineering Ltd, John Wariuba and Optima of Africa Ltd in Tanzania, Forestry Research Institute of Malawi and Naming'omba Tea Estates Ltd Macadamia Division. Recent offers of loan of equipment by Hua Feng Co and of literature follow-up in Mozambique by Dr Alberto Macucule of Eduardo Mondlane University, Maputo are gratefully acknowledged.

We would like to express our special appreciation to Annie and Denson Bonomali and their family for the active part they played in our various phases of adaptive research during 2001 and thank Mrs Bonomali for her help in communication with Tumbuka speakers in Mzimba North.

Encouragement and very useful advice were received from Drs Freddie Kwesiga, Andreas Boehringer, Festus Akkinifesi and Tony Simons of ICRAF. ICRAF's inclusion of our activities in its review processes was much appreciated.

We are sorry that time prevented us exploring 'off-farm' feasibility of extracting and commercializing Marula and Baobab kernel oils with Wildlife and Environment Society of Malawi and its associated producers, specially in Kam'wamba and environs.

Throughout this program Jeff Mulenga, Director of Land Resources Conservation in the Ministry of Agriculture and Irrigation and the Chief Land Resources Conservation Officer, James Banda led the review and planning processes and guided activities. We gratefully acknowledge their support and that given by Ministry field staff to investigations and discussions with producer communities.

Much of the inspiration for our work on two of our target species came from keen field observations of MAFE Technical Associates Goodwell Banda, Gift Chammagomo and Alubi Mpira; we also appreciated related guidance from Glynwell Siyeni.

We gratefully acknowledge the involvement and support from numerous University of Malawi contributors, especially John Kamanula and Kingston Nyirenda. Dr Henry Phombeya, MAFE Resource Center Coordinator, continues to play a key role in project promotion and liaison with producer partners.

We appreciate the support and inspiration provided by Washington State University - International Programs staff and particularly the multi-faceted guidance given by Dr Jan Noel.

Dedicated to the memory of
Alfred Katsina, MAFE and
Christopher Masamba, PhD, Forestry Research Institute of Malawi

PHOTO GALLERY : PARTNERS, ACTIVITIES, INNOVATIONS AND OPPORTUNITIES

CORRESPONDENTS/ACRONYMS AND ABBREVIATIONS

Agribusiness in Sustainable Natural African Plant Products (A-SNAPP), Ghana, Stellenbosch & Lusaka;
Avroy Shlain Cosmetics (Pty) Ltd
Binga Trees Project (BTP), Kariba;
BIOMASA Project , Nicaragua;
Blantyre Water Board;
Body Shop International PLC
Business Consult Africa Ltd (Busconsult);
Centre for Scientific and Industrial Research (CSIR), Pretoria;
Cheetah Industries Ltd (Cheetah);
Church World Service, Senegal (CWS-S);
Community Partnership for Sustainable Resource Management (COMPASS);
CRIAA Southern Africa – Development and Consulting (CRIAA SA-DC), Windhoek;
Department of Agricultural Research and Technical Services (DARTS): Chitedze/ Agricultural Research Station Farm Mechanisation Unit (CARS-FMU);
Department for International Development (DfID), Lilongwe: National Forestry Programme;
Eduardo Mondlane University, Maputo
Earthoils Plantations Ltd;
Enterprise Development and Training Agency (EDETA);
Evangelical Lutheran Church in Tanzania VYAHUMU Oil Seed Project (VYAHUMU);
FAKT Consult, Germany;
Forestry Department (FD);
Forestry Research Institute of Malawi (FRIM);
Freshtainer (Pvt) Ltd, Harare;
GTZ Integrated Food Security (GTZIFSP) Promotion of Horticulture (GTZPH) and Plant Protection (GTZPPP) Projects;
GTZ GATE information service;
Harmony Foods, Harare;
Institute for Food Research (IFR), UK;
International Eye Foundation (IEF) and IEF-assisted smallscale plant oil producers;
Jan Dekker International BV;
Leatherhead Food Research Association (LFRA), UK;
Leicester University (LU), UK;
Lower Shire Protected Areas Project - World Bank;
Malawi Chamber of Commerce and Industry (MCCI);
Malawi Bureau of Standards (MBS);
Malawi Export Promotion Council (MEPC);
Malawi Industrial Research and Technology Development Centre (MIRTDC);
Mzuzu University Depatment of Forestry;
Naming'omba Tea Estates Ltd (Macadamia Nut Division)
National Herbarium and Botanical Gardens (NHBG);
National Institute for Scientific and Industrial Research, Zambia (NISIRZ)
National Research Council of Malawi (NRCM);
National Smallholders Farmers Association of Malawi (NASFAM);
NRM and process engineering consultants (including Germany and UK)
Nyika-Vwaza Border Zone Project (BZDP);
Optima of Africa Ltd, Dar Es Salaam (Optima);

Parks & Wildlife Departement (P&WD)
Plan International (PI);
Promotion of Soil Conservation and Rural Production Project (PROSCARP);
PROPAGE – Association for the Promotion and Propagation of Arid and Semi-Arid Plant Resources, Paris;
process plant manufacturers (incl. Tanzania & Zimbabwe),
Rutgers University, New Jersey;
Southern Africa Development Community – International Centre for Research in Agroforestry at Makoka (SADC-ICRAF);
SADC Forest Sector Technical Coordination Unit (SADC-FSTCU);
Scottish Crop Research Institute – Lipid Analysis Unit (SCRI-LAU);
Shire Highlands Organic Growers Association (SHOGA) and private estate farmers;
soap manufacturers and paint manufacturers,
Southern Africa Marula Oil Producers Network (SAMOPN);
Southern Africa Natural Products Trade Association (SANProTA);
Southern Alliance for Indigenous Resources (SAFIRE), Harare;
Southern Region Water Board;
Tea Association of Malawi (TAM);
Technological Education Institute of Athens (TEIA);
Training for Enterprise in Exports in Malawi (TEEM) Project; ZOPP (Pvt) Ltd, Harare;
University of Malawi: Chancellor College Chemistry (CCCD) and Physics Departments, Blantyre Polytechnic (BP) and Bunda College of Agriculture (BCA);
United States Agency for International Development (USAID)
United States Department of Agriculture (USDA)
USAID NATURE Program;
vegetable oil and presscake producers/refiners;
Veld Products Research and Development of Botswana (VPRDB);
Washington State University International Programs (WSUIP) staff and its library and internet services;
Wildlife and Environment Society of Malawi (WESM);
World Relief, Mozambique.

ADD	Agricultural Development Division (Region)
RDP	Rural Development Project (District)
EPA	Extension Planning Area (sub-District)
asl	*above sea level (elevation)*
CBNRM	*community-based natural resources management*
dbh	*diameter at breast height*
fob	*free on board*
NPP	*natural plant product*
NR	*natural resource-based*
QA	*quality assurance*
R&D	*research and development*
TQM	*total quality management*

Map: Recommended Locations for Future Activities & Principal Species

EXECUTIVE SUMMARY

Malawi Agroforestry Extension Project (MAFE) aims to improve natural resource management (NRM) with sustained improvements in smallholder farming by increasing the adoption of agroforestry.

MAFE launched a Marketing and Enterprise Program (MEP) in October 2000 to promote production and marketing of natural resource-based (NR) products, with the view to enhancing rural incomes. MEP research and development and test marketing have been aimed to provide the genesis of one or more community-private sector partnerships. Early-maturing species promoted for NRM purposes were given priority. Investigation of subsistence uses was initially given little attention. This, and particularly the importance of trees in food security, eventually came into the program in June 2001, when detailed product/species selection criteria were agreed with USDA and USAID.

The principal challenge foreseen was to identify suitable NR products in Malawi to exploit markets that already existed. MAFE found there were few established markets for plant species and products under consideration. This observation was reinforced by the conclusions of a 2002 USDA/USAID/ WSU/MAFE Review of NR product markets in Southern Africa.

Following the inception phase, the MEP has operated as a research and development (R&D) partnership for 18 months with an indigenous NGO, Enterprise Development and Training Agency (EDETA), based in Blantyre, two University of Malawi Colleges and small-scale producers. University partners comprise Chancellor College Chemistry Department and Bunda College of Agriculture Department of Engineering. The partners have been assisted by Malawi Bureau of Standards, several other local and Tanzanian organizations and overseas laboratories. Total MAFE expenditure on these partners has amounted to some K3 million ($40,000) of which 75% has been spent in Malawi. Responsibilities have been divided according to the specific skills offered by each partner. Small-scale producers played an indispensable part. MAFE's contribution has been mostly in market assessments, economic analysis/feasibility determination and program coordination. Results overall are attributable to each partner fully satisfying the role determined by a respective Collaboration Agreement.

Species noted in the MEP Scope of Work for special attention were Neem *(Azadirachta indica),* Jatropha *(Jatropha curcas),* Moringa *(Moringa oleifera),*Tephrosia *(Tephrosia vogelii),* and Jujube *(Ziziphus mauritiana).* Since work on Jujube and other indigenous fruit species had already been taken up by SADC-ICRAF this was, by agreement, not pursued by MAFE.

As it was reported relatively localized, Neem was given low priority in MEP initial investigations. The USDA/USAID Review identified expectations about the scale of the regional Jatropha *(Jatropha curcas)* industry and the strength of the market for Jatropha products to be unfounded. Partners concentrated their investigations on Moringa. It was best known locally as a living fence tree and a very important subsistence/food security vegetable crop with a wide distribution in lowland areas. It had been the subject of extensive previous research as a possible oleaginous crop. On the advice of MAFE staff, oleaginous wild species such as Manketti *(Schinziophyton rautanenii),* African Star Chestnut *(Sterculia africana)* and Natal Mahogany *(Trichilia emetica)* became a second theme of investigation from March 2001. Marula *(Sclerocarya birrea)* likewise became a target of general investigation during the formulation of the USDA/USAID regional study. The range of commercial products that the foregoing species could supply to satisfy regional and international markets was identified as follows:

Soap oils, Medicinal extracts and pesticides/antifeedents from Neem;
Cosmetic oils from Marula and Moringa and, possibly, the other species;
Vegetable pods and, possibly, processed leaves of Moringa;

The partnership settled on Moringa oil as the principal target product. It was the only product to complete a full round of R&D that, within the 18 months available, rendered it ready for commercialization. A regional and international market for Moringa oil has been found by MAFE at a price in the region of K600/kg ($8/kg), moreover a supplier from within the region cannot satisfy demand. Marula oil enjoys a higher price but its trade is shrouded in secrecy. The partners have conclusively determined that Moringa oil of acceptable quality can be manufactured in Malawi by manual pressing methods at a direct cost of less than K300/kg ($4/kg) and by motorized methods at a direct cost in the region of K190/kg ($2.50/kg). The partners determined that manual systems have low fixed costs but require high levels of social organization and quality control. Motorized systems have high fixed costs, demand skilled operators and strict maintenance routines and need continuous throughput to be commercially viable. Analysis indicates both systems are viable for Moringa oil production for export at an FOB value of $6/kg (K450/kg). Manually pressed oil may be of higher quality.

Other tree seed oils investigated and experimentally processed would cost about K225/kg ($3/kg) to produce. As a toxic, mineral oil, Jatropha oil would be unable to compete with commercial mineral oils used in paint manufacture or as fuel. None of the tree seed oils is economic as a substitute for commercial edible oil such as Sunflower or Groundnut oil. These cost less than K150/kg ($2/kg).

Identified potential for implementation falls into three main categories:

1. **A 'Model' pilot commercial production and marketing project to produce some 4,500 kg of Moringa oil at an FOB value of $27,000 during the next production season, mobilizing in mid-2003 and commencing operations in September 2003.**

Both systems of oil extraction should be employed on two sites respectively (page XVI). Capacity building will be required in both programs. These would cost some K2.4 million ($32,000) to carry out over a period of some 4 months and would provide work for about 40 persons and provide them with direct income of over K550,000 in aggregate during a time of year that is traditionally a food-deficit season. The cost includes project support by existing Malawian partners. A motorized production unit designed to Bunda College specification should be purchased from Tanzania and stationed in Bangula, Lower Shire Valley. Production can be organized either as a development project, possibly as part of an income generating initiative, or as a purely commercial initiative of private enterprise. A small-scale production unit using hired Resource Center manual presses made by Bunda College should be set up in Salima (South) to work with groups already sensitized by MAFE and EDETA.

2. Further market research and market probing by specialists in specific market sectors.

3. Empirical research on characterization of species and their products and follow-up adaptive research.

Specific projects are proposed for University of Malawi in pure and applied research on five tree species. Research includes isolation of products with industrial, nutritional and cosmetic potential and development of suitable extraction systems. The University needs to maintain a partnership with an overseas laboratory. Once the properties, commercial potential and technology have been identified, a pilot project for commercial exploitation in each case can be established. In the case of seed oils/fats commercialization, experience from the 2003 pilot model of Moringa oil commercialization would shed light on how to proceed.

Care is needed to avoid duplicating research work elsewhere. Posting of activities on websites is recommended.

1 INTRODUCTION

The essence of this report was presented at the MAFE Closing Workshop on June 26, 2002. The detailed proposals were generated afterwards.

This program has been in operation for 22 months. Along with MAFE, it closes on the Project's tenth anniversary, July 31, 2002.

MAFE and its partners are carrying out market research and have undertaken technical development and production economic analysis that, besides fulfilling project objectives in Malawi, could contribute to natural plant product (NPP) development in Mozambique and Zambia. The socio-economic implications of the work in progress could be overwhelmingly beneficial and are centered on the potential to generate rural income from under-exploited existing tree resources. Once proven and widely acknowledged, this could result not only in better care of tree resources but also spontaneous planting of the beneficial species.

This report incorporates and updates a draft report on the program's first year's activities that was circulated in November 2001 for peer review. In addition to Washington State University - International Programs, the following organizations provided helpful comments on the first year's draft report: BIOMASA, Nicaragua, BTP, Zimbabwe, Cheetah, COMPASS, CWS, Senegal, SADC-ICRAF, SHOGA, Pirimiti Limited and Reinhard Henning, Consultant.

Activities undertaken since October 2001 are now described and the report assesses the overall results of the program and provides recommendations for follow-up. During the last six months of MAFE's life most of the work of the program has covered two activities:

?? detailed characterization of 'products',
?? market investigations and preparation for market probing with sample products.

Instructions for the preparation of this report required a *description of NPP marketing chains*, identification of their *problems and concerns,* description of *product supply and availability,* and identification of *specific market opportunities* and the *role of Government.* With the exception of a pair of *tree seed oils*, inquiries to cover these questions mostly revealed a very low level of market development. This was matched by resource constraints among most local institutions that might be expected to promote NPP development.

This report is divided into two Books and four thematic Parts:

Main Report (Volume 1):

EXECUTIVE SUMMARY

PART I: POLICY, STRATEGY AND PARTNERSHIPS

Chapters 2 – 7 describe the background to the Project and the MEP's scope of work. They explain the program's context in Government of Malawi and USAID policies and plans and describe MEP operating methods, expenses incurred, partners involved and their capacity. Institutional memory and the possibilities for future follow-up are also considered.

PART II: PRODUCTS AND POTENTIAL MARKETS

Chapters 8 and 9 describe knowledge of products, strategic species identified, respective sectoral commercial opportunities, the nature of trade, and trade interest in MAFE 'products'; Chapter 9 draws on the technical and economic analysis of Part III.

Chapter 10 presents an analysis of uses, possible commercial applications and NRM benefits identified for each respective species. The potential for exploitation is assessed, supply is discussed and, where information on competing products/uses and respective prices/costs is available, the ability of the species to compete is projected.

Findings from the Chancellor College Report on Chemical Analysis are quoted in Chapter 10.

PART III: TECHNICAL RESEARCH AND DEVELOPMENT AND PRODUCTION ECONOMICS

Chapter 11 describes the steps taken to investigate and acquire suitable processing technology and the engineering components of research and development (R&D) carried out. Chapter 12 covers production trials and the supply of 'products' for initial assay, and social and economic components of the R&D. Chapter 13 reproduces the Chemists' recommendations from the Chancellor College Report.

PART IV: CONCLUSIONS AND RECOMMENDATIONS

Chapter 14 is a *Validation of Experiences*, presenting *lessons learnt* from the program's *process* and the *strategies employed* and gives an overall assessment of *immediate and medium-term potential* according to species, agro-ecology and geography; *commercial* and s*ubsistence/food security* opportunities are assessed.

Chapter 15 provides *Key Recommendations* and a *Suggested Strategy* for *market development, promotion of production* and continuation of *partnerships* to enable identified potential to be tapped. For *commercial project implementation* it suggests who should be involved, for how long, the likely benefits and what implementation could cost. It identifies n*eeded further research,* who should do it and organizations that should be kept informed of plans and progress.

BIBLIOGRAPHY (Documents marked *** are at the *Resource Center)*

Annexes (Volume 2): restricted circulation

PART I: POLICY, STRATEGY AND PARTNERSHIPS

2 POLICY AND DONOR ENVIRONMENT

2.1 Government of Malawi Policy and Strategies

LRCD described (2001) the Policy of Government of Malawi on agroforestry as follows:

?? Establish long-term sustainable use of soil and related natural resources, with a focus (MAFE) on improving soil fertility;
?? Expand agroforestry support generally, with assistance from NGO and donor communities;
?? Establish a conducive investment climate to support investors in commercial production that has positive soil improvement/conservation benefits;
?? Through the Planning Division of MAI, monitor prices and identify (seasonal) market windows inside *and outside* Malawi;
?? Support production up to the level of foreseen market demand, and avert gluts;
?? Resuscitate former institutional R & D in agroforestry-based products, specially from Moringa;
?? Actively encourage agroforestry investment according to a farming system-compatible approach.

MAFE is a member of the **National Agroforestry Steering Committee** and collaborates closely with the **Forestry Research Institute of Malawi** (FRIM), specially in tree seed distribution. MAFE's work is relevant to two of the four FRIM core programs, i.e. ***Trees on Farm*** and ***Seed and Tree Improvement.***

The following Strategies of the **National Forestry Programme 2001** (Priorities for Improving Forestry and Rural Livelihoods) are routinely pursued by MAFE although it is not directly associated with it:

?? Support community-based forest management,
?? Improve individual smallholder livelihoods, and
?? Sharpen research and information systems.

2.2 Government of Malawi Specific Objective and Proposed Partners

Giving precision to the agroforestry products policy outlined by LRCD, the **8th National Forestry Research Committee Meeting** on 20 February 2002 adopted an objective to *enhance farmers' direct income from on-farm trees.* Mindful of USAID Strategic Objective 1 (SO1), MAFE participated in the debate on how this might be fulfilled.

The means chosen were:

✍✍Gather information on markets and create a database of commercial opportunities for:
Indigenous fruit trees (i.e. FRIM & ICRAF) – 3 years;
Moringa oleifera, including on-going socio-economic surveys of FRIM and MAFE – 1 year; and
Other species, including *Adansonia digitata, Azadirachta indica, Sterculia africana, Schinziophyton rautanenii* and *Trichilia emetica (& T. dregeana)* – duration to be determined.

- Characterize and develop products for:
Indigenous fruits;
Moringa oleifera; and
Other species, including *Adansonia digitata, Azadirachta indica, Sterculia africana*, *Schinziophyton rautanenii* and *Trichilia emetica (& T. dregeana)*.

- Establish collaborative linkages among Actors to promote and propagate good commercial practices for production – using institutional resources located closest to the production areas.

Partners proposed by the Committee for this work included:

- FRIM Trees on Farm Strategy Area;
- MAFE;
- ICRAF;
- EDETA;
- Bunda College of Agriculture and Chancellor College Chemistry Department;
- University of Mzuzu Dept of Forestry.

2.3 Sector Regulation

2.3.1 Regulations in force affecting plant collection

Although enforcement is weak, collection of plant materials on National Lands is subject to permit, i.e. from Forestry Department (FD) or the Parks and Wildlife Department (P&WD). "Co-management" of forest goods and services is the subject of a policy debate (Jere, P. et al.2000) but is already being tried out in various locations by P&WD with projects.

Collection of some endangered species is prohibited.

2.3.2 Regulations in force affecting marketing of products: quality standards

Levels of inspection and enforcement by Malawi Bureau of Standards (MBS) in respect of edible oils production and marketing are rigorous but, other than inspection at border entry or exit, inspection of most food products is not feasible.

2.3.3 Phytosanitary controls applied to imports and exports

The nation's borders are highly permeable to the movement of all merchandise including plant materials. Malawi generally applies high phytosanitary standards to its major exports, notably tobacco, and operates an internationally approved certification scheme. MAFE obtained phytosanitary certification on the export of tree seeds to Tanzania for processing trials.

2.3.4 Germplasm intellectual property and taxonomic research

A law for germplasm intellectual property protection has not yet been promulgated. The National Plant Germplasm Committee met in 1997 under the Chairmanship of the Director of Agricultural Research.

The National Herbarium and Botanical Gardens, Zomba has a small staff whose botanical identification and taxonomic classification skills may be called upon.

The Herbarium is the Regional Office for Southern Africa of the Netherlands-funded Plant Resources of Tropical Africa (PROTA) Program which was launched in 2001. This aims to document and distribute information on wild and domesticated plant resources, focussing specially on plants with commercial and subsistence uses. Operations commence in 2002.

2.4 USAID

In 1995 – 2000 MAFE operated under USAID's Natural Resources and Environment Support Program (NATURE) to fulfil Strategic Objective 2 (SO2) for *increased sustainable use, conservation and management of natural resources*. It now falls under USAID's 2001 – 06 Natural Resources Management Design Areas for Key Intermediate Result 1.3: Increased Local participation in NRM, i.e:

Design Area 1: Improved CBNRM
Design Area 2: Increased NRM-based Enterprise Development

Details of the USAID program are at www.kelp.org/mal.htm .

The USAID-supported *Community Partnership for Sustainable Resource Management* (COMPASS) project is also active in the foregoing Design Areas and is a potential funding source (small grants program) for community-initiated enterprises that may be initiated as a results of MEP R&D.

USAID encouraged MAFE to maintain dialogue with a USAID-funded continental program *Agribusiness in Sustainable Natural African Plant Products* (A-SNAPP) with the view to:

?? sharing experiences,
?? networking of information and
?? possible collaboration in NR product market research.

A-SNAPP has a mission to provide "*pro-poor assistance*" and support to "*smallscale rural producers and entrepreneurs*" (Brown, J., A-SNAPP Roundtable 2002) by way of gradual product and market development. MAFE's research with the help of local institutional partners and expansion of market investigations on behalf of smallscale producers and entrepreneurs are compatible with A-SNAPP's stated mission.

MAFE attended A-SNAPP's first Roundtable Meeting in Cape Town in 2000 and took up A-SNAPP membership. It presented a paper on its MEP at the A-SNAPP 2002 Roundtable Meeting in Ghana.

A-SNAPP is implemented by Rutgers University, New Jersey and administered from Coordination Offices in Ghana and Zambia. Much of the work of the program to date has been centered on activities carried out by Stellenbosch University in South Africa and TechnoServe in Ghana.

The current phase of A-SNAPP runs until 2003. Subject to an external review in mid-2002, plans are being rolled out for a significant expansion of A-SNAPP activities. This could be beneficial for the whole Southern Africa region. A-SNAPP should consider supporting the further work proposed in Chapter 15 as much of it is of regional importance.

3 THE PROJECT

The MAFE project purpose is to *improve natural resource management with sustained improvements in smallholder farming by increasing the adoption of agroforestry.* MAFE's vision is for Malawi's people to use and manage their natural resources in ways that will improve their quality of life today and sustain improvements into the future.

The current MAFE LandCare Phase has broadened the nature of support services to better reflect the range of NRM technologies offered. The program maintains MAFE's basic management and programmatic structure with its affiliation under the Land Resources Conservation Department (LRCD) in the Ministry of Agriculture and Irrigation (MAI). It continues its core operational framework to aggressively maximize the adoption of proven NRM practices through MAFE's support services and partnerships with an added dimension on value-added benefits. Many NRM practices yield products that offer tremendous opportunities for domestic and export markets, particularly in the manufacture of environmentally friendly bio-chemicals, insecticides, medicines and cosmetics. The identification and development of market niches for these products will help transform the narrow base of Malawi's smallholder agriculture to a more vibrant, market economy that offers sustained productivity in harmony with the environment. The approach is consistent with the USAID's evolving development plans for Malawi's agricultural sector, which has a key focus on increasing smallholder productivity and incomes through improved crops and practices, and the development of new markets for high-value NRM products.

Materials and services will be provided on a semi-commercial basis through the new MAFE Resource Center (now located in LRCD premises) to meet real market demands and to build capacity for sustainability where partners and clients share costs for services received. Basic support will be offered to field partners and other implementers on a scaled down level as they become more self-sufficient. Support will include quality germplasm, extension and training materials on recommended practices, and technical advice and training on establishing and managing NRM practices. The nature of Resource Center support will include:

- ??Formal Partnerships based on a record of successful field-based programs. These include specific ADDs under the MAI, the Forestry Department, PROSCARP, VIFOR, and several NGOs, namely ELDP, CSC, CRS, WVI, OXFAM and CARE International.
- ??Informal Support to individuals, groups, communities, clubs, small NGOs and others that come to the project for information or support on NRM practices.
- ??Investigation of production and new market opportunities for NRM products that offer value-added benefits through research and linkages with the private sector.

4 PROGRAM DEFINITION

4.1 Scope of Work, Personnel and Timetable

The MAFE Marketing and Enterprise Program (MEP) MEP was launched for a period of 22 months in October 2000 upon recruitment of a Marketing and Enterprise Specialist. The respective overall Workplan[1] was described in the MAFE Annual Workplan 2000 – 2001. The detailed plan for the current year was revised in September 2001. Both plans and the Specialist's Scope of Work/Terms of Reference are in Annex 1, Volume 2.

MAFE employees support specific activities of the MEP when their commitments permit. The Specialist collaborates with the Coordinator of the MAFE Resource Center and with LRCD's National Coordinator.

4.2 Aims of the Program

The main aims are as follows:

Goal
Enhance rural livelihoods through production and marketing of natural resource based (NR) products[2] from plants that contribute to the sustainable use and management of farm resources.

Purpose
Identify potential production and marketing opportunities of existing and new NR products for income generation (among farmers and others) and to enhance adoption of natural resources management (NRM) practices.

Principal Objectives
Investigate, research, pilot, select and promote the production and marketing of NR products having high commercial potential in Malawi.

MAFE research and development and the results of test marketing of products are expected to provide the genesis of one or more *community-private sector enterprise partnerships*[3] that sustainably exploit selected under-utilized agroforestry and, possibly wild, plant species.

It was intended that by July 2002 MAFE and its partners would be in a position to provide technical assistance to private interests that wished to apply developed technology at a pilot commercial level. Where sourcing of investment and working capital finance were a constraint, MAFE could consider facilitating discussions between the private interests and the funds provider/lender.

---

[1] In a meeting on 05/11/2001 USAID NATURE Program staff determined that the MEP should not involve itself directly in business planning for project implementation, rather it should provide information, training and tools of support to such planning.

[2] In June 2001 from discussion with USDA/USAID this definition was widened to include any sustainably produced NR product retained by rural producers and utilized directly in subsistence to result in any of the following benefits:

?? enhanced nutrition and balance of nutrients;
?? improved resistance to communicable disease and arrest of health decline associated with incurable disease;
?? forage, timber and fuel biomass self-sufficiency.

[3] Partnerships that would, by their nature, meet the support criteria of USAID/COMPASS.

Favorable impact and sustainability assessment of pilot production would provide the foundation for systematic promotion by the Resource Center and MAFE partners of expanded planting and management of prescribed strategic species/cultivars.

5 INFORMATION CAPTURE

5.1 General Search

MAFE has undertaken and is continuing a literature and internet search of products offering potential commercialization of agroforestry species included in the MAFE Extension Program. WSU IP and WSU College of Pharmacy have assisted searching and retrieval of documents. Very useful professional contacts have been made worldwide through subject searches and accessing institutional and commercial websites. Website searching began in December 2001 upon supply of a new computer equipped with a fast processor.

MAFE has consulted over 50 organisations in Malawi and abroad for advice and to identify areas of complementary interest in NR product development, as set out in the schedule of Correspondents.

5.2 USAID/USDA Collaboration

In early 2001 USAID/USDA approached WSU to support organization and implementation of a *Southern Africa Regional Market Survey* for products from a shortlist of 6 plant species. This would complement an A-SNAPP overview survey already completed by Rutgers University and its partners in West Africa.

MAFE was extensively involved in design and planning. Preparation of a *Summary Review of Current Knowledge* for Southern Africa commenced in January 2002 and involved MAFE staff and a team of regional consultants who reported on markets in Botswana, Malawi, South Africa, Zambia and Zimbabwe (Wyeth, P. et al. 2002). MAFE MEP staff spent some 1.5 work months on planning and preparation of the Summary Review as a whole. Findings from the draft of the Review, especially those contributed by Gus Le Breton and Priscilla Chunda in Zimbabwe, and Susie Burgess in Zambia, are quoted in this report.

MAFE benefitted considerably in two areas of research covered by the Review, i.e. from:

?? Excellent analysis carried out in Zimbabawe for *Jatropha curcas;* and

?? Inclusion of subsistence uses alongside commercial uses in the evaluation of opportunities.

In other respects the information gathered in neighbouring countries was of limited value to MAFE immediate *commercial* needs: MAFE and its MEP partners had already decided to pursue *Moringa oleifera* as their primary target for commercialization and were already investigating the respective international trade.

6 STRATEGY FOR MARKET INVESTIGATIONS

6.1 Approach

MAFE's approach to commercialization is holistic. Possibly a targeted species will become economically viable only when *several* of its uses/product applications are all fully exploited.

The commercial slant of initial investigations was tempered as a result of discussions and preparations for the USDA/USAID Regional Study. It was (June 2001) decided *that all potential subsistence and commercial* 'products' would be captured in surveys of species' uses. These could range from food uses of plant materials to timber and firewood, also uses of various plant parts in specialized applications such pesticides, anti-feedants and traditional medicines. Additionally, efforts would be made to value the environmental benefits (and costs, if any) of exploiting the species and their implications for NRM would be described.

MAFE *market* investigations follow three principal thrusts:

?? Investigation of potential markets for NPPs from Malawi agroforestry species, including chemical isolates/fractions, that are already traded nationally, regionally and internationally and assessment of Malawi's comparative advantage to supply them;

?? Determination of the physical and chemical characteristics of *potential* Malawi agroforestry NPPs and determination of the opportunity for them to replace and compete with other products in trade – by virtue of similarity of physico-chemical properties and competitive production costs;

?? For promising products, reporting on the means of compliance with national regulatory/safety standards in the more promising markets.

6.2 Product/Strategic Species Selection Criteria

6.2.1 Initial Selection Criteria

Discussions with local institutions, projects, the private sector and international organizations led to MAFE adopting the following provisional product/species selection criteria in 2000:

- ?? Products for which traditional use and/or recent research suggest there are possibilities of *commercialization;*
- ?? Potential for short-term research and development;
- ?? Abundance of raw material to allow immediate production trials and testing of product samples;
- ?? Probable suitability for small-scale production and marketing; and
- ?? Environmental impact benign or positive.

6.2.2 Final Selection Criteria

During 2001 the selection criteria were progressively refined in consultation with WSUIP staff, USAID/USDA and A-SNAPP, arriving at a decision in June 2001 that each *strategic* species and its product(s) should ideally:

1. Have national and regional market potential, and possibly (at a suitable scale of production[4]) international market potential;
2. Have *significant local subsistence* or commercial use (so the species shall still be of interest to producers if market conditions become temporarily poor);
3. Allow production and processing operations that are technically and economically feasible on a small or medium scale (i.e. determined as requiring capital investment of $30,000 or less);
4. Be widely grown or abundant, at least locally, allowing rapid production response to market promotion *without depletion* of the species.

Special favor would be shown to plants that offered:

5. Benefits in addition to commercial development, *such as food security, soil fertility or conservation, or wood supply*;
6. Production and processing opportunities/synergies with *potential to increase value added within existing farming systems*; and
7. Early maturity, and were already *promoted by MAFE for NRM purposes*.

[4] International market development demands the building of critical momentum of production and accumulation of product stocks (Green CL, pers. comm.) beforehand. In MAFE's opinion such prerequisites may best be met by first of all building a successful business based on local/regional markets, where product use may not necessarily be the same as that foreseen in the international market.

Useful discussions took place between MAFE and COMPASS[5] on product/species selection.

COMPASS very recently reported (July 02, 2002):

> **" COMPASS has tentatively agreed to fund a marula oil extraction project in the Lower Shire. Once we have discussed …….. this with the local *community trust* and reviewed their …….. budget, we will conduct an environmental screening. If all goes well, they may be in production in September or October ………"**

Chapter 15 advocates investigation of potential synergies between MEP Recommendations and this plan and suggestions for institutional support to COMPASS/the trust are given in Section 9.11.

7 ORGANIZATION AND OPERATING METHODS

7.1 Partners in Malawi

One MAFE staff member covers the MEP on a full-time basis. In addition to teaming up with WSU and USAID/USDA in market investigations, MAFE turned to several local organizations for practical assistance in implementation of the program and has supported their costs in the sum of about K2.3 million ($30,000).

Most of the technical development carried out has been commissioned under institutional collaboration agreements (Annex 2, Volume 2) that have operated for 18 months since February 2001 and include *Contract Research*. Concerned Malawian institutions accordingly retain the experience and institutional memory from their involvement and thus, including authors of this report, have the knowledge base required to carry the MEP work forward beyond 2002. Work under the foregoing and continuing arrangements has created several effective partnerships and catalyzed increased collaboration between Malawian organizations involved.

Details of MAFE's MEP partnerships[6] are presented in Table 1. The value of resources contributed by MAFE's Malawi partners, notably University of Malawi Colleges in *staff recurrent costs and equipment*, significantly exceeds the K2.3 million provided to them by MAFE.

In February 2001 an indigenous NGO, *Enterprise Development and Training Agency* (EDETA), joined MAFE in its NPP R&D to assist market research, monitoring and supervision of adaptive research trials and respective economic analysis. The trials included raw material supply and processing with active involvement of communities. In 2002 EDETA's role widened to include business training to beneficiaries. MAFE direct disbursements to EDETA since February 2001 have amounted to a total of some K580,000 (some $7,700).

---

[5] Lowore, J. April 2001:
"The two possible management objectives <u>for subsistence services and benefit</u>s or for <u>commercial enterprise</u> are quite different and require different management mechanisms that may not easily be reconciled ……………….
A focus on developing market outlets for NTFPs needs to be kept in balance with consideration of the huge continuing use of NTFPs for subsistence use
It is important to target and understand correctly the characteristics and dynamics of different markets and product situations. Much emphasis has been on developing products for the international markets – but these are susceptible to changes. Domestic markets may provide more easily realised avenues for development.
MAFE ………. identified tree oils as an area worthy of future investment. All of these species – *Moringa*, Neem and *Jatropha* – that grow well in the hot dry climate of Chikwawa" *(a COMPASS focal district; others are Rumphi, Ntcheu, Dedza & Nkhata Bay)* "are included."

[6] In April 2001 WSU's Project Director, Dr Jan Noel and Professor Linda Hardesty and a delegation from University of Botswana carried out a three-day field visit to Malawi and met the partners involved.

EDETA is involved in initiatives to utilize NPPs from National Parks and Wildlife Reserves. It is a founding member (2001) of the Southern Africa Natural Products Trade Association (SANProTA) which is a regional NPP NGO based in Harare, supported by IFAD. SANProTA website pages are presented at Annex 2, Volume 2. Focus species for R&D by SANProTA include Marula and Manketti[7], also Baobab. It is hoped that EDETA will be able to draw on SANProTA's knowledge and regional network (notably in Namibia and Zimbabwe) to improve and extend assistance to NPP producers in Malawi.

In February 2001 a small family business, Khumbo Oil Refinery (KOR) agreed to commence a two-month period of trial collaboration with MAFE and EDETA to produce seed oils that were to be targeted for R&D. KOR had previous experience of collaborating with IEF and EDETA. It was already the leading member of an informal national association of about twelve female small-scale groundnut oil producers. In 2001 KOR organized the formal Registration of the Association, taking the Business Name *BCM Moringa Oil Refiners' Association (BCMMORA)*[8] with a membership of seven drawn from Blantyre, Chikwawa, and Mangochi, and chaired by the Managing Partner of KOR.

In September 2001 BCMMORA negotiated with MAFE to carry out a scaled up semi-commercial production program under which BCMMORA was a partner responsible for both *raw material procurement* and *processing*. This represented a *fourfold scale increase* over KOR normal operations and demanded mobility of production teams and equipment. By February 2002 it became evident that BCMMORA would be unable to meet its production goal (Annex 12, Volume 2). The Association ran into communication and organization problems, especially in Salima, and these have not yet been resolved.

MAFE disbursements to producers since February 2001 have amounted to a total of some K240,000 (some $3,200), principally for hire of equipment during initial experiments and, latterly, in respect of traveling and incidental expenses to production sites.

MAFE and EDETA established productive collaboration with two Colleges of the University of Malawi, i.e. *Chancellor College Chemistry Department* (CCCD) and *Bunda College of Agriculture* (BCA) *Engineering Department*. This continues. MAFE disbursements since February 2001 amount to K380,000 ($5,100) to CCCD and K360,000 ($4,800) on various activities of BCA. BCA expenses include *manufacture and supply of equipment*. In addition BCA was sponsored to *undertake adaptive engineering research in Tanzania* at a total cost of some $1,800 (K135,000). Total disbursements to support the collaboration of the University have amounted to some K880,000 ($11,700).

Malawi Bureau of Standards (MBS) was commissioned to test production samples and to advise on the means of attaining acceptable quality in accordance with MBS Standards. MBS laboratory and inspection services have cost MAFE a total of some K440,000 ($5,900).

7 Negotiation may be required between SANProTA and A-SNAPP to avoid duplication of activities but this could (Lombard, C. personal communication) be worked out according to particular product clusters, e.g. SANProTA could continue working with Marula and Manketti.

8 The association changed its name in mid-2002 to Tayamba *("we have started")* Oil Producers' Association (TOP) and took up membership of SANProTA.

TABLE 1: MAFE Partnerships in Malawi

Collaboration Agreements (Annex 2, Volume 2) were established with the following organizations which carried out *activities* as indicated:

> **Enterprise Development & Training Agency (EDETA)**: *production monitoring; evaluation of extraction technologies; environmental impact assessment and, with MAFE, economic analysis; market research; with a WSU specialist*[9]*training of client groups in developing business plans and marketing strategies.*
>
> **Khumbo Oil Refinery (KOR)[10]**: *seed procurement, seed conditioning, small-scale oil extraction trials/demonstrations in Michiru and Bolero and preparation of samples for laboratories; evaluation of extraction technologies; marketing and market assessment.*
>
> University of Malawi: **Chancellor College Chemistry Department (CCCD)[11]**: *literature review, reporting on previous research, process monitoring, qualitative and quantitative analysis (also, research into natural polyelectrolytes for water purification), suggested commercial uses of products, linkage with overseas laboratories.*
>
> University of Malawi: **Bunda College of Agriculture (BCA)**: *literature review, reporting on previous research, equipment calibration, process monitoring and adaptive industrial research on oil extraction technologies with presses and expellers (Malawi and Tanzania).*
>
> **Malawi Bureau of Standards (MBS)**: *qualitative and quantitative analysis of production samples against Edible Oils Standard MBS 51and other Standards.*
>
> **Malawi Industrial Research and Technology Development Centre[12] (MIRTDC)**: *process monitoring and equipment calibration.*
>
> **Forestry Research Institute of Malawi (FRIM) –** Seed and Tree Improvement Strategy Area: *literature review, survey of neem production areas; supply of seeds for trials.*
>
> **Valmore Paints Ltd (Valmore)**: *Loan of expeller equipment and expeller trials with tree seeds.*

In addition, **Naming'omba Tea Estates Ltd** *undertook batch filtration of Moringa oil for MAFE in April 2002 at the factory of its Macadamia Nut Division.*

---

[9] Prof Jerman Rose, Director, Center for Entrepreneurial Studies.
[10] This was succeeded by the MAFE/EDETA partnership with BCMMORA.
[11] CCCD also collaborates with Imperial College at Wye (University), London in bio-chemical research through a British Council Environmental Sciences Link.
[12] No services payments were involved.

7.2 Potential Role of Other Identified Organizations

There are a number of other Malawi institutions, and associations, that could contribute to product development, detailed assessment of species, their identification and their silviculture/agronomy. They include several parastatals such as the Malawi Export Promotion Council and the Malawi Investment Promotion Agency (press reports anticipate their merger). The respective organizations and their potential roles are described in Annex 3, Volume 2.

7.3 Equipment maintenance frustrations

Laboratories of CCCD and MBS have useful but limited capacity to conduct assay of samples. During 2001 they both suffered from broken-down *gas chromatography – mass spectrophotometer* (GCMS) equipment and, although MAFE was regularly making payments to MBS for services supplied, the MBS *rancidity testing* equipment remained out of order throughout the program's 18 month research phase. The absence of GCMS equipment frustrated MAFE's plan to identify chemical components of plant parts and delayed the generation of vital information. The lack of rancidity testing equipment prevented quick determination of the stability of tree oils. These local deficiencies prompted preparation for further work to be undertaken in overseas laboratories[13] where some $10,000 (K750,000) was spent.

7.4 Partners abroad

7.4.1 Laboratories involved

Owing to limitations of local analytical services (Section 7.3), three overseas laboratories are assisting the local partnership:

Leatherhead Food Research Association (LFRA)[14], UK
Scottish Crop Research Institute – Lipid Analysis Unit (SCRI-LAU): Mylnefield Research Services Ltd, UK
Institute for Food Research (IFR), UK

All IFR support has been received free of charge on the basis of *public domain* sharing of information and materials.

Charges for services provided by LFRA (including freight charges, annual membership at $1,200 and books) amounted to £3,900 ($5,600) and SCRI-LAU final charges will amount to some £3,000 ($4,300). The total outlay on these overseas services, almost entirely for oils analysis, is about $10,000.

---

[13] Laboratory equipment of the Agricultural Research and Extension Trust (ARET) came to MAFE's attention too late to be exploited.

[14] After consultation among its partners, MAFE decided to take up membership of LFRA as it offered the combination of state-of-the-art analytical services under one roof, excellent web-based databases of reference material and the means of supporting international trade contacts.
LFRA has 1,000 members in 45 countries of which 81% are in the European Union, 7% are in the USA and 12% are in other countries.

7.4.2 <u>Deferred research</u>

CCCD recommendations in 2001 (Annex 2, Volume 2) for assay by LFRA included two areas of investigation:

?? Analysis of oils produced in *Stage 1* trials with KOR, and

?? Comprehensive analysis of whole tree seeds and their components (chemistry; nutritional value; toxins and anti-nutrients).

On the advice of CCCD (see CCCD Report Chapter 14), MAFE sent seeds and *Stage 1* oils (Annex 2, Volume 2) to LFRA in December 2001. The LFRA quotation received by MAFE for *routine* analysis of whole seeds ran to some $1,500 or more per sample *and* required additional sub-contracting of detailed analysis of minor components at further expense. Comprehensive analysis of, say 15 types of seeds by the respective professional laboratories, as initially contemplated, would probably have cost $30,000. MAFE decided to defer any testing of seeds until results of Stage 1 oils analysis had been received. With the exception of *cross-checking* a controversial batch of oil with a test on respective seeds, and certain work directly commissioned by CCCD at SCRI-LAU, no seed analysis has been done for MAFE abroad.

It is now evident that much of the intended analytical work on seeds would best have been carried out as part of University programs of postgraduate empirical research – specially in the case of one species that LFRA recently estimated would cost $50,000 to comprehensively analyse (Annex 2, Volume2). This issue is discussed further in the CCCD Report and is covered in our Recommendations (Chapter 15).

7.5 Overall Costs of Partners Covered by MAFE

MAFE disbursements to cover MEP partner expenses and related laboratory services are expected to amount to less than K3.0 million ($40,000) over an elapsed period of 18 months. At least 75% of this sum has been spent on partners within Malawi.

7.6 Human Resources Development and Institutional Memory

7.6.1 <u>Partners</u>

Besides organizing documentation of the Program's activities and results, MAFE has tried to ensure that a legacy of the MEP group partnership will be substantial human resources development and associated "institutional memory" along the following lines:

Commercial diversification and related production and business planning/marketing skills development: members of BCMMORA/TOP and other small-scale producer groups.

Economist, business planning trainer and market research officer: EDETA staff.

Institutional coordination, international networking, documents retrieval*[15]*, promotion of new technology, extension and seed supply: MAFE Resource Center Coordinator, & Manager.

Ethnobotanist/Herbalist for phenotype and germplasm identificationand registration: (largely unfulfilled) arrangements made with FRIM and/or National Herbarium personnel.

Food technologist for oil and by-product extraction, refining, filtration, storage, handling and packing: research graduates of CCCD; MBS personnel.

Process chemist for oil and by-product extraction, refining, filtration, storage and handling: Faculty and research graduates of CCCD.

Mechanical/Process engineer for oil and by-product extraction, refining, filtration, storage, handling and packing: Faculty and undergraduates of BCA.

See also Section 10.7.9 that describes an international website that may open the opportunity for the foregoing personnel to interact on topics of mutual interest with their international peers.

7.6.2 Clients

Several small-scale producers/processors who had been working with MAFE and its partners in tree seeds oils production trials since early 2001 expressed interest in being trained in business methods to enable them to commercialize recommendations provided by the MEP. In April 2002 these clients, mostly from BCMMORA, and a group of entrepreneurs and business trainers (17 in all) as listed in Table 2 were given an intensive two-week training course in business planning and marketing by a WSU-EDETA joint team. The team was assisted by invited speakers. Training was principally by seminars at the MAFE Resource Center. The course covered case studies, fieldwork and the following core topics:

a. Introduction to market assessment and business planning;
b. Researching markets for products of the business and determination of potential customer wants and sales forecasting;
c. Identification of competition and developing strategy to meet the competition;
d. Determining sources of raw materials in terms of cost, quality, and reliability of supply was covered in general principles, but not in specific detail to each participant's business;
e. Estimating costs of production and expected profits;
f. Estimating capital costs and cash flows; and
g. Estimating the need for outside funds and determining where to obtain them.

---

[15] On 02/07/02 four ram presses and accessories/tools, the MEP library (see Bibliography***), working papers (in subject files) and files of key subject matter as set out below were transferred to the Resource Center:

1. A-SNAPP;
2. *Jatropha curcas*
3. Manketti & Marula
4. Oils Chemistry & Properties
5. MBS; MAFE Testing Laboratories Overseas: SCRI; IFR; LFRA; also, UK plant materials import guidelines/regulations
6. *Moringa oleifera*
7. Research Institutions: Abroad; Malawi; & Projects in Malawi: Visits and Communications
8. Traders; Processors – Malawi
9. *Tephrosia vogelii*
10. *Trichilia emetica*

Benefits of the course to BCMMORA members need to be put to test.

Table 2 : PARTICIPANTS IN BUSINESS TRAINING PROGRAM: Prof Jerman Rose & Mr Emmanuel Mlaka

Name	Affiliation	Location	Business
Fruit and vegetable processors			
Mrs Lisa MAKOPA	ICRAF-trained	Magomero	Food processing: fruits and vegetables, including juices.
Mrs Ellen MKUMBA	ICRAF-trained	“”	Tomato trading and processing.
Community juice manufacture and distribution through urban retailers			
Shortex Lawrence ZIMBA	Wildlife Society of Malawi/GTZ project: Chairman, Local Steering Committee	Kam’wamba, Mwanza	Baobab and Tamarind juices extraction and sale. Other/occupation: CSC guard, restaurant & shop.
Absent P. TEBULO	Secretary, “”	“”	Guinea fowl raising & beekeeping; Baobab and Tamarind juices extraction and sale. Interested to extract Baobab seed oil
Business owners/ oil producers/would-be producers			
Mrs Annie S. BONOMALI	Chairperson, KOR and BCM Moringa Oil Refiners’ Assn/Tayamba Oil Producers Assn	Blantyre: Michiru Mulunguzi	Oil processing trainer. Tailoring & Proprietor, Khumbo Oil Refinery. Formerly fresh & dried fish sales & second hand clothes sales. Mr Bonomali is an accountant.
Mrs Tise KUNSAMALA	Member BCMMORA/TOP	Mangochi	Formerly drying & sales of fish. Basket weaving and (wef 2001) oil pressing.
Mrs Fanny MKONJO	Member BCMMORA/TOP	Chikwawa	Groundnut pressing (from IEF) & tailoring. Plans to extract Moringa oil; interested in Neem possibilities. Mr Mkonjo is a Pharmacist Assistant.
Mrs Elizabeth CHISASULA	Member BCMMORA/TOP	Dedza	Cotton, groundnut and maize farming; travelling second hand clothes dealer; donut baking & sales; (groundnut pressing)
Mrs Mary BOTHA	Member BCMMORA/TOP; trained in oil pressing	Rumphi	Maize, tobacco and paprika farming; possible Manketti oil producer.

Mrs Betty MWAWA	Chairperson, Zione Church community; Member BCMMORA/TOP	Salima	Hardware dealer; Plans to extract Moringa oil (after 2001 demo.)
Mrs Eles CHAKWAWA	Zione Church community; Member BCMMORA/TOP	“”	Grocery shop. Family business: farming + goats & chickens. Plans to extract Moringa oil.
Isaiah MEMYERE	Private farmer assisted by EDETA/trained in oil pressing. Borrower from MRFC.	Neno, Mwanza	Agric. Research retired. Maize, vegetables, groundnuts & macadamia farming. Wants to extract macadamia oil.
Business women			
Mrs Fern SADYALUNDA	Chairperson, Lilongwe, National Association of Business Women	Lilongwe	Tailoring & maize grinding mills. Mr Sadyalunda is an accountant
Mrs Rebecca CHISEMPHERE	National Association of Business Women; Member BCMMORA/TOP	Mchinji	Groundnut trading.
EDETA staff			
Mrs Dyless VINKHUMBO	EDETA Business Trainer	Blantyre (b. Rumphi)	CEFE business training. Mr Vinkhumbo is a mushroom farmer.
Ms Juliet CHILUWE	EDETA Executive/market research with MAFE	Blantyre	Researcher/trainer. Interested in poultry raising & mushroom cultivation. (Environmental scientist/laboratory technician)
Ms Lucy Chawinga	COMPASS-assisted business	Blantyre	Oyster Mushroom producer.

PART II: PRODUCTS AND POTENTIAL MARKETS

8 PRODUCT KNOWLEDGE

8.1 Knowledge within the sector

8.1.1 Producers

With the exception of traditional medicinal practitioners/herbalists, the number of producers/gatherers in Malawi involved in commercialization of NPPs from agroforestry species is small.

Up to the extent of their knowledge, producers and gatherers make full subsistence use of farm and wild tree species. MAFE has noted that the extent of use of each species varies according to locality, community and custom. There are a number of opportunities for promoting farmer-to-farmer extension to widen the knowledge and utilization, especially in subsistence, of respective plants. Table 3[16] illustrates this point.

Producers and gatherers recognize there may be under-utilization of some plant parts/products but suffer from the following constraints:

- lack of information on the products, their uses, their potential (including subsistence) and markets;
- lack of knowledge on how to access such information;
- taboos;
- lack of organization and resources to carry out respective investigations and research; and, even when opportunities are identified,
- difficulty to mobilize and coordinate gathering of NPPs (specifically tree seeds) in a timely manner.

8.1.2 Processors

The main technical constraints of local processors include:

- lack of information on the potential commercial applications of local species; and
- difficulty to change production processes from systems based on repackaging of imported semi-finished products (mostly from Zimbabwe and South Africa), to systems involving process chemistry and the blending of raw materials.

In the case of the pharmaceutical and cosmetic industries the latter observation is explained in Annex 5, Volume 2.

[16] For details of sites of interviews and map see Annex 4, Volume 2.

Table 3: MAFE-IEF-ADD Lower Shire Survey March 25 - 27, 2002

Planted on-farm Trees' Reported Relative Importance in Subsistence and Their Uses

Excel table

8.2 Product characterization

8.2.1 Products in international trade

NR products from other countries considered potentially suitable for production in Malawi have, in those countries, been fully analyzed and characterized and are routinely traded. Malawi could expect to produce matching products of broadly the same character. However, some local variation in NR product properties can be expected due to *genetic* and/or *agro-ecological difference* from other countries and/or *differences in manufacturing processes*. Results of overseas testing in 2002 of samples of Moringa oil that had been prepared using various extraction systems, presented in Table 4, illustrate the latter point and imply *variation in oil stability/storage life*. The implications are discussed later in this report and in detail in the CCCD Report.

MAFE and its partners felt it would be vital to define the respective NR products that Malawi might have to offer. So, early in this program, while the Project and its partners shared certain commercial hunches, they reached a consensus that the Project should commission local laboratories to determine the basic *physico-chemical properties* of products that could be offered *before* embarking on detailed market research. In the event the laboratory work had to be supplemented by further work abroad[17]. For example, this identified variation in quality of batches of MAFE *seed oils* that were attributed to differences in either plant provenance and/or agro-ecology or manufacturing process, or a combination of these factors. It became necessary to inquire in the trade about which oil specification best suited commercial requirements. Variation is discussed in Section 9.9.

8.2.2 Novel Products

Some NPPs with important traditional uses were identified by MAFE and its partners to have possible commercial potential. Unfortunately they are not cited in known literature and are so novel that – although they may have localized subsistence uses – they are not traded anywhere. CCCD's ongoing *pioneer* research into unusual fatty acids in seed oils of targeted species is an example of what has to be done to determine suitability. NPPs are being carefully characterized to determine their full physico-chemical properties. MAFE has begun market investigations based on initial results of assay, but it will not introduce samples to the trade until their full chemistry has been determined. Moreover care is required to assure that no adulteration has taken place.

8.2.3 Hazardous materials

This rigorous product testing approach has enabled MAFE Project to examine the safety of some of the substances it is dealing with and, in consultation with WSU, to determine the basis upon which further research and development, if any, on hazardous materials may be undertaken.

[17] In the case of Moringa oil, several samples did not match international standards and differed markedly from the characterizations given by earlier research in Malawi (Tsaknis, J. et al. 1998). Adulteration was suspected.

Table 4: ***Moringa oleifera:*** **Analysis of oil samples from MAFE compared with results of other research**

8.3 Pharmacological and health-associated products

At the start of the program (see TOR at Annex 1, Volume 2), as part of the holistic approach to product identification, MAFE decided to include inquiries into medicinal applications in the investigation of the uses of species but it was considered infeasible to explore these avenues comprehensively. This area would require separate study and employment of a specialized team[18].

Comprehensive inquiries into the commercial market scope of plant-based medicines would ideally be delegated to other, permanent organizations and/or a new project. With the program giving emphasis to products with *'short-term' commercial potential* and some species already showing potential for such exploitation, in March 2001 MAFE, WSU and LRCD determined that the project's NPP investigations should not extend to direct investigation of the potential of plant-based medicines.

MAFE has however facilitated public-domain medical researchers - specifically the Institute of Food Research (IFR), Norwich, UK and the University of Botswana - by supplying plant materials for tests. The cost of this assistance is nominal. Initial results obtained by these institutions to date are presented in Annex 2, Volume 2.

Although the herbal remedy/dietary supplement (nutraceuticals) market has met some official criticism in the USA for its lack of regulation, this sector and the biological pesticide/anti-feedant markets were retained in the scope of MEP work, since these might offer short and medium term returns. The principal nutraceuticals of interest to MAFE are *natural anti-oxidants/Vitamin E, and Vitamin F.* These are explained in Section 9.7.

Based on the 2002 findings in Table 3, WSU decided to commission its College of Pharmacy (TOR at Annex 2, Volume 2) to conduct an internet search and investigate traditional medicinal[19] uses in Malawi of species that had *already become the focus* of MEP and USAID/USDA attention. This assignment was carried out in May 2002 by WSU's Research Assistant Professor, Linda M. Robison, MSPH, a pharmacoeconomist and pharmacoepidemiologist, in partnership with EDETA's Juliet Chiluwe. The draft report is presented in Annex 2, Volume 2.

Some of the findings from the WSU-EDETA study are described in Chapters 9 and 10.

[18] Medicinal testing and registration under US Food and Drug Administration and other importer-country regulations typically take several years so MAFE could not realistically expect to get tangible results from developing a medicinal product within its own lifespan.
[19] Previous preliminary traditional medicine studies (see Bibliography) need to be followed up by usage and market investigations that cover measurement of dosages, sampling for chemical assay, clinical monitoring and determination of respective marketing systems and prices

9 PRODUCTS/STRATEGIC SPECIES IDENTIFICATION AND TARGETING

9.1 Preference for agroforestry species

The 2000 – 01 MEP Annual Workplan stipulated focusing on and exhausting the scope of potential products from agroforestry species currently promoted by MAFE *before* embarking on investigation of other species. During the *Inception Phase* this criterion dominated the initial process of product identification and selection. All decisions on selection of strategic species were made jointly with LRCD and the project's MEP partners. Respective selections have:

- ?? met the criteria agreed with USDA/USAID;
- ?? enabled MEP work to focus on a few species; and,
- ?? prevented diluting efforts over too wide a menu of species.

9.2 Indigenous fruit species covered by SADC-ICRAF

MAFE was briefed by SADC-ICRAF in 2000 on its work-in-progress with Malawian organizations on fruits of both Jujube (*Ziziphus mauritiana*) and Marula (*Sclerocarya birrea*). MAFE and LRCD soon decided it would be unjustified to double up the effort of SADC-ICRAF by also devoting MAFE/USAID resources to indigenous fruits R & D and marketing. Moreover, in late 2001 SADC-ICRAF was awarded a new 3-year *regional* project by 'BMZ' to continue its work on indigenous fruit with greater emphasis on product development and marketing (F. Akkinifesi & A. Boehringer. personal communication.). MAFE took up an invitation to participate in meetings in early 2002 to plan implementation of the BMZ project; SADC-ICRAF acknowledged that MAFE's NPP R&D complemented, and did not duplicate, the work of this project[20].

MAFE's role as an innovator in Central African tree seed oils R&D and its complementarity with SADC-ICRAF's fruit work was acknowledged by SADC-ICRAF at the ICRAF Annual Regional Conference, Pretoria in May 2002. MAFE presented two papers and BCA Engineers presented their MAFE *seed oils work.*

9.3 Strategic species

The following species, all of which were promoted in the MAFE *1995 Agroforestry Field Manual*, have been given special consideration in this program:

Marula *(Sclerocarya birrea)*
Moringa *(Moringa oleifera)*
Natal Mahogany *(Trichilia emetica)*[21]
Neem *(Azadirachta indica)*
Tephrosia *(Tephrosia vogelii)*

Jatropha *(Jatropha curcas*) was also included because of its wide importance as hedge resistant to ruminant grazing.

[20] Dr John Saka of CCCD is a partner in the BMZ Project.

[21] Also recommended for investigation by MAFE Technical Associates Gift Chammagomo and Alubi Mpira, and Glynwell Siyeni.

Investigation of the commercial potential of other agroforestry species was initiated when time permitted. This resulted in the addition of the following to the list of 'strategic' species:

African Star-Chestnut *(Sterculia africana)*[22]
Manketti *(Schinziophyton rautanenii)*[23]

The justification for their selection[24] and the sources of ideas are presented in Annex 6, Volume 2. Over 170 uses were identified with the help of the checklist devised by MAFE in Table 5:

[22] Recommended by Gift Chammagomo.
[23] Recommended by Alois Sander, BZDP on the basis of his knowledge in Namibia.
[24] African-Star Chestnut and Manketti were not included in the analysis because they were not formally adopted into the MEP until March 2002. A total of 9 uses and 6 uses respectively are identified for them in Table 6.

Table 5: MAFE NPP and NRM USES checklist

Products classification and hierarchy (6 categories)

Seed for cultivation
Nutritional
Cosmetic/skincare
Medicinal/homeopathic
Biocide/anti-feedant
Non-food industrial

NRM benefits classification and hierarchy (6 categories)

Energy
Mulch/soil fertility
Erosion prevention (wind; water)
Plant/crop protection (wind; rain; hail)
Shading
Carbon sink

User classification (2 categories)

Human
Livestock/veterinary

Sector classification (2 categories)

Subsistence & emergency subsistence
Commercial

Hierarchy of Plant Parts (17 major categories)

- Flower buds
- Open flowers
- Pollen
- Nectar
- Seed pods immature
- Seed pods mature
- Fruits
    - Fruit pulp
    - Seeds immature
    - Seeds mature
        - Aril
        - Shell
        - Kernel
            - Kernel oil
            - Kernel residue
                - Extracts
                - Filterpress
            - Foots
- Seed pod shucks
- Young leaves
- Old leaves
- Pruned wood
- Pruned foliage
- Bark
- Timber
- Roots
- Dead stump
- Dead root ball

Other/associated sources: *Micro-organisms and mycorhiza (soil)*
Insects
Birds
Mammals

9.4 Opportunities Identified

Table 6 presents the count of all identified respective uses for the strategic species as set out in Annex 6, Volume 2.

Table 6: Count of Products, Possible Products and NRM Benefits Notified for Targeted Species

Botanical name	***Sterculia africana***	***Jatropha curcas***	***Schinzio-phyton rautanenii***	***Sclerocar-ya birrea***	***Moringa oleifera***	***Trichilia emetica***	***Azadir-achta indica***	***Tephrosia vogelii***
English name	**African Star-Chestnut**	**Jatropha**	**Manketti**	**Marula**	**Moringa**	**Natal Mahogany**	**Neem**	**Tephrosia**
Local name	**Ngoza**	**Nsadsi**	**Mahuwi** ***(Tambuka)***	**Mfula**	**Chamwa-mba; Nsangoa**	**Msikitsi**	**Nimu**	**Mthuthu**
Seasonality Product Classificati-on (6 categories)	**Seeds harvested in dry season.**	**Fruits harvested in dry season.**	**Fruits harvested in dry season.**	**Fruits harvested in dry season.**	**Seeds harvested mostly in dry season.**	**Fruits harvested in wet season: *seeds aflatoxin-susceptible.***	**Fruits harvested in wet season: *seeds aflatoxin-susceptible.***	**Seeds harvested in dry season.**
Seed for cultivation	*Not significant*	*Not significant.*	*Not significant*	*Not significant.*	*Not significant.*	*Not significant.*	*Not significant.*	Significant
Nutritional	3	2	3	13	13	4	1	0
Medicinal/homeopathic	2	9	0	9	35 (some duplicates)	6	8	4
Biocide/anti-feedant	0	2	0	1	0	1	5 (several muti[lr products)	5
Non-food industrial	3	3	2	2	7	2	4	0
Product Total	8	16	3	25	55	13	18	9
NRM Benefit Classification (6 categories)								
Energy	0	1		2	2	0	2	0
Mulch/soil fertility		1	1	0	2	0	2	1
Erosion prevention (wind; water)	0	1	1	0	1	0	0	1
Plant/crop protection (wind; rain; hail)	1	1	1	1	1	0	0	0
Shading	1	0		0	1	1	0	0
Carbon sink	0	0	0	1	1	1	1	0
Other associations	0	0	0	1	0	0	0	0
NRM Total	2	4	3	5	8	2	5	2
ALL ENTRIES	9	20	6	30	63	15	23	11

9.5 The special case of Tephrosia *(Tephrosia vogelii)*

Owing to the complexity of Tephrosia chemistry, it was not feasible to anticipate that MAFE could commission comprehensive R&D that would result in identification and MAFE commercialization of a Tephrosia product. There has nevertheless been some progress: MAFE's contribution to Tephrosia research is regarded as a small step in a wider international effort to increase knowledge about the potential applications of this plant.

Tephrosia is a favored leguminous under-sown annual and fallow crop/inter-crop shrub recommended by MAFE for addressing soil fertility and mulch deficits. It exhibits a number of pesticide and pharmacological properties (as listed in Annex 6, Volume 2) attributed to active principles including *rotenoids*. SHOGA has repeatedly expressed interest in promotion of this plant for both (organic management) soil fertility improvement and pesticide/anti-feedent purposes (Schwarz, A. personal communication).

For several years MAFE has been committed to investigating properties and potential uses of Tephrosia but it was unable to find a local partner to assist chemical investigations for characterization purposes. Soundings with CCCD[25] indicated that no research team could be found to lead this work in Malawi. Following a visit to Malawi arranged by WSU, in May 2001 the Natural Products Research team at the University of Botswana (UB)[26], led by Prof Berhanu M. Abegaz, undertook preliminary analysis of leaves provided by MAFE[27]. The leaves yielded three compounds: *tephrosin, deguelin* and *alpha toxicarol*. This is not a typical composition as reported in literature. Alpha toxicarol has not been known to occur in Tephrosia vogelii. And tephrosin was present in very significant amount (B.M. Abegaz, PhD pers comm). See Annex 2, Volume 2.

University of Botswana studies of MAFE seeds had to wait until 2002, when research students were available. Results were as follows:

" The present, incomplete investigation of the seeds has revealed that the seed extract of *T. vogelii* contains tephrosin, deguelin, dehydrodeguelin and 5-methoxyisolonchocarpin. The first three are known to occur in the seeds, but the fourth compound (5-methoxyisolonchocarpin) is reported …….. for the first time. There are many more compounds that ……… are yet to be identified. The only remaining previously known constituent of the seeds vogeletin may be one of them. The preliminary data obtained on some of the compounds seem to suggest that many more novel structures are likely to be identified.

Some of these compounds are reported to have interesting and relevant properties. For example tephrosin is known to have insect antifeedant properties at concentrations of 382 ppm. It is also cytotoxic and piscicide (Duke 1992). Tephrosin has also been shown to be active against tumors including skin cancer (Andrei et al 1997). Deguelin is described (Merck Index 12th edn) as an insecticide and skin irritant. It also warns of possible fatality due to pulmonary damage by inhalation (See also J. Nat Prod. 53(4):774)….

The seeds also contained 12% of thick, brown oil which resembles that of clover and of peanut…… The bulk chemical properties of *Tephrosia vogelli* seed oil (obtained by petroleum ether extraction of the seeds, yield = 7.6%) were determined to collect data that can be used to characterize the oil. The properties determined in this work are saponification value, iodine value, acid value and unsaponifiable matter.

---

[25] In 1998 (also early 2001) CCCD was invited by MAFE to write an outline proposal for such work.
[26] WSU and UB collaborate in the UB academic program with support from USAID.
[27]

WSUIP/ P. Wyeth July 9, 2001 download from www.medindex.org/~hanyang/basicsym/29.html of Dr Sang Kook Lee's "Rotenoid-mediated cancer chemoprevention" paper:

……… "As a result of bioassay-guided fractionation, the rotenoids **deguelin** and tephrosin were isolated as potent ODC (phorbol-ester induced ornithine decarboxylase activity in cell culture) inhibitors from *Mundulea sericea* Will. (Leguminosae). Further, these isolates inhibited chemically-induced preneoplastic lesions in mammary organ culture and papillomas in the two-stage mouse skin model. Since **deguelin was considered a promising antitumor promoter** ...."

Table 7: Chemical Parameters of *Tephrosia vogelii* oil

Chemical Parameter	Value
Iodine value (Wijs)	94.03-96.50
Saponification value (mg KOH/g)	165.98-170.12
Acid value (mg KOH/g)	15.99-16.26
Unsaponifiable matter (%)	1.72

(Source: Berhanu M. Abegaz, Bonaventure T. Ngadjui, Modise Rammika, O. Yeboah, Julia Lesholo and Joan Mutanyatta - Department of Chemistry, University of Botswana)

The Iodine value (which is a measure of the degree of unsaturation) of *T. vogelli* oil is value is comparable to that of groundnut oil (80-106 Wijs). The oil may be classifed as a moderately unsaturated oil since its iodine value falls roughly between sunflower oil (generally regarded as highly unsaturated with iodine value of 110-143Wij's) and the common saturated oil (palm oil with iodine value of 50-55Wijs)."

Further investigation will be required to isolate and determine the uses of chemical constituents in Malawi Tephrosia and more detailed work is required to characterize the seed oil. Actual seed oil content at 12% is less than half that indicated for any other species reviewed in this report.

Work on Tephrosia was also delegated to IFR. Results of the IFR work are presented in Companion Document No 4 and were received after editing of this report.

Investigation of the market for Tephrosia seed for planting was excluded from the program scope of work and is regarded as an area within the domain of the MAFE Resource Center.

9.6 Common threads of opportunity: oleiferous species

After 3 months (i.e. in January 2001), the product screening process had led to identification of two *early-maturing* agroforestry species, Moringa[28] (*Moringa oleifera*) and Jatropha[29] (*Jatropha curcas*), with potential products for short-term research and development. They thus became a focus of program attention. Both had undergone previous product research abroad and were well documented. Moreover they had *previously been researched in Malawi* by CCCD, Blantyre Polytechnic and other institutions for a number of reasons, including their *ability to yield seed oils with known histories of commercial use*. Their previous research funding in Malawi ran out in 1997[30].

Literature review, internet searching and advice from sources worldwide, including MAFE's *Technical Associates* and past and present researchers of University of Malawi, led to MAFE investigations and research widening to include the five other oil bearing species described in Section 9.3.

After one year's research on the seven *oleaginous* species, it has been possible to:

?? identify the physico-chemical properties of the seed oils of all except Natal Mahogany,

?? in several cases compare results of direct assay with results of earlier work in Malawi and overseas, and

?? make a start on determining the extent to which the oils might replace and compete with other products in trade – by virtue of similarity of physico-chemical properties and competitive production costs.

The scope for substitution of commercial oils by oils from the strategic species is discussed under the respective species sections in Chapter 10.

The partners are also investigating possibilities for subsistence and commercial uses of oil by-products, especially presscakes.

9.7 Special nutritional/pharmacological/industrial factors to seek in tree oils

Nutrition

Review of literature encouraged MAFE to consider plant oils that contain important human nutritional principles. Two main sub types of *polyunsaturated fatty acids* are considered vital for nutrition: *omega-3s* and *omega-6s* (www.health-pages.com/cgi-local/aff2.pl?SRC=G093T&URL-fa). "*Linoleic acid* (an omega-3)", better known as *Vitamin F* "and *alpha-linolenic acid* (an omega-6) are the only true 'essential' fatty acids" because in healthy humans alpha-linolenic acid is converted, albeit slowly,

---

[28] Coote C, Stewart M and Bonongwe C. 1997. The Distribution, Uses and Potential for Development of *Moringa Oleifera* in Malawi. FRIM Forestry Research Record No. 67. Malawi Government.

[29] Also known as Pulsa or Physic Tree.

[30] Unfortunately the proceedings of a June, 1998 "further research planning conference" for Moringa, sponsored by the World Bank, were never documented (Chipofya, V. personal communication).

into necessary nutrients "*eicosapentaenoic acid (EPA)* and *docosahexaenoic acid (DHA)* – both important fatty acids of the omega-3 family.

Gamma linolenic acid
Recognising the above basic 'rules' for nutrition, MAFE's investigations widened to include (Rossell, B. 1999) *Gamma linolenic acid* (GLA) which is commonly sourced (10% by weight; all *cis ?*-6-9-12-octadecatrienoicacid) from *Evening Primrose oil* (high Iodine Value and very prone to oxidation) and important in human metabolism. It is also availablefrom blackcurrant pip and borage oils. Healthy adults can convert dietary linoleic acid (common in numerous polyunsaturated oils) into GLA for further metabolic changes into prostaglandins that have hormone-like functions but (www.13.netrition.com/oils_page.html) by age 60 (Horrobin, D.) metabolic efficiency declines to 50% and dietary supplementation may be required (also in premature babies and some young male alcoholics) to combat symptoms such as atopic dermatitis that are thought to be caused by weakness of the *delta-6 desaturase system*. GLA also has a history of prescribed use for cyclic breast pain (UK) and premenstrual discomfort (USA).

Natural anti-oxidants
Natural anti-oxidants, notably *tocopherols* that are found in edible vegetable oils and are precursors of Vitamin E. They are necessary components of the normal human diet. They play a part in protecting *low-density lipoprotein* particles and cell membranes from damage by oxygen 'free radicals' that are released in the body in the normal course of energy production from carbohydrates, proteins and fats. Free radicals are considered involved in development of coronary diseases, cancer and cataracts, and the aging process (Minihane, A.M. 1999). Table 4 may be indicative of anti-oxidants being denatured under high temperature/friction motorised crushing of respective oilseeds and suggests that hand pressing may be less damaging.

Conjugated linolenic acid
Isomers of *conjugated linolenic* (not linoleic) *acid (CLN)/*conjugated trienes may have applications for treating cancer (Suzuki, R et al. 2001) and in *zein film* treatment for fresh produce preservation (Rakotonirainy, A.M. et al 2001) but actual suitability depends on the isolation of the correct isomer or group of isomers.

Sperm oil substitution
In the mid-19th Century, trade in one of MAFE's targeted tree seed oils, Moringa, collapsed when the oil was replaced by *Sperm oil*. Given current international moratoriums on whale hunting, there may now be opportunities for exploiting reverse substitution opportunities on Sperm oil commercial applications (for which Jojoba oil is sometimes cited).This first requires separate research into known Sperm oil applications. Internet searches to date have revealed only superficial information and much further investigation in this field is required.

The accompanying CCCD Report Section 8.2.3 and CCCD's individual species Sections describe other possible applications.

9.8 Commercial Benchmarks: Industrial/mineral oils and cooking oils

Nutrition is a major component of MEP investigations. Unfortunately, as discussed in Chapter 10, several, but not all, tree seed presscakes contain unpalatable factors and anti-nutrients that make them unsuitable for food or feed use without major reprocessing.

Production economics research (Section 12.5) revealed that seed oils from the strategic species cannot compete either as edible substitutes for imported/local soya and sunflower cooking/salad oils and imported palm cooking oil, or as *paint oils* and commercial *soapstock*. In Malawi 'paint oil' costs about K40/liter ($0.53/liter @ R.O.E 75:1) and semi-refined sunflower oil from local seed is sold by various factories (Annex 5, Volume 2) at about K87/liter ($1.16/liter); sunflower presscake is an important by-product selling at about K8/kg as a livestock feed ingredient. These prices also broadly apply in Tanzania (Mtui, F. personal communication).

Naming'omba Tea Estates Ltd (NTE) produces about 20,000 litres of (by-product) macadamia nut oil annually. It sells to its employees and the general public at a price (excluding packaging and surtax) of K117/litre ($1.60/litre), and K149 including container; the same oil can be bought in Zomba at about K215/litre (retail, packed).

The Lilongwe soya bean processing business, SEBA Foods (SEBA) was visited in September 2001. SEBA processes about 2,500 t of beans annually, supplied by a trader network (Burgess, A. personal communication). It manufactures various SEBA food products. Oil[31] is produced as a by-product and probably amounts to up to 400 tonnes annually. The filtered oil is sold unrefined to other industries and could be the cheapest domestically pressed vegetable oil.

International wholesale price benchmarks for crude oils taken for reference on July 5, 2001 were:

	US$/kg	K/kg (K75 = $1)
Palm Oil	0.27	20.25
Soya Oil	0.35	26.25

After allowing for handling and transportation charges and taking advice from importers, it was considered by MAFE that the landed (Blantyre) price of such crude oils for food and mineral/fuel/ paint oil use should be taken as some K35/kg.

Mindful of competition from common oils and the impracticality of using several tree presscakes for food or feed purposes, MAFE and its partners found it necessary to investigate higher specification uses for the tree oils[32] (as suggested by the literature).

On pricing, Jatropha, which offers a non-edible oil, is a possible exception. MAFE investigation suggests the opportunity cost of seeds in Malawi could make the oil commercially viable at some K180/liter ($2.40/liter)[33]. *Crude* oils from all the other tree seeds under consideration cost more to produce, typically at an overall cost of about K280/liter ($3.70/liter), before refining, management and premises charges. Further details are provided in Section 12.5. Under experimental monitoring it has

[31] Insoluble foots/fibrous matter is removed by filtration and settlement (6 vessels before filter; two after filter).
[32] Vigilance in production is required since inexpensive common oils present a temptation for tree seed oil producers to adulterate genuine tree seed oils.
[33] Le Breton, G. (Wyeth, P. et al) reported the following for Zimbabwe: "It takes in the region of 4kg seed to produce 1 liter of oil, so the raw material costs alone would be Z$80 per liter. Add to this the processing costs and processor mark-up, and it is hard to see how a liter of oil could sell for less than Z$120. At the official exchange rate currently in force, this is equivalent to US$2.18 a liter."

been demonstrated that when processing tree seeds on manual presses, producers seldom exceed 15% oil extraction (by weight) although *yields in excess of 20% are possible with traditional oilseeds such as sunflower*.

9.9 Oils characterization and potential applications

Table 8, drawn up from a MAFE review of literature and results of project research (as recommended by CCCD, to fill gaps in secondary data), presents a simple comparison of the chemistry of the oils[34] of the strategic species with other oils that are traded internationally and have similar properties. The Table tracks *saturation* and the presence and quantity of *natural anti-oxidants*. Oils are categorized according to *unsaturation*, *monounsaturation* and *polyunsaturation*[35], with the latter considered most favourable from a nutritional and health viewpoint. Highly saturated commercial oils such as *Coconut* and *Palm Kernel* are not included because no equivalent/substitute tree seed oil has yet been discovered in Malawi. Excepting Mango kernel oil, Natal Mahogany seeds contain the most highly saturated oil from Malawi to come within the sight of the MEP partners.

As it is already enjoying success in international markets, Marula oil attracted much attention from the partnership and has recently attracted the interest of COMPASS (Section 6.2.2). Of all the tree oils considered, its chemistry appears to be remarkably similar to Olive oil[36]. Reasons for Moringa oil attracting research interest in the past included its chemical similarity to olive oil – but its negligible polyunsaturation needs to be noted. Current reasons for interest in it include its similarity to Marula oil.

Macadamia oil, which has been placed in the Table between Moringa and Marula (but scores fractionally more unsaturation overall than Marula), has a market both as a cooking and salad oil and is used in cosmetics. NTE produces the oil using three *Komet two-stage bench-mounted expellers*[37]. It used to export 200 l drums at a price of about $3.60/kg (K270/kg at today's value)[38] through a company called Tea Importers, filling a 20' container load annually (Phakamea, E., Katandika M.U.M. & Likangala, R. personal communication), also 6 containers annually of *Tung Oil*[39] until the latter was superseded by synthetic paint ingredients.

Natal Mahogany oil, the most saturated tree seed oil under review, appears to contain some 49% or more of fatty acids considered beneficial for skincare, with the major contribution coming from the

[34] Although it sent seed samples abroad to LFRA on the advice of CCCD in readiness for testing, MAFE decided to limit its R&D outlay to tests on oils that had already been extracted by the partnership in Malawi. Total characterization of seeds and associated analysis of extrected seed cakes by overseas laboratories was deferred and the project has accordingly relied almost wholly on *solids* analysis carried out by CCCD and MBS. Seeds are available at LFRA for other researchers to use.

[35] The numerous different forms in which unsaturated fatty acids occur in tree seed oils are described in detail in the CCCD Report. Some specific *isomers* may have niche commercial applications, especially in medicines/cancer therapy (apoptosis).

[36] Plant breeders have been successful in developing new strains of rape and other oilseeds that yield oils with a fatty acid profile (specially a high oleic acid content) to closely match olive oil (Rossell, J.B. 1999).

[37] Factory output (24 hours, continuous) is some 180 kg of oil/day from 400 kg of reject nuts, i.e. about 8 kg oil/hour from 20 kg nuts/hour. During a visit in April 2002 (section 11.5), MAFE took the opportunity to test the temperature of the presscake outlet ports of the three Komet macadamia expellers. It was in the range of 123 - 135°C (highest for cake on its second pass) which, interestingly, is about the same as experienced with a *Sundhara Sayari expeller* on Moringa in Morogoro, Tanzania.

[38] It should be noted that international Macadamia nut prices are in the range $4 - $6.50/kg (K300 – K490/kg) (highest for *Super Macs*) so oil production is simply a *by-product* activity that (Section 9.8) imputes a value of less than $0.66/kg (K50/kg) to reject nuts.

[39] NTE owns a large Andersen oil expeller that is not currently used; Optima reports that large Andersen expellers can be very efficient, achieving high extraction ratios – possibly 1:5 for Moringa (Sutherland, J.P. personal communication).

saturated fraction. Jatropha contains some 58% ‘beneficial’ percentage, with the major contribution coming from the polyunsaturated fraction. Possibly these oils could be blended as a skincare composite product containing about 55% ‘beneficial’ oils[40]. However the suitability of both oils for cosmetic use needs further investigation and, possibly, ‘clinical trial’ (for Jatropha see Section 10.4.6).

Manketti appears to be a slightly stronger candidate for skincare at 68% of fatty acids favouring this use (Pavey, B. and DeLange, Y. personal communication). CCCD discusses Manketti’s natural anti-oxidants in its Report Section 8.2.3.3.

African Star Chestnut (CCCD Report Section 8.2.3.5) requires further investigation due to the unusual *Malvalic* and *Sterculic* fatty acids accounting for 40% of the oil content.

Natal Mahogany requires an array of analysis as discussed in the CCCD Report: solvent extraction, fat separation/fractionation and study of associated toxic principles in the seed coat. The cost of the work in commercial laboratories would be prohibitive (see LFRA indicative quotations in Annex 2, Volume 2). It would be best split up into several *postgraduate research assignments.*

[40] Note the qualification reported in Section 10.4.6.

Table 8: MAFE Study of Saturation of Fatty Acids in Tree Seed Oils

Double page display of Excel file: 25 oils

9.10 Best Bets

"Best-bet" potential NPP *short-term* commercial opportunities identified by MAFE concern applications in cosmetics either as stable carrier oils (for fragrances) and/or for skincare where tree oils' natural anti-oxidants, especially *tocopherols*, and *polyunsaturated fatty acids* are considered beneficial. It is thought that some tree oils could possibly be marketed as substitutes for higher-priced oils, notably Sweet Almond and Jojoba, that are used as body/massage oils, cosmetic bases and carriers, in addition to finding food/edible oil uses.

Other possible opportunities for the utilization of tree oils indicated by literature and personal advice include:

lubricants and lubricant additives (Walters, P.R. et al. 1979),
leather-making (to improve 'run') (Walters, P.R. et al. 1979),
polishes (Grundy, I. & Campbell, B.M. 1993, also Annex 2, Volume 2),
soap-making (Kone, S. undated),
anti-feedants/insecticides (Bunderson, W.T. personal communication), and
oils blending/upgrading (Allam, S.S.H. 2001).

On the advice of CCCD, further investigation is recommended for oils of the following:

?? African Star-Chestnut *(Sterculia africana)*: malvalic and sterculic acid; and
?? Manketti *(Schinziophyton rautanenii)*: tocopherols and trienoic fatty acid isomers.

Each species is analyzed for its possible commercial uses in detail in Chapter 10.

9.11 Trade Structure

A formal marketing chain exists for only a handful of *real commercial products* identified hereunder, notably Marula and Moringa oils.

Expectations to find a vibrant marketing chain for Jatropha oil in Central Africa (like Mali) proved to be unfounded. In the case of several possible MAFE NPPs, the marketing chain has yet to be developed, essentially because the products are unknown - particularly by local processing industry (Section 8.1.2).

Looking at large-scale *new product* initiative, although the Moringa industry in Tanzania reports firm markets for its oil, it continues to grapple with the costly challenge of launching its *water flocculant* product locally and internationally – so far without result.

The role of Government in trade related to this study was described in Chapter 2.

The Regional Market Study organized by WSU (Wyeth, P. et al) identified negligible oils trade development for all the targeted species except Marula. Baobab oil had been developed on a modest scale in Zimbabwe with promising results but, although it could be covered by a future initiative of the partners, Baobab (being a wild tree) has not been a MAFE target species. *Tree oils* and their by-products need to be launched in national and international markets through a carefully formulated strategy that, besides playing on their novelty and exotic cachet, includes educating buyers in the actual applications for which the products are – from a physico-chemical perspective – genuinely suitable.

Within Southern Africa, the emerging Marula oil trade probably provides the best model of a formal supply chain and trade structure. The supply chain is understood to be short, with production, consolidation and export marketing all essentially controlled by the *managing partner*, CRIAA, Windhoek which also has a London, UK office. Development of the Marula oil business has taken CRIAA some 5 years (Lombard, C. personal communication); MAFE has spent less than 2 years on its 'marketing'effort.

Information on Marula oil trading is held by CRIAA and SAMOPN (including its South African member, the *Mineworkers Development Agency*) but is confidential. SAMOPN members in Namibia have a direct link with SANProTA (see information on the Marula Net and SANProTA in Annex 2, Volume 2). SAMOPN would best be accessed by establishing through EDETA and SANProTA an agreement to collaborate and, if technically feasible, to run marketing of Malawi Marula oil through these two organizations; SAMOPN production standards would need to be met. This might be a suitable strategy for COMPASS and its *Trust* partners in Lower Shire.

Fresh fruits mostly are traded in informal markets and, due to their perishability have to be turned around quickly; SADC-ICRAF/BMZ is examining ways of processing fruit into stable products that have a long shelf life and lend themselves to formal marketing nationally and regionally. Naturally the MEP partners wish to examine the scope of using waste seeds from these processes for oil manufacture.

Examination of the trade in botanical *medicines* was delegated to WSU Department of Pharmacy and EDETA.

9.12 International Trade Contacts and Price Indicators: Cosmetic Industry

During the first year of the MEP, MAFE became aware of commercialization of oils of Baobab, Marula, Moringa and a Melon Seed (from Namibia) for cosmetic use. The market has been developed within the region and, on a limited scale, in Europe and North America through *boutique* websites and cosmetic chain-retailers associated with 'natural' raw materials. In South Africa, MAFE has established dialogue with *Avroy Shlain Cosmetics (Pty) Ltd* - a Sara Lee Subsidiary and contacted *Arch Personal Care* – a Subsidiary of Arch Brooks, USA.

Through A-SNAPP Directories and other means (see Acknowledgements), MAFE made contact with international buyers. The following firms have requested samples of MAFE oils for testing:

Body Shop International PLC[41]
Earthoils Plantations Ltd[42]
Optima of Africa Ltd
Jan Dekker International BV

Marula oil is thought to command a price in excess of K900/kg ($12/kg). Actual prices are a closely guarded secret. Moringa oil appears to have a *fob* floor price (filtered cold-pressed crude oil) of about K600/kg ($8/kg). Looking at the cost of Malawi imports, Malawi Pharmacies Ltd (MPL) (Annex 5, Volume 2) imports Olive oil from overseas suppliers at a cost of about K400/kg ($5.30/kg). MPL uses Wheat Germ oil, at an imported cost of some K900/kg ($12/kg), as a principal source of Vitamin E.

[41] The Buyer has comprehensive working experience of manual presses and expellers.
[42] The Buyer is investigating several potential production locations in Eastern and Central Africa.

MPL would be very willing to use *MBS-approved* local substitutes for such imports (Manjolo, V. personal communication).

Traidcraft Exchange PLC, the management company for the *Training for Enterprise and Exports in Malawi (TEEM)* Project, Blantyre has briefed MAFE on its experiences in piloting *essential oils* production in Zambia and India. While it is not involved in vegetable or tree seed oils in Southern Africa, it is setting up a *TEEM Trading Company* in Blantyre that could facilitate exports planned by MAFE's beneficiaries.

In the USDA/USAID Regional Market Study, Susie Burgess reported the following firms as requesting Baobab, Marula and Moringa *cold pressed* oils since 2001:

Meadows of Canterbury (UK)
Adrian (France)
Organic Herb Trading Company (UK)

9.13 Cosmetic Trade Motivation

Tree seed oils appear to be gaining increasing popularity in the international cosmetic trade for reasons[43] that include:

- ?? Novelty;
- ?? Exotic *cachet* from the plant name[44], origin and cultivation environment or habitat;
- ?? Product association with perceptions of conscientious social and environmental-protection values;
- ?? In some cases, association with fair trade principles benefitting small-scale, poor producers/minorities with perception of protecting human rights;
- ?? Health-giving assumptions for the natural chemicals present in the oil, notably anti-oxidants, Vitamins E and F and fatty acids considered beneficial to skin maintenance and/or hair care;
- ?? Certified or passive association with organic, chemical-free production methods (Burgess, S. personal communication);
- ?? Perception of environmentally sustainable production;
- ?? Decreasing reliability of supply of other oils from traditional sources; and
- ?? Contamination/adulteration of oils from traditional suppliers (e.g. almond oils).

9.14 Required trade investigations

Study of Sperm oil uses and scope for its substitution (as in Section 9.7) is strongly recommended. This could be combined with a study of current uses and demand for Jojoba oil.

No progress has been made in investigating oil uses in the leather trade and in lubricants/lubricant additives. A systematic investigation in both sectors is required, starting with determination of fatty acids that are particularly in demand.

[43] See website www.bodyshop.co.uk/usa/aboutus/body-ctrade.html .
[44] Babassu oil from Brazil is chemically similar to (85% saturated) palm kernel and coconut oils (Rossell, J.B. 1999) yet is used and named as a specific ingredient in Body Shop *Community Trade* cosmetic products.

9.15 Adulteration: Characterization Challenges

Assay of oil samples by MBS, LFRA and IFR respectively from *common* batches gave virtually mirror-image results as would be expected. A serious analytical challenge was presented in 2002 by two batches of ‘Moringa’ oils prepared by different extraction processes. One was an experimental sample from early 2001 and the other was a large batch produced with minimal project supervision, under arrangements described in Annexes 11 and 12, Volume 2, to test producers’ capacity to independently organize themselves. The laboratory results in May 2002 revealed conclusively, and expensively, that at some stage in the production process adulteration or replacement by one or more *highly unsaturated* commercial oils had taken place. This *flaw* was formally determined in June 2002[45]. Samples of the faulty batch have been retained in evidence.

To provide necessary data, the work has to be repeated with a high level of production supervision. The discovery was made before samples drawn from the large batch had been dispatched to overseas buyers for commercial testing. Planned sendings to commercial buyers are therefore in suspense but this ‘trade opportunity’ remains wide open.

[45] Further cross checking through arranging solvent extraction by SCRI-LAU of oil from seeds of the respective provenance, and analysis of the resultant oil confirmed our suspicions.

10 SITUATION, USES, MARKETING AND POTENTIAL OF STRATEGIC SPECIES

10.1 Food Security

Investigations have revealed a wide number of subsistence uses of the targeted species, particularly uses that fall in the category of *food security*. These are highly significant and partners would need to carefully factor this subject into the design of any future follow-up research and commercial development.

10.2 Seasonal Complementarity and Context of Other Oilseeds

Seasonality

The seasonality of "seed drop" of the MAFE *cluster* of oil-bearing tree species has been considered. Although harvesting, sun-drying and storage of Neem and Natal Mahogany may be frustrated by rainfall and high humidity in their respective harvest seasons, the overall annual sequence of harvesting for the indicated species may, subject to feasibility assessment, provide opportunities for one or more commercial processors to specialize and orient their entire operations to tree seeds. Respective harvest seasons are:

Moringa (*Moringa oleifera)*	Sep – Dec with local variation
Neem *(Azadirachta indica)*	Dec – Jan (rainy season)
Natal Mahogany *(Trichilia emetica)*	Jan – Mar (rainy season)
Manketti *(Schinziophyton rautanenii)*	Mar - Apr
Jatropha *(Jatropha curcas)*	Apr – Jun
Marula *(Sclerocarya birrea)*	Apr - Jul
African Star-Chestnut *(Sterculia africana)*	May – Sep with local variation[46]

Synergy with other oilseed productio systems

In some locations it may become attractive for businesses that crush conventional oilseeds, such as sunflower and/or groundnut, to integrate some tree seed oil production into their annual program, thus *increasing value added in the farming system* as a whole, specially during the conventional oilseeds "off-crop", i.e. December – April. This subject is discussed in Sections 11.1.2.2 and 11.2.2.2 and fits our Selection Criterion 6. (Section 6.2.2) but great caution will be required to prevent mixing of oils.

In the North it might be feasible to integrate oil extraction from Natal Mahogany into the IFAD/FAO-sponsored *African Oil Palm (Elaeis guineensis)* small-scale oil extraction industry around Karonga (Mills, S.; Chammagomo, G. & Mpira, A. personal communication).

The NTE 'off-crop' for Macadamia nut processing lasts throughout December (Likangala, R. personal communication) and may present a brief window of 'opportunity' for use of plant and equipment.

[46] Feb – Apr reported by one village in Lower Shire.

10.3 African Star-Chestnut *(Sterculia africana)*

10.3.1 Distribution, habitat, taxonomy and cultivation

African Star Chestnut is the least documented of all the species under review. It is described by Coates Palgrave (1997) as having a wide distribution in the region but the uses of the tree are barely mentioned.

The typical habitat of this species is the arid, 'African bush/savannah' of the South Luangwa valley in Zambia, Lake Malawi lowlands, especially around Mangochi and the lower levels of the Lower Shire valley. Its habitat tends to coincide with that of Baobab, opening the idea of exploiting these species jointly. The species is *not* the *Sterculia* formerly exploited in Lower Shire as a source of ADMARC *gum copal* and (now logged out) harvested for timber for *plywood manufacture* (Murtland, R. personal communication).

The tree may be grown from truncheons as a living fence but its natural situation is as a massive single tree with a fully stretched canopy reaching beyond and above the branches of any neighbouring tree. The trunk is an ashen white colour with bark, to varying extent peeling like European paper-bark Willow, that is 'stringy'.

The seeds are eaten by numerous wild animals and are attacked also by a number of insects.

10.3.2 Circumstances of owner-communities

MAFE has sighted this species in the farming systems of Salima District and Lower Shire. Trees growing in 'fences' appear to reach a maximum size that is about 25% of the maximum achieved by the oldest wild trees. This is probably due to in-the-row competition for soil, moisture and light.

Uses of the species are summarised in Table 3. One community in Lower Shire (Table 3) ranked this species as the second most important on-farm tree after Neem.

10.3.3 Previous work

None reported.

10.3.4 Food/Nutritional uses

The seeds are used for relish, usually after pounding into an oily paste, and as a children's snack. Although *Sterculic acid* is present as to some 30% of the oil content, no digestibility problems have been reported. The seed is prized by a *minority* of communities as a food rather like Manketti kernels (Section 10.5.4) in the North. The leaves and seed pods appear to be much more important than seeds in the diet, implying that *the seeds in most communities are not valued.*

In the Lower Shire Valley:

> **The seed pods are carefully heated to an ash[47] which is very widely used as a cooking soda (lye) especially in okra cooking (75% of the communities that were interviewed);**
>
> **The leaves[48] are cooked in relish when new (August – September) with Moringa and/or Okra (35% of the communities that were interviewed)**

[47] There was one report of its use as an ingredient of tobacco snuff.

[48] Muona Mission staff reported use of the young leaves of Avocado and Guava as being beneficial for combatting anemia (Kadete, M. & Nyakuipa, R. personal communication). Margareta, F. (Chikwawa RDP) reported introduction of an Indian oilseed into Lower Shire: *Parinari curatellifolia*, but this has not yet been seen by MAFE.

These uses are not reported in literature.

10.3.5 Cosmetic/skincare applications

None reported.

10.3.6 Pharmacological applications

In Lower Shire 65% of communities interviewed reported making the bark into a rope for which uses include donning around the neck as a health remedy – especially to *cast out evil spirits.*

Two commmunities reported removing, and burning to an ash, the irritant hairs along the splitting point of the pods to be used as an eye infection ointment – especially on suckling babies. A chemical explanation for this use is required.

10.3.7 Biocide/anti-feedant applications

None reported and the seeds are insect-susceptible.

10.3.8 Non-food industrial applications

Subject to the advice of CCCD

10.3.9 NRM benefits

Useful as a live fence/hedge

10.3.10Other possible applications requiring research

None.

10.4 Jatropha *(Jatropha curcas)*

10.4.1 Introduction

This section quotes extensively from the work of Wyeth, P, et al (2002). MAFE's expectations for Jatropha had been inspired largely by the extensive literature available on this plant. The project anticipated being able to import off-the-shelf technical and marketing know-how from established 'Jatropha industries' within the region but, when information was eventually obtained, the expectation turned out (2002) to be unfounded.

10.4.2 Distribution, habitat, taxonomy and cultivation

The meaning of the specific name 'curcas' is not known. It was first given 400 years ago to 'certain seeds' by the Portuguese doctor Garcia de Orto, who published a work on Indian medicinal and drug plants in 1563. (ICRAF Agroforestree Database, www.icraf.cgiar.org/treessd). Jatropha (*Jatropha curcas)* belongs to a very large family, Euphorbiaceae, including cassava and rubber, and propagates easily from both seed and cuttings. It is a fast growing poisonous plant. Although native to tropical America, Jatropha is now common throughout Africa and Asia. It is a multipurpose, drought resistant tree and can be cultivated in areas of low rainfall. In dry seasons it tends to shed its leaves. Where rainfall is high – above 1,000 mm, it does better in hot rather than temperate climates. Jatropha can grow in soils that are quite infertile. It is usually found at lower elevations (below 500 m.). Since it will survive with little or no fertilizer input, it is an attractive species for resource-poor farmers. Higher rainfall and fertilizer inputs can substantially increase its yields. Stored seeds have relatively short viability.

Jatropha seeds yield a non-edible oil (30% of whole seed content by weight[49]). This makes an acceptable smokeless lamp oil and has potential as an insecticide, for instance in the control of cotton bollworm; methanol extracts of Jatropha seed (which contains biodegradable toxins) have been tested in Germany for control of bilharzia-carrying water snails. Jatropha presscake contains curcin, a highly toxic protein similar to ricin in Castor. Jatropha oil can be used as an expensive[50] diesel motor fuel, for which purpose it is at its most effective when transesterified. Seed from a Jatropha variety of Mexican provenance is edible.

10.4.3 Circumstances of owner-communities

10.4.3.1 Malawi

In Malawi Jatropha is normally planted around homesteads and bathrooms as a hedge/living screen. It is useful as a livestock fence since it cannot be grazed; it is poisonous to ruminants. Jatropha is widely distributed and common in the Lilongwe West plains. Unlike other species investigated (notably Moringa), it is seldom found planted by *all* households in a community. Nevertheless, in May 2001 MAFE had no difficulty in purchasing 1,200 kg of defruited Jatropha seeds in Nkuka at a collection-point price of K15/kg ($0.20/kg). As the crop has not been heavily promoted, its potential for immediate industrialization is considered insignificant. This needs to be verified by investigation. If time permits, Nkuka residents and other communities in Lilongwe West will be visited to estimate the quantity of Jatropha seed that could be purchased for industrial purposes.

[49] MBS test of MAFE sample. Workers in West Africa reported oil content ranging from 28 to 42%, according to provenance. Henning, R. (1996) reported an average content of 35%.

[50] The ambitious BIOMASA *fuel-from-Jatropha* project in Nicaragua has been wound down because Jatropha cultivation by smallholders *as a plantation crop* proved to be uneconomic (N. Foidl, pers comm).

10.4.3.2 Other countries in the region

In response to its planned search (May, 2001) for inspiration from elsewhere in the region, MAFE received information about Jatropha in Zimbabwe in 2002 as a result of Gus Le Breton's research for the regional study. The results were discouraging:

> Plant Oil Producers Association (POPA) made significant efforts to interest commercial farmers in *Jatropha* as a cash crop, grown both as live fencing and plantations. POPA's optimistic prediction that, by the end of 1998, 400 commercial farmers would be growing *Jatropha* was not realised. Political developments made commercial farmers become more risk-averse. The Chairman of POPA, was himself evicted from his own farm in 2001, leaving behind possibly the only existing *Jatropha* plantation in the country. It is believed that the total land area in Zimbabwe under *Jatropha* is somewhat less than 2,000 hectares. In fact, it is probably a fraction of this. Although its distribution is widespread, the fact that it is predominantly used as a live-fence means that its volumes are relatively insignificant.

In the same study Susie Burgess reported from Zambia:

> A GTZ supported initiative is promoting cultivation of *Jatropha* in Southern Province. It is estimated that over 100 local farmers are involved. Africare has promoted the crop among communities in Southern and North-western province. Africare trained 1 person to learn about processing of *Jatropha* (extraction of oil and production of soap). The gentleman currently operates independently and can be contacted through Mrs. Lubozya (Head Oil Research Program, Mount Makulu). It is estimated that over 100 hectares have been established by small-scale farmers through the Africare and GTZ initiative. Most of this is now matured crop and available for harvest. 1 hectare has been established at Mount Makulu Research to test the performance of the germplasm collected from the Eastern province.

In April 2002, through ICRAF linkage, MAFE received Charles Mwamba's NISIRZ Photo-documentation on the Promotion of Soap and Fuel Production from *Jatropha curcas* Oil in Zambia. This is a very useful document explaining physico-chemical properties and fatty acid composition and soap and fuel-making practices. It states oil yields as around 20% by weight from conventional presses. Seed costs are not estimated.

10.4.4 Previous work

The Farm Mechanization Unit of Chitedze Agricultural Research Station (FMU-CARS) carried out Jatropha oil extraction experiments in partnership with the EU-funded Promotion of Soil Conservation and Rural Production (PROSCARP) Project in 1997. The purpose of this work was to demonstrate the feasibility of manual, ram pressing of Jatropha but no work was undertaken to extend and commercialize production. FMU-CARS conducted similar trials on Moringa but the throughput and extraction ratios were uninspiring.

10.4.5 Food/Nutritional uses

The young leaves are safely eaten, steamed or stewed cooked with goat meat to get rid of smell. Seed kernels from a Jatropha variety of Mexican provenance are edible but no long-term experience of this has been gained in Central Africa (Makkar, H.P.S. et al. 2001); the Agricultural Research Trust in Zimbabwe may still have plants from imported seed, although trials were abandoned due to lack of funds (Le Breton, G. in Wyeth, P. et al). The respective presscake is non-toxic to livestock because phorbol esters are absent. (Makkar, H.P.S. et al 2001).

10.4.6 Cosmetic/skincare applications

A long history of use suggests Jatropha oil[51] is safe for soap-making. In the early part of the twentieth century Cape Verde exported large amounts of *Jatropha* seed to Europe for soap making. Jatropha oil appears to have several desirable properties. It is rich in palmitic acid, with high levels of hydrophobicity, and makes a soft, durable soap under even the simplest of manufacturing processes. It is also used in West Africa, Zambia, Tanzania and Zimbabwe as a soapstock including the manufacture of soft laundry soap. Mwamba, C.K. (2002) reports on Jatropha soap manufacture by Hindustani Lever/Godrej Soaps Ltd in India.

The 36% linoleic acid (C18:2) content in Jatropha kernel oil is of possible interest for skincare. Jatropha oil is advertised for sale on at least one web site (**http://www.africasgarden.com/naturalcarrieroils.htm**). However, its toxicology should be investigated further before advocating its use for skin care. Body Shop International PLC is unwilling to use Jatropha-based soap since Indonesian research revealed the phorbol ester in the oil as a cancer promoter although it is not itself carcinogenic (Jones and Harris at HDRA 1995.

During the USAID/USDA regional investigation, MAFE obtained information on the respective oil extraction and soap industry in Zimbabwe from Gus Le Breton to determine the scope for technology transfer to Malawi,. There is no industrial-scale *Jatropha* soap manufacture in Zimbabwe. This market 'opportunity' could not be described as either growing or secure. Absence of wide-scale demand in Zimbabwe is though to inhibit supply, and the absence of any significant levels of supply is restricting industrialization.

10.4.7 Pharmacological applications

Jatropha soap is perceived in Malawi as a 'medicated' soap. The soap from unrefined oil is considered, like neem-based soap, to be an effective, gentle anti-scabies wash (Bonomali personal communication and Kone S. undated).

The seed oil can be applied to treat eczema and skin diseases and to soothe rheumatic pain. (Heller, J. 1996). It is also reported to be a strong purgative.

The leaves are mildly laxative. They also have uses in the treatment of swellings, psoriasis and syphilis (Wegmershaus, R. & Oliver, G. 1997) and leaf extracts have anti-inflammatory effects (Staubmann, R et al 2001).

The bark is used as a pain reliever for flatulence and as a wound coagulant (37% tannin on dry matter basis) (Wegmershaus, R. & Oliver, G. 1997).

Excepting soap-making in West Africa, none of these uses has been commercialized.

10.4.8 Biocide/anti-feedant applications

The oil and aqueous extract from oil (active principle probably phorbol ester) has potential as an insecticide, for instance in the control of 4 insect pests of cotton including cotton bollworm (Solsoloy 1995) and on pests of pulses, potato and corn. Methanol extracts of Jatropha seed (which contains biodegradable toxins) have been tested in Germany for control of bilharzia-carrying water snails (Rug M. et al. 1999).

[51] The cost of extraction of Jatropha oil is lower than for Moringa oil as the oil yield is higher and the real opportunity cost of seeds in Malawi could be lower than the K15/kg ($0.20/kg) paid by MAFE. In Tamil Nadu, India a price of $0.085/kg is reported (Vedamuthu, P. pers comm). The oil yield may exceed 20% and use of the oil for subsistence 'mineral' purposes might be feasible as indicated by reports from other countries.

The pesticidal action of the seed oil is the subject of research of ICRISAT, India (Jones, N & Harris, P.J.C. at HDRA 1995).

10.4.9 Non-food industrial applications

10.4.9.1 Non-fuel uses

Binga Trees Project (BTP) reported Jatropha oil use by tanneries in Zimbabwe where there was demand of 600 litres (Warndorff, J. pers comm; Jones, N & Harris, P.J.C. at HDRA 1995).

From the oil, it is reported that a number of individual fatty acids, or combinations of fatty acids, could be used as key intermediates in the manufacture of different products. These include:

Fatty chlorides used in the making of detergents and soap
Fatty alkanolamides for laundry softeners
Fatty esters for cosmetics, pharmaceuticals and candles
Methyl stearates used for lubricating oils and greases
Fatty amines for metal working, paints and varnishes
Quaternary ammonium chlorides for plastics and printing inks
Methyl esters for specialty surfactants that are used in the formulation of detergents, cosmetics and lubricants.

The fatty acid profile of Jatropha oil is shown in Table 8. A product that has received some attention in Zimbabwe is a fatty acid amine derivative used in the metalworking industry (Le Breton, G. ibid).

10.4.9.2 Motor Fuel Oil

Opinions regarding the suitability of Jatropha oil as a motor fuel are very mixed. MAFE was partly enticed towards Jatropha because the oil had long been seen as an eco-friendly, economic substitute fuel oil for engines, stoves and lamps. However, review of literature reveals there are far more efficient oil-yielding species, led by commercial hybrids of oil palm *(Elaeis guineensis)*. Although Jatropha can yield up to 2,400 litres of oil/ha under plantation conditions *with efficient extraction* (Gaydou et al, 1982), the oil output/ha and energetic yield/ha is barely more than one half that attainable with oil from commercial oil palm. However Jatropha will grow in much harsher environments than oil palm.(http://newcrop.hort.purdue.edu.newcrop/duke_energy/Jatropha _curcas.html).

With certain modifications to conventional diesel engines a GTZ project in Mali found it an economic substitute for diesel in remote locations (where diesel was expensive); to some extent Jatropha oil could be blended with diesel to avoid the need for engine modification.

Research in Zimbabwe concluded that Jatropha oil was flawed as a diesel substitute. It is inferior to diesel in its energy content, flash point, and solidifying point. Diesel, as a hydrocarbon, has 8-10 carbon molecules per mole; Jatropha oil, on the other hand, has 16-18 carbon molecules per mole and is thus more viscous and has a poorer ignition quality than diesel. Trans-esterification of the plant oil is then required to give the bio-diesel similar properties to mineral diesel, and this is a process that requires considerable investment. Under the current world petroleum prices it is not economic as a motor fuel, except possibly for certain types of engine. On the other hand, Jatropha oil has a slightly higher cetane rating and much lower sulfur content than diesel. Moreover, it apparently works well in a refined but otherwise untreated form in certain kinds of engines such as the Lister engines commonly used to run small scale flour mills or electric generators. The specifications of diesel and Jatropha oil are compared in Table below:

Table 9: Specifications of Diesel and Jatropha Oil

	Diesel	Jatropha
Oil Energy content (MJ/kg)	42.6 - 45.0	39.6 - 41.8
Spec. weight (15/40 °C)	0.84 - 0.85	0.91 - 0.92
Solidifying point (°C)	-14.0	2.0
Flash point (°C)	80	110 - 240
Cetane value	47.8	51.0
Sulfur (%)	1.0 - 1.2	0.13

(Plant Oil Engines at www.jatropha.org)

10.4.9.3 Domestic fuel

Many researchers have described Jatropha as a potential domestic fuel for cooking and lighting, with properties similar to kerosene. It is in fact, a very poor kerosene substitute. High ignition temperatures and viscosity (75.7 10^{-6}m2/s) as compared to kerosene (50-55 C, and 2.2 10^{-6}m2/s respectively) mean that Jatropha oil will not burn well, and would clog up the tubes and nozzles in a conventional kerosene stove or light. Approaches to circumventing these problems are being tried. A low intensity lamp with a wick has been developed. The oil lamp requires a very short wick so that the flame is very close to the oil surface. Ideally the wick floats on the oil surface (Warndorff 2001, personal communication). At Hohenheim University, a group is developing a special stove to solve the problems. So far, models require kerosene both to start the stove and to clean it just before it is turned off (www.jatropha.org).

10.4.10 NRM benefits

The presscake (3.5% N) can be used effectively as a high-nitrogen manure where a value of $0.03/kg (K2/kg) was suggested (Henning, R. 1997).

As well as being useful as a living fence, preventing animal access, Jatropha is an effective hedgerow that prevents wind and water erosion (Henning, R. 1997) and reduces pressure on timber resources and increases soil moisture retention.

The qualities that make *Jatropha* especially desirable as a live fence include:

- Rapid growth rates from both seed and truncheons
- Low maintenance and drought resistance
- Relatively low rates of natural spread (i.e., it tends to grow where it has been planted, without colonizing neighboring land)
- Unpalatability to livestock, making it a particularly effective barrier between livestock and either crop fields or homesteads

Jatropha's drought tolerance (i.e. rainfall conditions as low as 200 mm per year) makes it a suitable species for reclamation of eroded and degraded areas.

10.4.11 Other possible applications requiring research

None.

10.5 Manketti *(Schinziophyton rautanenii)*

Taking up the interest of Southern Africa Natural Products Trade Association (SANProTA), Wildlife and Environment Society of Malawi (WESM), World Bank Lower Shire Protected Areas Project (for community based NRM in Southern Malawi National Parks) and Nyika-Vwaza Border Zone Project (BZDP), investigation of the scope for manufacture and marketing of seed oils of Marula (*Sclerocarya birrea*) and Manketti was initiated by MAFE in April 2001. Manketti is a short-listed target species of SANProTA.

10.5.1 Distribution, habitat, taxonomy and cultivation

Manketti is a member of the *Euphorbiaceae* and native to Botswana, Malawi, Namibia, Zambia and Zimbabwe, principally in a belt from East to West coast between latitudes 15 and 21 degrees South (http://www.naturalhub.com & http://polytechnic.edu.na). Its best known habitat is raised sandy plains of deep *Kalahari sands* at an elevation around 1,200 m asl. It is deciduous and has a spreading canopy reaching 15 – 20 metres high. Fruit drop is between March and May. Fruits are egg-shaped, velvety and contain a thin layer of edible flesh (very dry texture) around a thick, hard pitted nutshell that encloses the edible, oil-bearing[52] kernel[53]. (http://ww.sanprota.com/products/manketti.htm). Fruits will store for months without deterioration of the contents.

The timber is notably light and can be used as a balsa wood substitute such as in float and dartboard manufacture.

In Malawi its distribution is confined to sandy, rain-shadow lands around Rumphi and Mzimba North-West that are mostly unsuitable for settled agriculture, in Silvicultural Zone Bb (Hardcastle, P.D. 1977). Before clear-felling for establishment of a short-lived tobacco estate industry, Manketti was the dominant endemic species in the *Nkamanga Plain* (Jalira, C. personal communication). It could possibly be re-established there through a suitable planting program after clearance of bush regrowth.

10.5.2 Circumstances of owner-communities

In Malawi Manketti occurs usually as individual, massive trees on farms and as thickets/woods of numerous trees under ownership of the Traditional Authority or National Parks (Vwaza Marsh). Some of the biggest stands of Manketti are in the Vwaza Marsh National Park along the Zambia border (Tsambalikagwa, P. & Manda, L. personal communication; Annex 2, Volume2) – to which Parks and Wildlife Department is willing to grant "*border zone*" communities *supervised* access (MAFE field program, May 2001). MAFE trials with communities in 2001 indicated that several hundred kg of Manketti fruits could be collected annually in the Rumphi area, possibly tonnes if the Park were included.

10.5.3 Previous work

No previous research could be traced in Malawi.

In Namibia, CARE Austria sponsored preliminary socio-economic studies in the Kavango Region in 1998-99, including trial purchase of nuts, that established the potential for improving rural income. The donor was interested in taking the work forward but would not support "critical technical and market research and development components". Instead it wanted to fund "capacity building, training and micro-enterprise components". Project management insisted that critical technical and market research and development were a prerequisite to the capacity building, training and micro-enterprise components. Talks broke down and the project did not proceed to a second phase (Lombard, C. personal communication). SANProTA has now resuscitated the idea and is in discussion with British

---

[52] 46% exhaustive oil extraction *from kernels* by CCCD, 2001.

[53] The kernel constitutes 8.3% by weight of the ambient-dried whole fruit (MAFE research, May 2001).

Aid about the possibility of a window being created for Southern Africa to address the identified funding need *for technical and market research*. This might present the MEP partners with a funding window for R&D post-2002 to follow-up on the work that has been supported by USAID.

10.5.4 Food/Nutritional uses

Food uses are confined to subsistence where the nut and fruit have localized importance. SANProTA reports Manketti being an important component of the diet of *San* bushmen in Namibia. They steam the fruit to soften the skins, peel them then stew the fruits until the maroon flesh separates from the nuts. The pulp is eaten and the nuts are later roasted in an even heat (without burning). The nuts are cracked and the kernels are either eaten direct or pounded for relish.

In Mzimba North, use of Manketti kernels, principally as asource of relish, has declined in the last 20 years but for some families Manketti fruit (Mahuwi in *Tumbuka* language) collection is an important seasonal activity providing an important food bonus. The fruit pulp can be used to produce wine.

Unlike African Star Chestnut there is no reported use of the leaves.

10.5.5 Cosmetic/skincare applications

Manketti oil is reported on the SANProTA website to have a history of traditional use as a body rub in the dry winter months to improve skin tone.

10.5.6 Pharmacological applications

None reported.

10.5.7 Biocide/anti-feedant applications

None reported.

10.5.8 Non-food industrial applications

The low-density timber could be industrialized as a balsa wood substitute such as in float and dartboard manufacture but MAFE has no information on its exploitation for these purposes.

10.5.9 NRM benefits

The tree is a useful shade tree in the summer.

10.5.10Other possible applications requiring research

These are discussed in the CCCD Report.

10.6 Marula *(Sclerocarya birrea)*

10.6.1 Distribution, habitat, taxonomy and cultivation

There are four species of Marula, all of African origin. *S. birrea* is the most widespread and, of its three subspecies, *caffra* is also the commonest. (Shackleton et al 2001).

In Malawi, Marula is widely distributed and found principally in Chikwawa/Lower Shire, Southern Lakeshore (Bwanje, Sharpe-valley, Ncheu, Nkope, Liwonde), in the Southwest around Mwanza, and Mzimba North around Vwaza and Rumphi. Plenty of wild Marula is reported in the rolling hills around Ngabu (Margarita, F. personal communcation)

Phenotypic variation from other phenotypes in Southern Africa needs to be determined.

10.6.2 Circumstances of owner-communities

MAFE has not investigated the social economy of Marula. An approach was made to SADC-ICRAF for such information, based on published articles, but the required information was not received. Future workers should first of all channel their investigations through SADC-ICRAF to gather such information.

10.6.3 Previous work

Most previous work relates to FRIM and SADC-ICRAF efforts to determine different phenotypes and explore the possibility of making varietal selections for improved fruit productivity. This work is ongoing.

10.6.4 Food/Nutritional uses

Marula fruits are harvested in the dry season and used as food

The Vitamin C content amounts to 150 – 400 mg /100g in flesh. The flavour & sweetness are highly variable (Scafer, G. & McGill, A.E.J. 1986). The juice can be used as a beverage or porridge flavoring (von Teichman, I. 1983). Stabilisation of fresh fruit juice is reported as being studied by the University of Pretoria Department of Horticultural Science).

The fresh fruits are a source of pulp/flavoring for food and beverage industries, e.g. Amarula liqueur – but most of the flavoring in this is from other ingredients. Brandy has been made from distilled beer (Pretorius, V. 1985) and commonly the fruits are used for mokhope/marula 'beer'/wine making (von Teichman, I. 1983). They are used also in lemonade and jelly manufacture

Kernels have a long history of use as subsistence food: 33% protein; 46% oil. The reported % composition varies according to provenance (Burger, A.E.C. et al. 1987).

Seed kernel cooking oil could be used for subsistence or sale. It is an edible oil with possible nutraceutical/anti-oxidant properties (but low tocopherols: Burger A.E.C. et al. 1987).

The kernel presscake is a source of toxin-free 54 –70% edible protein. But, low in Lysine (Weinert, I.A.G. et al. 1990).

The leaves are browsed by wild and domestic animals (von Teichman, I. 1983). The bark is browsed by elephants (von Teichman, I. 1983)

10.6.5 Cosmetic/skincare applications

Marula seed kernel oil has potential as a commercial fragrance carrier (Lombard, C. pers comm; Burger A.E.C. et al. 1987). Namibia and South Africa have started exporting *Marula oil*[54] to cosmetic firms in Europe under arrangements agreed by the *Southern African Marula Oil Producers' Network (SAMOPN)*. The fob price is reported to be in excess of $12/kg (K900/kg). Its chemical properties are quite close to those of Macadamia, Moringa and Olive oils.

The oil is used as a body oil and is reported as a meat preserver (von Teichman, I. 1983). It may have potential as a bathing soap ingredient/softener.

Taking up the interest of the SANProTA, Wildlife and Environment Society of Malawi (WESM), World Bank Lower Shire Protected Areas Project (for Community based NRM in National Parks), and Nyika-Vwaza Border Zone Project, MAFE intended to investigate the scope for manufacture and marketing of seed oil of Marula (*Sclerocarya birrea*). The oil was already receiving significant R & D attention from various organizations in four Southern African countries[55]. At the Mid-Phase Review in July 2001, MAFE secured agreement from its partners to collaborate with the respective organizations and, specifically, to support a regional program of testing of Marula seeds from various provenances, following up on earlier work of Burger, A.E.C et al. 1987.

10.6.6 Pharmacological applications

Noristan Limited, a pharmaceuticals manufacturer carried out an evaluation of South African flora, including Marula in 1982 but the results were not made public.

A number of traditional medicinal uses for Marula leaves and bark are reported. Leaf juice has been used in gonorrhea treatment (von Teichman, I. 1983) and leaves and leaf extracts have been used for boils, abcesses, burns, stings and wounds (von Teichman, I. 1983). A bark decoction (internal and external use) is reported as prophylactic against gangrenous rectitis (Bryant). Crude extracts of bark exhibit weak anti-hypertensive, anti-inflammation and analgesic activity (von Teichman, I. 1983) There is a secretagogue action of methanol-extracted bark compound: (-)-Epicatechin-3-galloyl Ester (Galvez Peralta, J. et al. 1991).

A *pre-leaf emergence* bark decoction in half-pint doses is reported for dysentery/diarrhoea (Watt, J.M. & Breyer-Brandwijk M.G. 1932) where the bark contained up to 20.5% tannin + alkaloids trace. The bark is used in malaria treatment (clinical action like quinine) and a brandy decoction of bark is cited as a malaria prophylactic; powdered bark is reported in teaspoonful doses as a malaria treatment.

10.6.7 Biocide/anti-feedant applications

Marula fruit is reported to have an insecticidal action against ticks (Bryant)

10.6.8 Non-food industrial applications

The Marula oil induction period (i.e. heat-promoted oxidative breakdown period) is 30 – 40 hrs under standard testing procedures which gives 10 times the induction time of olive oil (Burger A.E.C. et al. 1987), and (on average) only a slightly shorter induction period than (undegummed) Moringa oil.

Although Marula is not regarded as a significant commercial timber species, the timber has been used for fruit boxes, furniture and handles (von Teichman, I. 1983)

---

[54] Rossell, B. is a consultant to the industry.

[55] MAFE planned to support an initiative of the Southern Africa Marula Oil Producers Network for 2002 to supply various provenances of Malawi (and other) marula seeds for assay by the South Africa Centre for Scientific and Industrial Research (CSIR) which is in a position to make comparison with other provenances tested by CSIR in 1987.

10.6.9 NRM benefits

At the household level nut shells and wood can be used for firewood.

A palatable fodder grass is associated with the under-canopy.

Since Marula is long-lived it can be regarded as a potentially useful carbon sink.

10.6.10Other possible applications requiring research

Marula is reported to be host to the *Polydada* beetle larva that is highly poisonous and has a history of use as an arrow poison (von Teichman, I. 1983). The active principles of the poison are not reported but should be investigated for possible pharmacological action.

10.7 Moringa *(Moringa oleifera)*

10.7.1 Distribution, habitat, taxonomy and cultivation

The generic name comes from the Sinhalese name 'morunga'. (ICRAF *Agroforestry Database*, www.icraf.cgiar.org/treessd/ .)

Moringa is native in India and Arabia and now naturalized in many areas of the tropics. As reported by Coote (1997), Moringa came to Malawi with Indian sub-continent settlers during the last century for use principally as a food crop, providing edible young fruit pods and vegetable leaves. It has spread throughout the Southern lowlands along the Lakeshore and Shire Valley into Mozambique. The tree occurs almost entirely as a *living fence* tree. No *plantations* have been identified in Malawi. Notable areas for Moringa include Nsanje and Bangula, Chikwawa, Mangochi, Balaka, Mtakataka and Salima. Further North the population density declines markedly although FRIM reports its existence in Karonga. MAFE regards all these stands as an under-exploited, locally-abundant potential commercial resource although in some communities it already provides major subsistence benefits principally as a vegetable (Annex 4, Volume 2: The Nation 2 April 2002 – cover story).

It is a small deciduous tree usually 5-10 m tall but sometimes up to 15 m, with a light, feathery canopy. It is seasonally subject to drought-induced leaf fall and, occasionally, wind damage owing to the soft nature of the wood. It is extremely fast growing and can attain a height (if unpruned) of 6 metres in the first year. In Malawi it is normally planted as a hedge/living screen around homesteads ***(see Photo Gallery, page 14)***. In this setting it may benefit from passive fertility derived from animal manure and household cess. The tree is tolerant of a number of soil types and of drought. It is considered to generate its own nitrogen needs through a mycorhizal association. However, unless receiving manure and/or dry-season irrigation the tree is seldom vigorous when grown in open fields.

The bark is pale grey, thick and corky in trees over 4 years old; the leaves are pale green, compound 30-60 cm long, leaflets small and oval 1-2 cm long; flowers creamy-white, fragrant, in long sprays; fruit a long, triangular shaped capsule, splitting to release 3-winged seeds. (Bunderson et al, 2001.)

Moringa can be propagated from either seeds or truncheons. In Malawi it is mostly planted from truncheons and each plant has a lifespan of up to 10 years, seldom more.. In India varieties have been developed for intensive cultivation that yield harvests of vegetable pods within a year.

In Malawi there are thought to be at least 3 races that differ in their appearance and their oil-bearing properties (Bonomali, A. personal communication.) It may be necessary to determine whether variation is due to agro-ecology or genetics. Commissioning of this work is subject to chemical analysis first being undertaken on oils and seeds from various “provenances”. Analysis would have to be done after MAFE has closed. On the advice of KOR[56], MAFE has initiated discussion with the National Herbarium and FRIM[57] with the view to determining the different races. Dr Geoffrey Muluvi, Kenya may be able to assist[58]. Moringa yields seeds within 1 - 2 years[59]. The main harvest season in Southern Malawi (Table 3) runs mostly from September (dry season) until January by which time seed collection and storage are frustrated by rainfall, however flower initiation is staggered between one location and another and, for example, it is possible to find significant quantities of ripe pods even in August (Bonomali, A. personal communication.)

It is recommended that FRIM be engaged to investigate, and possibly conduct field experiments on *household/hedgerow/live fence* (but not plantation) production costs, inputs and outputs for Moringa.

Useful Moringa *plantation* management guidelines have been provided (Annex 2, Volume 2) by Optima of Africa Ltd in Tanzania. Although the Company has some experience of growth and yield monitoring under *plantation* conditions, MAFE has been unable to locate any information on long-term yield of Moringa plantations. Optima Company forecasts of yields from mature plantations may need to be treated with caution.

Optima has developed canopy training/pruning techniques that reduce Moringa’s susceptibility to wind damage and greatly improve seed set and seed pod retention (for oilseed cropping). Moringa foliage is susceptible to periodic caterpillar attack. In India this can be controlled by spraying neem anti-feedant preparations.

Coote et al (1997) recommended:

> ………. existing trials should ………… investigate the potential for adoption and promotion of more productive and vigorous varieties. Should the *socio-economic value of continued work on Moringa oleifera be proven* there will be a need to develop a focused national breeding and improvement programme. ……

(See also Section 10.7.9 and Table 11)

---

56 Observations by KOR indicate that Moringa from the Lower Shire Valley gives more oil than that from Mangochi. It is not known if this variation is due to agro-ecology or genetics.

57 28/02/01: Mr Humphrey Chapama described his knowledge of Moringa's geographical distribution, its morphological traits and his familiarity with FRIM Moringa collections. Yield of seeds from pods by weight has not yet been determined although FRIM (1997) carried out some studies of pod yield per tree.

58 Dr Muluvi prepared a (SCRI) study of varieties/species of Moringa "oleifera" along the Mombasa railway corridor. C/O Jomo Kenyatta University Dept of Agricultural Technology. E-mail: gmmuluvi@avu.org . He may also be associated with work of Janet Sprent.

59 The Coote report described a mean yield of 375 pods/tree/year in mature, pollarded ‘living fence’ plantings in sample areas in Lower Shire. These yielded some 0.8 kg of clean seeds/tree without any management for pod production at a mean seed count of 20/pod.

Optima *field staff* forecast their overall plantation yields (at 800 trees/ha; Kenya provenance) at 250 pods/tree and some 1 kg of seed/tree (4 g of seed/pod) but, with correct canopy management, the Company expects peak yields to reach some 3 kg seed/tree from Year 4 onwards *without the use of synthetic fertilizers*. At Optima one worker can harvest 3,500 pods (containing 14 kg of seeds) in a day (M. Malik, pers comm, 2001).

MAFE Project has weighed six different samples of sun-dried Moringa seeds (5 from Malawi; 1 from Tanzania) and determined a *common* count of some 4,000 seeds/kg for 5 samples (but exceptionally Ngabu seeds gave a count of 3,100/kg). Taking an estimated yield of 250 pods/mature tree and a conservative projected ‘count’ of just 17 seeds/pod (4.25 g of seed/pod), MAFE Project has arrived at a forecast “minimum maintenance” yield from a living fence of 1 kg of seed/tree/year for planning purposes. It is thought that the mean ripe pod weight in Malawi is in the region of 13 g (air-dry stored weight some 8.5 g), giving a projected sun-dried seed yield of about 30% by weight.

10.7.2 **Circumstances of owner-communities**

Table 4 summarises the information gathered during the 2002 survey of Lower Shire Valley communities that, among other things, cultivate Moringa principally as a live fence. These communities comprise a population (1998 National Census) of some 551,000 and are among the poorest in Malawi and suffer from the heaviest incidence of infant mortality, at 141 infant deaths for every 1,000 live births (National average: 121). The nutritional plight of these communities was highlighted in a Nation newspaper headline article (Annex 2, Volume 2) on April 2, 2002. In the opinion of the authors Nsanje is the poorest District of all. Here any initiative resulting in improved nutrition and or enhanced family income would have the greatest incremental impact.

The Moringa cultivators of the Lakeshore from Salima to Mtakataka probably have less marginal livelihoods but would still benefit considerably from any initiative that could improve nutrition and/or income.

BCMMORA is a registered women's association that has been collaborating with MAFE in seed oils research since February 2001. Its members include private producers/Moringa plot owners from Blantyre, Chikwawa and Mangochi, encompassing the Central and Southern regions. A group of Moringa cultivators at Zione Church (Table 2), Salima South that recently took part in a BCMMORA production program and attended the business/marketingtraining program is exploring scope to establish infrastructure where *integrated* development of groundnut oil and tree seed oil production is contemplated. This group estimates it could harvest some 200 bags, i.e. about 5 tonnes of Moringa seeds annually from plantings in its neighbourhood (Mwawa, B. personal communicaton). MAFE considers the Salima area as a whole probably could provide a higher yield than indicated by the Zione Church community, possibly as much as 10 tonnes.

It has not been possible to quantify the available Moringa 'resource' in Lower Shire but it is thought by MAFE that existing hedgerows throughout the valley could, without any special management, yield between 20 and 50 tonnes of seeds annually. Moringa is also extensively grown in the areas of Mozambique that border Malawi's Lower Shire and, doubtless, elsewhere in the Lower Zambezi basin.

10.7.3 **Previous work**

In the mid-1990s Chancellor College, FRIM and other research organizations demonstrated that Moringa yielded a seed oil (26% of whole seed content by weight[60]) suitable for culinary use. Malawi and Tanzania (to a minor extent Senegal and Zimbabwe and possibly Madagascar) are considered to be the only countries in Africa engaged in systematic research and development on Moringa for oil commercialization. World Relief in Mozambique recently commenced investigation of respective project feasibility in lowland areas of Mozambique (Gudz, S. & Stevens, A. personal communication).

Moringa for water treatment

Adaptive research on Moringa was undertaken at Thyolo Waterworks in the early and mid-1990s by water engineering teams from Blantyre Polytechnic, Southern Region Water Board and Leicester University (UK) with DfID support, based on technology developed in the Sudan by Jahn, SAA in the 1980s. This proved the cationic polyelectrolyte protein in Moringa powdered seed (& expressed seedcake) to be an effective sediment flocculant[61] (instead of alum) for drinking water preparation.

[60] MBS test of MAFE sample. Previous work of Machell, K. (1994 –97) on samples from Malawi, Mozambique and Zimbabwe indicated oil content of 25 – 39%, and averaging 29%. Optima figures (2001) are in the range 25 – 28%. TEIA figures are 25 – 43% for a range of species.

[61] *Monograph:* Ndabigengesere, A., Narasiah, K.S. and Talbot, B. 1994. Active Agents and Mechanism of Coagulation of Turbid Waters using *Moringa oleifera. University of Sherbrooke, Quebec*

The Thyolo work was carried out with a crude mixture; further work was required at Leicester University to develop a proprietary pure flocculant extract from Moringa. Without isolation of the active principle, the Moringa powder would be too bulky to handle and (probably) cause contamination of water from microbial action on the sugars, celluloses and residual proteins present in the seed. Related work in Tanzania is described in Section 10.7.7.2.

10.7.4 Food/Nutritional uses

10.7.4.1 Vegetable

In West Africa dense plots of cash-cropped ‘dwarf’ trees provide the base for an expanding smallscale commercial enterprise, notably in Niger, for preparation of Moringa leaf powder food supplements. This system is also under trial in Nicaragua (Foidl, N. personal communication.). Although there are evident nutritional benefits from the protein and vitamin content of the leaves (CCCD Report Section 7.1) and a “history of use” over the last decade, no toxicological studies have been carried out.

Moringa had already been promoted in Malawi as a vegetable and oil crop for food security/vitamin nutrition purposes, notably by IEF for several years. IEF began (2001) a new COMPASS-assisted CBNRM program in the areas adjacent to Lengwe and Majete Wildlife Reserves involving, among other things, promotion of Moringa planting. IEF hopes to benefit from MAFE Project’s results of research and product development. This interest is shared by SADC-ICRAF.

SADC-ICRAF and GTZIFSP promote Moringa cultivation. This and the IEF work has been principally modeled on work elsewhere to exploit the nutritional/food security benefits of Moringa leaves, notably by Lowell Fuglie and partners in Senegal; Moringa flower buds are a popular savoury dish in India. In West Africa preparation of Moringa leaf powder food supplements from dense, plots of cash-cropped ‘dwarf’ trees is an expanding smallscale commercial enterprise, notably in Niger. The composition and nutritional properties of Moringa leaves are comprehensively presented by Foidl, N, Makkar, H.P.S and Fuglie, L.J. in Fuglie, L.J. (Ed) (2001).

In Southern Ethiopia coffee lands (also Northern Kenya) *Moringa stenopetala*, an upland species[62], is cultivated as a shade tree and dry-season vegetable crop that is used in the *daily* diet. It has relatively large, fleshy leaves that are ideal for this purpose.

In Southern India almost the entire focus of the *Moringa oleifera* industry is on *intensive horticultural enterprise* in which bundles of vegetable pods known as “drumsticks” are marketed fresh; they are also canned (Folkard, G.K. & Sutherland, J.P. 1996). Unlike many vegetables, they have several days’ “shelf life”. It is a lucrative business for which new cultivars such as *PKM1* and *PKM2* have been developed. These give exceptionally long pods, have a dwarf habit and require intensive cultivation methods. Replanting takes place every 4 years. In Malawi villages where Moringa is grown, flower buds and/or young leaves are cooked as a vegetable relish; green pods are used in subsistence cooking in Lower Shire (L. Satali personal communication). Seed powder is used as a (minor) curry sauce/vegetable relish seasoning/filler in India, and locally in Malawi in Karonga and Nsanje (Coote, C. et al. 1997). Young roots can be used as a seasoning base for ‘horseradish’ sauce (alkaloids may be present).

“ The purified proteins are more effective coagulants than alum. As a coagulant, *Moringa* is non toxic and bio-degradable. It is environmentally friendly, and unlike alum, does not significantly affect the *pH* and conductivity of the water after the treatment. Sludge produced is ……….. four to five times less the volume than the chemical sludge produced by alum …….. *Moringa oleifera* may be a potentially viable substitute for alum”

[62] It may be unsuitable for lowland cultivation.

10.7.4.2 Edible oil

Moringa oil is a palatable and durable cooking oil, i.e. its has good stability when used repeatedly for frying (Tsaknis, J. 1998). When refined it has almost no taste. It has a very similar fatty acids profile to Macadamia nut oil (an oil produced in Malawi as a nut industry by-product: Section 9.9 & Table 8). It was perceived by Coote et al as a potential, highly stable edible substitute for olive oil. The physico-chemical properties and fatty acid composition of Moringa oil of *Nicaraguan origin* are comprehensively presented by Foidl, N, Makkar, H.P.S and Fuglie, L.J. in Fuglie, L.J. (Ed) (2001).

Moringa oil contains about 76% monounsaturated fatty acids of which, like olive oil, nearly all is oleic. Moreover *cold-pressed* Moringa oil is rich in natural antioxidants/Vitamin E precursors, notably the powerful anti-oxidant, ?-tocopherol.

10.7.4.3 Aphrodisiac/fertility possibilities

Indian consumers recognize the 'drumstick' vegetable for its high vitamin content and it features frequently as an appetizer. It is considered to prevent eye disorders and, in men, to increase semen qualitatively and quantitatively (Rajangam, J. et al. 2001).

Seed kernel oil is reported as an aphrodisiac/nerve toning principle (Ranjangam, J. 2001) moreover as identified in Table 3, men in Southern Malawi contend that chewing a few Moringa kernels at regular intervals during the day improves their sexual stamina appreciably (Coote, C et al 1997). These assertions need to be verified by science.

Long term ingestion of leaves or leaf powder is thought to enhance mammalian ovulation. More twinning than normal has been witnessed in both humans and cattle but no formal statistical analysis of this phenomenon has been carried out (Foidl, N. personal communication).

10.7.4.4 Livestock feeding

Phytates and saponins in the seeds deter birds and prevent use of the seed or seedcake as a livestock feed. However, it is thought that kernel presscake could, like certain animal feeds used in the USA, be treated with the proprietary enzyme *phytase* to provide a feed supplement for poultry and swine (not ruminants) (Foidl, N.; Safalaoh, A.C.L. personal communication; Harper, A.F. 1999). The composition and nutritional properties of Moringa kernels and presscake are comprehensively presented by Foidl, N, Makkar, H.P.S and Fuglie, L.J. in Fuglie, L.J. (Ed) (2001).

In Malawi ducks have been found eating two year-old seeds spilling from sacks (Table 3: James, O. personal communication.)

The proprietors of KOR have recently developed a Guinea Fowl ration based on Moringa presscake, minerals and other ingredients. The formulation is confidential. BCA Department of Animal Science (Safalaoh, A.C.L. personal communication) may consult KOR and write a research proposal that will encompass adaptive research with phytase and possibly collaboration with KOR in product development. Such work is vital to establish the presscake's potential as a livestock feed.

10.7.5 Cosmetic/skincare applications

Moringa oil is cited as a commercial fragrance carrier (Le Poole, H.A.C. 1996), and historically known also as Behen, Ben, and *(arch.)* Myrobalanum or Balanos oil. It is advertised for sale on speciality cosmetic oils retail websites in the USA, both as a body and haircare moisturizer/conditioner, as a pre-shampoo dirt remover and as a carrier oil for home-blending with fragrances/essential oils. It is stated to be an ingredient in lip balms, cremes and soapmaking:

http://www.uncleharrys.com/info.htm : $4.00/oz, i.e. $140/kg (K, African origin;
http://www.2rich.com/scripts/jaciis.dll : $20/100ml, i.e. $220/kg, West Africa origin

As a possible comparison, Sweet Almond Oil B.P. (KTC brand, UK) has been found in a Lilongwe supermarket priced at K695($9.30)/500 ml (17.5 fl oz), i.e.$22.30/kg (K1670/kg). It is used as body oil. Moringa oil is sold in small quantities by Zimbabwe producers to masseurs (Warndorff, J & T. pers comm).

In a meeting in April 2002, the Production Manager of Malawi Pharmacies Limited (Annex 5, Volume2), explained to EDETA and MAFE that the Company used imported olive oil at the rate of 50 kg annually in a popular hair care formulation. He expressed considerable interest in procuring an olive oil substitute and said - provided MBS attested to the precise composition and safety compliance - Moringa oil could be incorporated in a test batch of 10 kg. The substitute price for olive oil is about K400/kg ($5.30/kg).

Moringa oil is reported to be used as lubricant sex aid in India (Vedamuthu, P. pers comm).

Table 10 reproduces an industry standard for Moringa/Ben oil (1997); this (2002) needs to be verified.

Table 10: Commercial Specifications for Behen Oil

(Source: Machell, K. Zimbabwe. May 1997, attributed to Jan Dekker International)

Commercial Product Name:	Oil of Moringa, cold pressed, filtered
INCI name proposed:	behen oil/*Moringa pterygosperma* (?)

Peroxide value:	< 3 meq O/kg oil
Acid value:	<1.0
Iodine value:	60 – 70
Saponification value:	185 – 195
Unsaponifiable matter:	1 – 3 %
Refractive Index (20 C):	1.460 – 1.480
Relative Density (20 C):	0.91 – 0.93
Colour (Lovibond 5.25")	<8.0 R
Cloud Point:	<10 C

Typical Fatty Acid Profile:		%
C16	Palmitic	6 – 10
C16:1	Palmitoleic	1 – 3
C18	Stearic	3 – 6
C18:1	Oleic	72 – 79
C18:2	Linoleic	1 – 2
C20	Arachidic	1 – 4
C20:1	Gadoleic	1 – 3
C22	Behenic	2 – 6
C24	Lignoceric	0.5 – 1.5

Shelf life: Under normal storage conditions, in original unopened containers: 1 year

Storage conditions: Keep in cool, dry storeroom

Packaging conditions: All packagings are nitrogen-capped. Once opened, the oil must be treated with nitrogen before resealing.

Moringa oil samples extracted by MAFE's partners using various methods have varying solidification temperatures. This implies that the higher melting point, stearine fraction varies. Laboratory tests being carried out abroad may help explain the differences and help determine suitability of each extraction process for commercial purposes. Meanwhile four foreign buyers have expressed interest in testing samples of MAFE Moringa oil, where a price in excess of $8.00/kg is indicated. Guidance from the trade indicates that *de-gumming* and *winterizing* of Moringa oil are not necessary (Moeller, L. personal communication).

10.7.6 Pharmacological applications

Numerous references on the medicinal properties of Moringa have been traced – far more than for other species that have been targeted - and they are set out in Annex 6. Two principal themes of possible opportunity are described below.

10.7.6.1 Blood pressure and diabetes disorders

Among the references, components of young leaves are reported to have hypotensive activity (Faizi, S. et al. 1994). Green pods are reported to have hypotensive activity by virtue of the presence of nitrile and mustard oil glycosides (Faizi, S. et al. 1998). Seeds are cited to contain the hypotensive and spasmolytic principles Isothiocyanate and Thionocarbamate as hydrolysis products (by the enzyme myrosinase) of 0-glycosylated glucosinolate (8 – 10% of seed weight) (Dr Elizabeth Henry pers comm; Rositor, J. 2001). Leaf juice (Senegal; India) is reported to stabilize blood pressure and control blood glucose levels in diabetes patients (Fuglie, L. 2001).

Root bark is described as a source of *moringinine* with applications as a cardiac stimulant, bronchiole relaxant and inhibitor of involuntary intestinal movement (Fuglie, L. 2001). Roots are reported to have carminative and purgative/laxative actions (Fuglie, L. 2001).

10.7.6.2 Cancer

Numerous references attest to experimental demonstration of the potential of Moringa in treatment of cancers/tumours and ulcers and there is a wide history of traditional use of Moringa plant parts and extracts for cancer treatment.

Root bark is used in India to destroy tumours and heal ulcers and treat sores and boils (Fuglie, L. 2001). Flower buds have anti-ulceronic properties (Aktar, A.H. & Ahmad, K.U. 1995) and young leaves have anti-tumour effects (Murakami, ? et al. 1999; Guevara, A.P. et al. 1999). Seeds are consumed in India to treat abdominal tumours and reduce pain and inflammation from arthritis and back pain (Fuglie, L. 2001). An oral seed infusion is reported useful as an antiinflammatory e.g in pedal edema (Caceres et al. 1992).

Seed kernels contain possible anti-carcinogenic[63] and/or metabolism-influencing principles (10% of whole MAFE seeds approx.) that are being tested in *in vitro* research at IFR:

4-(a-L-Rhamnopyrano-syloxy)-benzyl glucosinolate
and
3-Hydroxy, 4-(a-L-Rhamnopyranosyloxy)-benzyl glucosinolate (Bennett, R. pers comm)

[63] LFRA reported from its website www.foodlineweb.co.uk/FoodWeb/displaynews.asp?newsid=758 on 23/04/02 that researchers at University of California had found that polyphenolic antioxidants obtained from various food and beverage sources can protect against cancer by inducing apoptosis (programmed cell death) in cancer cells. Quercetin and other compounds were found to be responsible. This is a field of professional interest of Prof Gary G. Meadows, PhDDirector, Cancer Prevention and Research Center, WSU: www.pharmacy.wsu.edu/PharmSci/faculty/GaryMeadows.html .

10.7.6.3 Biocide/anti-feedant applications
Moringa has no known insecticide action but root secretions may give resistance to soil nematodes.

10.7.7 Non-food industrial applications

10.7.7.1 Moringa oil as a lubricant
Moringa had a remarkable 1800s history of commercial production in Jamaica, notably as a source of watchmakers 'Ben oil', before being superseded by Sperm Whale oil. Sperm oil has a history of use as an additive to extreme high pressure lubricants and gum-free industrial cutting lubricants (Walters, P.R. et al 1979). Now, Moringa oil is reported to be used as aerospace/high temperature/high stress lubricant in India (Vedamuthu, P. personal communication) and is recommended as a lubricant extender (Anbarassan, P. et al. 2001).

Moringa oil is notably resistant to rancidity and exhibits a much longer 'induction' period than olive and other edible oils which helps to account for its history of industrial use. The induction period (undegummed oil) is 9 –16 times that for olive oil; 4.4 times if degummed (Tsaknis, J. 1997).

It has been suggested that the oil be considered for use as a non-toxic/food grade lubricant in food processing machinery (Iveson, D. personal communication).

Moringa oil might possibly be suitable as a substitute for Sperm oil as an ingredient in leather fat-liquors, imparting softness and 'run' to leathers. (Walters, P.R. et al 1979)

10.7.7.2 Water treatment commercial R&D in Tanzania
In 1996 in response to a 'Le Monde" French newspaper article on Moringa attributed to Leicester University, four Swiss venture capitalists established Optima of Africa Ltd in Tanzania as a Company to adapt and commercialize the technology described in Section 10.7.3. MAFE staff met Optima's Tanzania management in June 2001 and later at a Moringa conference in Dar Es Salaam. Optima has established 62 hectares of its own Moringa plantations and, promising an attractive purchase price of $0.30/kg (K22/kg at present values) for seeds, is promoting major investment by outgrowers to develop 12,000 hectares of Moringa plantations for:

oil production of up to 8,000 t/year (food, skincare and cosmetic applications) and

commercial development of a proprietary cationic polyelectrolyte extract, "Phytofloc™"[64]for water treatment; also (subject to research)

commercial utilization of (protein-rich) *detoxified* filter cake.

The Optima Product Development Manager (to February 2002) formerly worked in Malawi on behalf of Leicester University and Optima has links with *faculty* of the University. While much of the Optima development concerns intellectual property and is commercially sensitive, this industrial development needs to be tracked. During March 2002 MAFE was told that Optima had downsized its professional staff to reduce expenditure.

10.7.7.3 Constraints to water treatment commercialization in Malawi
Following a hiatus of 4 years since the last Malawi forum[65] on the subject, in June 2001 CCCD convened a meeting of the Blantyre and Southern Region Water Boards, MAFE and the National

[64] 12.5% of presscake by weight (J.Sutherland, pers comm).
[65] A Moringa conference in Blantyre in June 1997 sponsored by the World Bank.

Research Council of Malawi (NRCM). The purpose was to renew investigations into possible substitution of proprietary water treatment products (polyelectrolytes and alum) by Moringa extracts. Investigations would follow up the earlier work of Blantyre Polytechnic, however no further action has been taken. The Polytechnic has not responded to this initiative and a key researcher (out of two) took up a full-time post with Northern Region Water Board in Mzuzu several years ago.

To enable Malawi to catch up on technical development achieved by Optima and take steps to commercialize Moringa for water treatment, a purpose-designed project promoted by NRCM and with suitable funding of full-time human resources for several years would be required. However such a project would, against competition from bids by other national 'projects', be unlikely to receive priority. The best use of resources would be to invite and encourage Optima to conduct its R&D in Malawi.

10.7.7.4 Village water treatment hazard
Using Jahn's technique, crushed seeds can be used as a turbid water flocculant in village subsistence. At a dosage of 0.5 – 5 g/l (Schwarz, D. 2000) this precipitates out insoluble particles and much of the bacterial/microbial 'load' in the water *but it does not guarantee removal of waterborne pathogens and needs to be supplemented by sterilization or fine filtration.* Moringa alone cannot be safely recommended for rural water supply treatment.

10.7.7.5 Activated carbon
Stripped pod shucks and seed husks were used in experiments in Malawi to make activated carbon (Mc Connachie, G.L. 1997) for water treatment but it is unlikely that they have distinctive properties favoring commercialization of their use for this purpose.

10.7.7.6 Wood
Moringa wood, which is soft, and in young trees has a spongy texture similar to cabbage stalk, has been cited as a suitable source of pulp source for newsprint, writing papers + viscose rayon (Booth, F.E.M. & Wickens, G.E. 1988). In Malawi it would have to compete with plantations of *Pinus* species that are ready for harvest but for which no pulping facility exists.

10.7.8 NRM benefits

10.7.8.1 Energy
Seed pod shucks, seed shells and prunings may be used as firewood.

The wood has a low density, providing 4,600 kcal/kg (Dalla Rosa, K.R. 1993).

10.7.8.2 Mulch/soil fertility
Moringa is considered to benefit from a mycorhizal nitrogen-fixing association but there are no residual nitrogen benefits for future crops.

Moringa foliage does not provide significant residues with mulching benefits.

Return of pod shucks and seed kernel presscake to the soil improves mulch + fertility. Approximate analysis of presscake is N22:P3:K4 (dry basis) (Foidl, N. pers comm).

10.7.8.3 Other
Moringa is fast growing and has a shallow root system with some use in resisting water erosion but unpruned trees are susceptible to wind damage. The low-density canopy enables light penetration to

the under-canopy/other crops. Moringa is not suitable as a carbon sink/carbon fixer owing to its low density and relatively short life span.

10.7.9 <u>Other possible applications requiring research</u>

International Moringa products workshop
The MAFE Resource Center Coordinator, Dr Henry S.K. Phombeya and the Program Specialist attended an international Moringa products workshop[66] in Dar Es Salaam in November 2001 at which previous work on Moringa was reviewed and the status of current knowledge of various Moringa species was determined.

Discussions focused on three topics:

- Farm production and genetic improvement,
- nutrition and health,
- oil production, and flocculation properties of seedcakes.

The organizers provided the groups with a discussion grid designed to establish levels of knowledge about the theme, and then identify constraints and action priorities. The result is summarized in Table 11. Full proceedings of the conference, promised on CD, are awaited.

The workshop culminated in the proposition to create a Moringa worldwide network coordinated by a specific website. This is now being built by PROPAGE. MAFE has provided PROPAGE with details of the Resource Center, BCA, CCCD and EDETA and their respective key staff so that they will be ‘posted’ as resource organizations/specialists on the site.

[66] The Workshop was sponsored by the following organizations:
PROPAGE – Association for the Promotion of and Propagation of Arid and Semi-Arid Plant Resources, Paris
Church World Service – which has conducted extensive work on Moringa in Senegal
CDE – Centre for Development of Enterprise, Brussels
CTA – Technical Centre for Agricultural and rural Development, Paris
SILVA International Network for Tropical Trees, Paris
Optima Environnement SA, Nyon, Switzerland – Holding Company

Table 11: Further Work Proposed by the Moringa Conference, Dar Es Salaam, November 2002

Markets

?? Regional market study for countries of southern Africa, including Tanzania, covering markets for oil, cakes and flocculants at national, regional and international levels.

Product quality

?? Biological tests and studies to make Moringa products comply with safety and health standards.
?? *Post-harvest technologies* adapted to *safeguarding the properties of seeds and leaves*, i.e. to work out the effects of *storage conditions* and develop *optimum preservation methods*.
?? Mechanical and semi-mechanical processing of Moringa leaves, to obtain a leaf powder with standard size particles and preserved nutritional quality.

Processing technologies

?? Improvement of extraction of *Moringa oleifera* oil at medium scale performances (200 kg of seeds per hour) based on two factors:
seed quality (optimum humidity level, degree of hulling); and
actual *extraction technology (testing expellers and altering them accordingly*).
?? Drinking water provision at village level: water clarification as a pre-processing operation associated with sterilization (ozone or UV).

Production systems

?? Assessment of Moringa-growing agroforestry systems in Tanzania (associating ICRAF in it), to determine the best small farmer methods of Moringa production in association with other crops.
?? Identification and description of cultivation methods for *Moringa oleifera* in Malawi.
?? Integrated cultivation of Moringa oleifera in West Africa (three sub-proposals): incorporating it with other crops.

Farming techniques

?? Techniques for intensive leaf production, to produce Moringa leaf powder in large amounts for use in trial nutritional programs designed for HIV-infected persons (South Africa; Malawi) and 0-5 year old population (Binga, Zimbabwe)
?? Development of the organic cultivation of Moringa for the production of leaves and green fruit.
?? Effect of different tree management practices on Moringa leaf, pod and seed yields: plantation densities and pruning techniques.

Genetic improvement and propagation

?? Improvement of Moringa oleifera productivity and quality for its various products (leaves, seeds, green fruit) from collection and assessment of genetic diversity and selection of best provenances: for East Africa and India. (See also Coote, C. et al. 1997).

Potential of *Moringa stenopetala*

?? Multi-site Moringa stenopetala cultivation tests in terms of nutritional use, flocculation and resistance to drought.

The recommendations above have been considered by the MEP partners and largely incorporated into Chapter 15.

10.8 Natal Mahogany *(Trichilia emetica)*

Through advice from BTP and initiative of MAFE Field Technical Associates and with assistance from PROSCARP and LRCD, Natal Mahogany (*Trichilia emetica*) is being investigated for its seed[67] oil properties and yield, and uses of aril paste[68] and bark extracts. Very little literature on this species exists yet the tree has numerous traditional food (Macucule, A. personal communication) and medicinal uses and formerly sustained significant soap industries in Southern Tanzania and Mozambique (Williamson, J. 1975).

10.8.1 Distribution, habitat, taxonomy and cultivation

This tree, from the same *Meliaceae* family as Neem, is common in Karonga and already promoted by MAFE as a reasonably fast-growing timber species. It is sometimes grown as an ornamental tree in Lilongwe.

10.8.2 Circumstances of owner-communities

Groups in Karonga, specifically communities of *Lupembe & Kapolo North*, take great care of the tree and use it for food, medicinal and mosquito-repellent purposes. While two other species have attracted MAFE attention in Central/Northern rain-shadow areas, this is the only widespread species in the far North of Malawi to attract attention under the MEP. It is also found thinly dispersed elsewhere in the country such as Salima (Ntonga Village) and outside its natural habitat it is sometimes found as a planted ornamental (e.g. Lilongwe). It is also frequently found in graveyards (Chituwi, K. personal communication).

Seed harvesting mostly takes place in the rainy season so special measures are required to dry the seeds for food uses and to avert mould growth on the seeds.

10.8.3 Previous work

Previous research could not be traced in Malawi; work of Macucule, A. and his undergraduate associates in Mozambique should be followed up.

10.8.4 Food/Nutritional uses

The oil-rich seed aril (arillodium) 'milk' is extractable by hot-water soaking and rubbing for use as a sweet subsistence drink or relish (de Wilde, J.J.F.E. 1968; Williamson, J. 1974). The aril yield varies between trees (Mpira, A. & Chamagommo, G.C. personal communication).

After removal of the poisonous testa, seeds may be cooked/mixed with maize meal or vegetable relishes (Williamson, J. 1974). Oil extracted from (testa-removed) kernels may be cooked although it is bitter. Seed 'bitterness' varies between trees (Mpira, A. & Chamagommo, G.C. personal communication).

Leaves are browsed by wild and domestic animals (Grundy, I.M. & Campbell, B.M.1993; Chituwi, K. personal communication).

10.8.5 Cosmetic/skincare applications

The oil may be used for hair and body (Williamson, J. 1975).

[67] 44% exhaustive oil extraction *from kernels* by Chancellor College Chemistry Department.
[68] 11.2% oil content: Malawi Bureau of Standards.

10.8.6 Pharmacological applications

Smith-Klein Beecham published an article on the properties of *Trichilia.* This is available from Prof Gary Meadows, WSU (PW: March 30, 2001).

Leaves can be used as a soporific when placed in bed at night (Grundy, I.M. & Campbell, B.M. 1993).

A hot leaf infusion can be used both as a lotion for bruises or as cough mixture (Coates Palgrave, 1984).

In the Karonga area aril 'milk' is considered to have malaria prevention properties for children (Mpira, A. & Chamagommo, G.C. personal communication).

The oil can be rubbed into cuts and on fractured limbs to hasten healing, also taken internally for rheumatism (Coates Palgrave, 1984). It was described as an ingredient for leprosy remedy (Jamieson, 1916).

The bark infusion is well known as an as emetic specially as an enema. A survey report described the enema as being best when made from an 'east or west-facing' bark infusion. The same report cited a pounded root infusion and/or pounded leaf infusion being used for male illness 'after sex with aborted woman' (Mwanyambo, M.L. & Nihero, D.A. 1998).

10.8.7 Biocide/anti-feedant applications

Through informal assistance from the Centers for Diseases Control and Prevention (CDC), MAFE has acquired insight into confirmed pesticidal properties of this plant. Its seed coat is thought to contain acetonitrile and hydrogen cyanide (Calafat, A.M. personal communication). These are discussed in the CCCD Report

*Although exposure to these principles may cause cognitive degeneration, s*eeds are burned at night in Karonga (Lupembe & Kapolo North EPAs) as mosquito repellent (Mpira, A. & Chamagommo, G.C. personal communication).

10.8.8 Non-food industrial applications

Carefully controlled experiments confirmed unrefined seed oil to be superior to linseed and other oils as wood polish (Grundy, I.M. & Campbell, B.M. 1993).

MAFE provided curio makers with a crude wax (solid at ambient winter temperature) to try as a wood polish. In May 2002 they reported favourably on its performance saying it was good at preserving the original 'look' of the woodcraft and that "a little is sufficient to effectively polish a large area" (Chipoka, J. personal communication: Annex 2, Volume 2 pp 230 – 232). They suggested a price of K20 per 'tub' (about 100 ml) or some K200/litre (about K220/kg; $2.90/kg). **This could fall within a scheme of economic viability for oil extraction with minimum refining.**

The seed oil had a major use in the past as a soapstock base in Mozambique and Kyela, Southern Tanzania. (Williamson, J. 1975).

The unrefined oil is stable under storage and moreover it can even be manufactured from fungus-coated seeds (MAFE; Grundy, I.M. & Campbell, B.M. 1993).

The timber is suitable for furniture, dugout canoes and utensils *but borer-susceptible* (Palgrave, K.C, 1997).

10.8.9 NRM benefits

The main benefits of Natal Mahogany are its use as a dense shade tree over meeting places. As it is long-lived and produces a dense timber it can be regarded as a good carbon sink.

10.8.10 Other possible applications requiring research

The chemistry of the pharmacological principles requires pure research.

10.9 Neem *(Azadirachta indica)*

10.9.1 Distribution, habitat, taxonomy and cultivation

Owing to its relatively localized distribution, Neem investigations were started by MAFE one year after those for Moringa and Jatropha. Neem is a MAFE-recommended lowland agroforestry species. It has been investigated by MAFE as a potential source of seed oil, seed oil extracts, foliage, and foliar extracts with pesticidal/anti-feedant applications and as a source of timber and fuel.

It is found mainly in the lowest points of the Shire Valley and concentrated in Nsanje, Bangula, Mlolo, Chiromo and Makhanga (all areas where Moringa is common). It also occurs in Mangochi, Balaka and Liwonde (Zeledon, B. 1999) mainly as a result of planting initiatives of various projects and the Forestry Department. In the opinion of specialists concerned with promotion of neem as a source of botanical insecticides/anti-feedants in *integrated pest management*, its net area of distribution and population is less than half that of Moringa; casual observers in Central Malawi often mis-identify Persian Lilac *(Melia azaderach)* as Neem (Hoeschle-Zeledon, I. personal communication). Unlike Moringa, Neem is not common along the Western Lakeshore.

There is thought to be one species but there has been no investigation of phenotypic variation in Malawi.

10.9.2 Circumstances of owner-communities

Field investigations were conducted by MAFE with IEF and ADD assistance in March 2002 and the results are summarized in Table 3. Neem is grown by communities who are among the poorest groups in the country.

10.9.3 Previous work

Much of the technical information gathered in this study is quoted from Childs, F.J. et al, 2001.

One million trees were estimated by FRIM to be planted countrywide over the period 1981-1998 (some 55,000/year). Their survival has not been determined (Zeledon, B. 1999).

FRIM undertook investigations for MAFE in 2001 to forecast neem seed availability. The team recommended collection in Makhanga, Chikwawa and Bangula where a total of some 12 tonnes of extracted (de-fruited) seed was forecast for December from 2,700 trees.

FRIM's investigations (Companion Document No. 5) for MAFE in 2001 revealed the farmgate cost of Neem seeds to be K15/kg – K25/kg ($0.20 - $0.33/kg) according to extent of fruiting. A price of K25/kg ($0.33/kg) was paid in late 2000 by the GTZ Plant Protection Project (GTZPPP) for 1.5 tonnes of seed from Lower Shire for use in the Central Region. Neem seed is more difficult to handle than Moringa because for processing it has to be de-fruited. *It is also much more costly*.

As fruits are harvested mainly in the wet season, seeds are susceptible to mould if not properly dried. GTZPPP further reports that the logistics of procurement and shifting neem seeds from the South to the Central Region are cumbersome.

10.9.4 Food/Nutritional uses

The only reliable food use of Neem is to provide pollen and nectar in bee-keeping.

Pirimiti Limited uses Neem leaves as a minor ingredient in mixed herbal teas (Stevens, A. personal communication)

10.9.5 Cosmetic/skincare applications

Neem is mainly known in the cosmetic trade for use in soap, not skincare preparations. Skincare potential could be re-examined since Neem oil, although made up principally of saturated and monounsaturated fatty acids, is approximately 20% linoleic acid (polyunsaturated), which is a source of Vitamin F and important in skin maintenance.

10.9.6 Pharmacological applications

A neem oil-based intravaginal contraceptive formulation, “Sensal”, is reported from India (Vietemeyer, N.D. et al. 1993). Actual use needs to be verified.

Neem twigs contain natural antiseptics favouring their traditional use (India) as toothbrushes (FAO website).

Muona Hospital in Lower Shire had been reported to use dried neem leaf powder in cancer cure treatment (Walker, J. personal communication). MAFE’s visit to the Hospital in March 2002 revealed that it had been used principally to provide relieve in a limited number of cases of cancer (Angelina, S. Pharmacist. personal communication). It is not used there on HIV/AIDS.

Neem is used in malaria treatment in Indian Ayurveda medicine where the leaf teas may contain the identified limonoid Gedunin, an effective quinine substitute (lab test only).

Leaves are used in traditional Malawi medicine against gut worms, fevers and to treat ulcers (Zeledon, B. 1999). The **MAFE Lower Shire survey confirmed that leaves were used throughout the region to provide relief from ‘stomach ache’**. A pharmacological explanation needs to be found as a basis for promoting wider use for this purpose, particularly for subsistence use and possibly for informal commercial application. Linda Robison’s report (Annex 2, Volume 2) reports further neem uses.

Neem oil and other neem components are reported as fungicides and bactericides (laboratory trials) (Vietemeyer, N.D. et al. 1993).

In Malawi “medicated” neem soap from unrefined oil is considered to be an effective, gentle anti-scabies wash (Bonomali, A. pers comm; see also Kone S. undated).

10.9.7 <u>Biocide/anti-feedant applications</u>

Subsistence: In Lower Shire 25% of communities interviewed reported using pounded dried leaves for maize storage to great effect for up to one year. The idea had been aggressively promoted by ADD staff.

Substitution benefits

In Ngabu local residents reported that the proprietary long-term storage insecticide Actelic[69] was used at a concentration of 25 g/50 kg bag of shelled maize. It was sold (March 2002) at K60/200 g pack[70] (i.e. equivalent to K15/100 kg maize treated) pack. Use of neem in its place, if of equal efficacy, is worth a saving of K0.15/kg maize and moreover, may have an enormous return (by way of crop saved) on the investment.

One community reported dipping sacks in leaf 'juice' for the same purpose and, additionally, using leaf juice solution as a 'borer spray' in fields.

Nimbecidine 0.03% and/or neem seed kernel extract is used in the Indian 'drumstick' industry as a Moringa fruit fly repellent (Rajangam, J. pers comm). The anti-viral principles *Nimbin* and *nimbidin* (2% of kernel) are known to be active against potato virus, vaccinia virus & fowl pox.

Neem oil, leaf and seed-based insect repellents and *ecdysone* blocker/growth regulator/pesticides contain Azadirachtin active ingredient at 0.03%; 0.15%; 0.3%; 1%; 3% and 25% w/w, in some cases with other *limonoids* (Childs, F.J. et al. 2001). *These compounds degrade quickly*. Other insect feeding inhibitor principles *Meliantriol* and *Salannin* are reported from Neem leaves (Vietemeyer, N.D. et al. 1993).

Leaves are used in Malawi as a mosquito repellent and are applied on animal skins as a tick and flea repellent (Zeledon, B. 1999) also on wounds to eliminate maggots, and the human scalp for lice (Vietemeyer, N.D. et al. 1993). Neem oil and neem seed extracts are used in India as fly repellents on sheep and cattle (Vietemeyer, N.D. et al. 1993). Dried leaves are used in Malawi to protect stored crops, cloth and books from insect attack (Bunderson, W.T. et al. 1995).

The nearest known commercial manufacturer of neem preparations is *SAROC, Nairobi* (Chamberlain, J. personal communication) which developed products in collaboration with *the International Center of Insect Physiology and Ecology*: drocco@icipe.org.

10.9.7.1 Malawi anti-feedant case study

The 1.5 tonnes of seed purchased by the GTZ Plant Protection Project (GTZPPP) in late 2000 from Lower Shire was provided to an assisted group of upland horticultural farmers near Ncheu, *Njolomole Farmers Association*. Caterpillars of Diamond Back Moth had been identified as a seasonal pest of cabbages and GTZPPP promoted the use of a fresh aqueous solution of crushed neem seed as an anti-feedant/repellent. The neem seed in this case was provided free of charge to the Association to establish a revolving fund, where farmers would pay the association for seeds to enable seeds to be resupplied in future seasons. However, few farmers were willing to pay and over 1 tonne of the original stock lies unsold[71] and, probably, no longer contains viable quantities of the active principles (Hoeschle-Zeledon, I. personal communication).

---

[69] ZENECA Agrochemicals, Fernhurst, UK: Pirimphos-Methyl; shelf life 2 years; Distributor: Royale Chemical Enterprises Ltd – see Annex 5, Volume 2.

[70] A.R. Issa Wholesaler, P.O. Box 3, Ngabu

[71] It could possibly be crushed for use of the oil as soapstock.

The neem initiative at Njolomole has been frustrated also by the habit of farmers spraying synthetic pyrethroids to combat aphids, which also eliminates the caterpillars.

10.9.8 Non-food industrial applications

Cold-pressed seed kernel oil is used in India as soapstock (small-scale speciality manufacture) but *careful oil refining is required* (boiling water) to *remove taint and colour* yet prevent loss of active substances.

Hexane-extracted seedcake oil is also used in India for soap; the seedcake is purchased by large-scale solvent extraction processors. Crude oil is used for manufacture of coarse laundry soap.

In India the sulphurous crude oil is used as a non-drying lubricant for cart axles – mostly village use.

The timber (properties resemble commercial mahogany) is relatively dense: adequate for furniture but risks splitting. Neem has good termite and woodworm resistance.

It is a good coppicing species for construction poles.

10.9.9 NRM benefits

At the household level in India the sulphurous cold-pressed crude oil is used for lighting and heating. (Vietemeyer, N.D. et al. 1993)

Neem presscake is considered to be useful as a urea fertilizer additive to inhibit bacterial denaturing of soil nitrogen (Vietemeyer, N.D. et al. 1993)

Neem presscake may be used as a mulch and NPKCaMg fertilizer. It has some nematicide and termite-repellent properties.

Neem has very important fuelwood/charcoal uses in N. Nigeria. (Vietemeyer, N.D. et al. 1993) but in Ghana it is reported to be an invasive species.

In Lower Shire the tree is prized as firewood, especially for brick kilning. Trees of around 0.45 m *dbh* and 10 m height are valued at up to K500 each (see Table 3).

10.9.10Other possible applications requiring research

The principal application needing investigation is the stomach-ache cure.

PART III: TECHNICAL RESEARCH AND DEVELOPMENT AND PRODUCTION ECONOMICS

11 MEANS OF PRODUCTION: OIL EXTRACTION TECHNOLOGIES AND ADAPTIVE ENGINEERING RESEARCH REQUIRED

Having settled on a *cluster* of oil-bearing species for initial investigation, MAFE and LRCD decided to investigate and take advice on available mechanical oil extraction technologies suited to small or medium-scale operation (Section 6.2.2 species selection criterion No. 3). Another technology, aqueous extraction, is discussed in Section 11.4.3.

The Project's inquiries revealed that although suitable mechanical oil extraction systems were being used in India on Neem, in Namibia on Marula (see Annex 2, Volume 2: Marula Net) and on Jatropha in several countries, technical problems were encountered worldwide in extracting Moringa oil. In Zimbabwe BTP had found that motorized 'Jatropha' expellers could cope reasonably well with Natal Mahogany but tended to 'polymerise' the oil and presscake of Moringa[72] (see also Machell, K. 1994). No secondary data could be obtained on efficiency of oil extraction with the minor species of interest to the partners, i.e. African Star Chestnut and Manketti, therefore this would require 'pioneering' R&D.

It was agreed that systematic investigation of mechanical oil extraction systems and associated adaptive research should be carried out by BCA. In order to avoid delaying efforts to characterize products (for which no samples were available) it was decided that the investigation would be commissioned by MAFE *concurrently* with the KOR program to manufacture product samples.

11.1 Manual Oil Extraction Systems

11.1.1 <u>Background</u>

In 1997 with financial support from PROSCARP and with the view to assisting the smallholder sector, CARS-FMU carried out oil extraction trials on seeds of both Moringa and Jatropha on a CAMARTEC[73] BP30 manual ram press bought from Zimbabwe. The key components of this machine are a lever-operated piston (diameter 30 mm) with a stroke of 75 mm moving through a reinforced cage of 15 longitudinal iron bars spaced typically at some 0.8 mm (0.5 or 0.6 mm for Sunflower), through which oil is released (see Photo Gallery). Press cake is released past an adjustable end-of-cylinder choke cone. The press is operated by one person but the work necessitates frequent rests and normally needs two operators, taking turns. CARS-FMU crude oil extraction rates by weight were 7.7% for Moringa and 18.3% for Jatropha with output at the rate of some 0.30 kg and 1.36 kg of oil/hour respectively. It was felt that the design was inappropriate for Moringa and not ideal for Jatropha and that further experimentation and (later) demonstration were necessary at the farm level.

Jatropha oil extraction by ram press has in recent years been promoted by Appropriate Technology International (renamed Enterprise Works in 1998) and Africare (sponsored by

[72] If not flushed out of the machine with another oilseed, such as sunflower, at the end of a batch, a hard oil/presscake crust sets solid on the 'worms'; this can be lifted after soaking in water overnight.
[73] Centre for Agricultural Mechanistion and Rural Technology, Tanzania.

USAID), GTZ and their respective partners in Mali, Tanzania, Zambia and Zimbabwe. A press manufacturing and sales facility was established in Zimbabwe in partnership with Shamen Engineering Ltd and ZOPP Pvt. Ltd.

For several years Malawi Industrial Research and Technology Development Center (MIRTDC), International Eye Foundation (IEF), Plan International (PI) and other organizations[74] have promoted the use of versions of the ram press mainly for sunflower oil extraction. IEF and its partners have supported demonstration and development of Sunflower and Moringa oil extraction using ram presses in various locations in Lower Shire as part of a food security support strategy. Most presses in Malawi have been manufactured by MIRTDC (which continues to offer this product at a price of some K9,000); some have been bought from Tanzania and Kenya (PI) at a cost ex-factory of some $275 (K22,000) each. Khumbo Oil Refinery (KOR) was one of the family businesses assisted by IEF and has continued operating a MIRTDC prototype ram press[75] for 4 years; its main business is groundnut oil extraction. PI-assisted communities in Kasungu press Sunflower with a Kenyan ram press where a potential extraction rate of 41.7% has been claimed but is unlikely to occur in practice. ZOPP Pvt. Ltd considers that for sunflower a mean extraction rate of 25.5% (whole seeds) is normal. Manufacturers' performance statistics for pressing conventional (but not tree) oilseeds are enclosed in the *MAFE Dossier on Mechanical Oil Extraction Systems* that accompanies this report.

In 1994, under a Moringa collaboration between Blantyre Polytechnic (BP) and Leicester University (LU), the Intermediate Technology Development Group, Zimbabwe (ITDG-Z) carried out Moringa oil extraction experiments. The first was with a Ram Press, the second - with Valmore Paints Ltd - on a Tinytech mechanical expeller from India and the third on a manual Spindle Press made by Malawi Entrepreneurs Development Institute (MEDI) (Machell, K. personal communication). The Ram Press (design unspecified) was quickly discarded as being of too low labour efficiency, yielding oil under trials at the rate of just 170 ml/hour. Work at Mponela with the MEDI Spindle Press gave a *maximum* Moringa oil yield of 21.6% from crimped seeds but the oil was of poor quality because there was charring during seed pre-treatment.

In early 2001 MAFE and Bunda College of Agriculture (BCA) staff attended an EDETA field demonstration of manual oil extraction from Groundnuts and Moringa at Neno. The MIRTDC ram press could not be made to operate efficiently.

Based on the results of the work of CARS-FMU and the results of its own collaborative trials in early 2001 (see below), MAFE commissioned BCA to carry out adaptive research to improve the performance of ram presses and a spindle press with tree seeds.

11.1.2 Summary of results of adaptive research

The complete results are presented in the *Dossier on Mechanical Extraction Systems.*

11.1.2.1 Engineering

✍✍*Seed conditioning*

Besides requiring gentle heating immediately before pressing, Moringa and Jatropha seeds should be partly decorticated. BCA experiments indicate that a ratio of 50% decorticated to 50%

[74] IFAD and FAO have supported African Oil Palm producers in Karonga with the supply of Costa Rican seeds and smallscale fruit oil extraction equipment (Mills, S. pers comm).

[75] The bar spacing on the MIRTDC cage *now* ranges from 0.9 mm to 1.0 mm (measured by BCA on 11.10.01)

undecorticated seeds is optimal. At the village level this implies that seeds should be lightly pounded in a pestle and mortar, and part of the seed shell should be eliminated by winnowing.

✍✍*Ram press suitability*
Conventional ram press bar cages are suitable for Jatropha and Trichilia oil extraction but give a poor extraction ratio for Moringa. Although a standard cage bar spacing of 0.5 mm was required for tests, it was not possible to identify an immediately available press of the desired precision for the initial trials (under a *Stage 1* program) due to the nature of the local manufacturing process. MIRTDC had observed that this provided an actual spacing in the range of some 0.5 – 1.1mm. In various MAFE-sponsored Moringa trials (see *Stage 1*) the maximum oil yield obtained from the above pressing mixture was 9% (i.e. 6% on whole seed); prior to achieving design improvements, the BCA trials yielded just 6% (4% on whole seed).

✍✍***Cylinder cage***
BCA has developed a perforated cylinder to replace the "conventional" bar cage[76] for Moringa oil extraction, achieving (under triplicate trial replication) some 12% extraction on the foregoing 50:50 mixture (equivalent to 8% extraction from whole seeds). The manufacturing process is cheap and dependable, moreover the cylinder is easy to clean and significantly more hygienic than a bar cage - which can be fully cleaned only when dismantled. 1 mm cylinder perforations are best for Moringa but 1.5 mm perforations are good for both Moringa and Jatropha. The cylinder is unsuitable for Trichilia.

BCA's invention needs to be published in *an agricultural engineering* Journal.

✍✍*Spindle press*
During tests the machine tested collapsed under the pressure of 'normal' use (high torque to the screw by high diameter of the lever arms' pushing points). Before this event BCA found that this machine offered no advantages over a ram press in throughput and, at a unit cost of some K40,000 upwards, it was relatively expensive.

11.1.2.2 Economics
✍✍*Ram press*
Manufactured in Malawi, this machine costs no more than K10,000 and for Moringa can produce about 0.5 kg of crude oil/hour, say 4 kg crude oil/day at a throughput of some 6.5 kg of pressing mixture/hour. In *Stage 1* trials Jatropha and Trichilia gave approximately twice this output.

On an estimated life of about 3 years, and assuming low oil output (i.e. Moringa only) of some 500 kg/year[77] the rate of "write-off" of the capital cost of the press in relation to the output during its life (1,500 kg oil) would be some K7/kg ($0.09/kg) crude oil. This projection assumes

---

[76] ***Results of Commissioning Trial for prototype Bunda Ram Press ordered by MAFE***
The following results were achieved on October 12, 2001 in the sequence indicated:

Seed mixture	Pressing chamber	Crude oil yield (unfiltered) g	% by weight	% above or (below) target	Duration mins	Crude oil g/hour
Salima 2000 1kg	0.4 – 0.5 mm precision bar cage	104.1	10.4	73.3	14	446
Salima 2000 1kg	1 mm drilled cylinder	91.5	9.2	(20)	9	597
Khumbo pre-mix of Salima 1997 1kg	1 mm drilled cylinder	92.1	9.2	(20)	12.5	442
Salima 2000 2kg	0.4 – 0.5 mm precision bar cage	221.7	11.1	85	Not available	Not available

[77] 125 days X 4 kg oil

that the press would be used for 25 weeks each year, i.e. some 50% utilization (single shift basis).

Compared with Malawi-manufactured ram presses, the ram presses from neighbouring countries cost twice as much[78], in the region of K20,000 each. The projected rate of their capital write-off cost on Moringa – perhaps K14/kg crude oil – is correspondingly high but does not approach that of a motorised expeller.

MAFE calculations (see *Dossier*) for capital write-off (50% utilization) on Moringa oil extraction of a Sundhara Sayari mechanical expeller[79] from Tanzania *over a 5-year life* indicate a charge of about K20/kg ($0.27/kg) crude oil. This is considered by MAFE to be among the cheapest expellers available yet its projected "capital cost/kg extracted oil" compares poorly with locally made ram presses.

It should be noted that when used principally for groundnut or sunflower seed crushing, the capital cost of imported ram presses *and* expellers becomes almost insignificant in relation to output, i.e. it reduces to about one sixth that estimated for Moringa and amounts to about K3/kg ($0.04/kg) crude oil. Durable ram presses may have a working life greatly in excess of 3 years but, excepting one special case, i.e. of KOR, MAFE has no data on ram press life.

11.2 Motorized Oil Extraction Systems

11.2.1 <u>Background</u>

Komet
The Chitipa District Health Project (assisted by GTZ[80]) has helped the Kafora community to establish a Sunflower oil extraction business that uses a "high-tech" electrically powered German "Komet" expeller of the type used by NTE. This is a bench-sized 2-stage machine fitted with seed pre-heaters. In the 1999 trial season some 800 litres of Sunflower oil were produced over a period of 3 months (62 litres/week) at an oil extraction rate of 18.1%. Small tests with Groundnut variety CG7 and Moringa gave reported extraction rates of 45% (unlikely) and 10% (credible) respectively. Groundnut oil was palatable; Moringa oil colour was unexpectedly dark and thick (probably polymerised) – see Footnote on NTE Komet operating temperatures at Section 9.9. The same make of machine is used by Optima in Tanzania for small-scale Moringa oil extraction[81], where an extraction ratio of 1:7 (14.3%) is achieved but clogging of cake is a problem. This machine is thought to cost far more than the *Sundhara* that is discussed below.

Tinytech
The Tinytech expeller of Valmore Paints Ltd is a machine fitted with a steam seed pre-treatment apparatus and suitable for conventional oilseeds including Castor (for paint-making). Tinytechs are operated by at least one Blantyre sunflower oil refiner on a full-time basis (see Photo Gallery). Several of these machines were imported in the 1980s through a credit program administered by the Small Enterprise Development Organisation of Malawi (SEDOM). SEDOM may also have been involved with Komets.

[78] Possibly manufacturing labor costs are higher outside Malawi.
[79] MAFE Dossier on Mechanical Oil Extraction Systems – October 2001
[80] Horticulture in Malawi: Vol. 2 / No. 3 / 2000. Malawi – German Project for Promotion of Horticulture.
[81] Naming'omba Tea Estate owns 3 Komets.

In a 1994 trial run organized by Machell, K. of ITDG-Z at Valmore using Moringa, the Tinytech was found to give unsatisfactory oil extraction from crimped kernels; oil leaked out with presscake and cake clogged in the worm.

In 2001 MAFE commissioned Bunda College of Agriculture (BCA) to test the Valmore Tinytech and ascertain the causes of its 1994 failure. The report is in the *Dossier*.

ITDG-Z work in Zimbabwe in 1995, cold-pressing with a small, motorised expeller (no seed pre-treatment) gave a Moringa oil extraction rate of 10.8% (Machell, K, personal communication).

Sundhara
The Zimbabwe soap 'industry' based on Jatropha oil was developed with assistance from ITDG-Z and other organizations. Oil was reported to be extracted by Tinytech and Sundhara expellers. The Sundhara was developed in Nepal under a GTZ *public domain* assistance program through FAKT-Consult and has been adapted for use with Jatropha in a number of countries, notably Mali.

The Sundhara is manufactured in two factories in Zimbabwe and in a factory in Tanzania (prices and specifications appraised in *Dossier*). BTP uses a Zimbabwe Sundhara on Jatropha, Natal Mahogany[82] and Moringa seeds. It initially experienced frequent clogging with the latter; it considers Moringa oil extraction efficiency can be raised by reducing the rotation speed from 44 rpm to 36 rpm through changing the gearing of belt sprockets.

Sundhara manufacturers do not require trade mark owners/copyright permission since the Sundhara is not patented. The Tanzanian Sundhara (8 h.p.power rating) is advertised at a rated sunflower seed (local variety; whole) throughput of some 60 kg/hr and an impressive crude oil extraction rate of about 26%.

MAFE ranked manufacturers of this machine within the region according to several criteria and decided that the Tanzanian source scored highest on several points *including easy access by coach service for refacing worms at the factory*. Price details are given in Footnotes on the next page.

MAFE then commissioned BCA to investigate the Tanzania machine, determine its suitability for tree seed oil extraction and conduct adaptive research to configure it for use with tree seeds. In June 2001 the Head of Agricultural Engineering of BCA, Mr Henry F. Mbeza, carried out the assignment in Morogoro, Tanzania according to agreed terms of reference, submitting his final report in September 2001 (see Dossier).

11.2.2 <u>Summary of results of adaptive research</u>

11.2.2.1 Engineering

✍*Komet*
MAFE and its partners have little experience of this expeller. Valmore owns a new, unused Komet that could be commissioned and tested. Information was sought (October 2001) on machines operated by NTE: see Footnotes under Section 9.9.

[82] BTP's Natal Mahogany expelled oil contains some 20% foots which can be settled out only by keeping the (high melting point) oil warm during storage/settlement.

✍✍*Tinytech*
MAFE and BCA have no experience of working with a new machine. MAFE and MIRTDC visited a commercial refinery in Blantyre to see an old model crushing sunflower; this machine had been extensively rebuilt.

The machine owned by Valmore provided useful experience to BCA and MIRTDC staff in the technical challenges of expelling tree seeds but, as was the case for Machell, K. 1994, major mechanical problems were encountered. The machine could not be made to run effectively and no useful production data could be generated.

✍✍*Sundhara*
The Sundhara model from Tanzania is an adaptation of the original design and is called a *Sundhara Sayari* .

The principal findings of BCA were as follows:

- **Reconfiguration of settings of the Sayari to graduated cage bar spacing of 0.4 mm – 0.2 mm and cone diameters of 90-98-98 respectively achieved satisfactory Moringa oil extraction of 14.7% on whole seeds, equaling a ratio of 1:6.8, i.e. about the same as achieved by Optima with a *Komet.***
- **In its 'standard' setting of 0.8 – 0.4 mm and 86-96-98 the Sayari is suitable for Groundnuts, Sunflower and Jatropha.**
- **For ease of operation, a complete set of spare worms and cones should be kept with the machine so that cleaning of one set (hot water and detergent) can take place during running time.**
- **Further work is required to configure the Sayari for Natal Mahogany and Neem. Results for Natal Mahogany were disappointing with a very low rate of extraction.**
- **For eye safety, oil splash guards should be fitted.**
- **V-belt grooves should be fitted on pulleys.**
- **An electric motor of less than 5.5 kw may be adequate.**
- **Lubrication of the machine with high-temperature grease may be required.**
- **The effect of high operating temperatures (from friction) on Moringa[83] and other oils should be compared with that from cold pressing with ram presses.**
- **Cage holders are over-designed and the bottom of the oil receiver should be uncovered.**
- **BCA ideas for replacing the bar cage with a prototype perforated cylinder in tree seed oil extraction should be tested in a further adaptive research project.**

11.2.2.2 Economics
✍✍*Sundhara*
- BCA recommended that detailed cost analysis of this machine, and the scope for economizing on the cage holder and oil receiver specification should be investigated.

[83] Using a probe thermometer, typical operating temperatures detected on the expeller with Moringa were some 90°C at the inlet end (0.4 mm bar spacing) and 110°C at the outlet (0.2mm bar spacing). These were significantly higher than for sunflower. See also Footnotes to Section 9.9.

- MAFE's latest calculations, taking account of recent exchange rate movements, (see Dossier) indicated that on an estimated life of 5 years the capital repayment and *single-shift* operating cost of a Sundhara Sayari expeller (diesel driven), as quoted[84], would be as follows:

	Kwacha/kg crude oil
Sunflower oil (12 months' operation/year)	17 ($0.23/kg)
Moringa oil only (6 months' operation/year)	59 ($0.79/kg)

Consideration of equipment utilization leads to a conclusion that, provided suitable *cones* and *worms* are available for fitting, integration of Moringa and/or other tree seed oil production with Sunflower or Groundnut oil production could be advantageous.

11.3 Overall Results of Research on Mechanical Extraction Systems

Overall results of BCA, MAFE and EDETA research and development on mechanical oil extraction systems up to Sepetember 2001 for Moringa were as follows:

Table 12: Comparison of Efficiency of Mechanical Oil Extraction Systems

Parameter	**Manual Ram Press (improved) Seasonal use only**	**Small motorized expeller Seasonal use only**	**Larger motorized expeller (source: Optima of Africa Ltd) Full-time use**
Efficiency of extraction:	**25%**	**50%**	**53%**
Extraction ratio weight % whole seeds:	**6.6%**	**14%**	**16% (estimate)**
Ratio of oil to whole seeds:	**1:15**	**1:7**	**1:6**
Capital and operating cost (excluding seed cost)/kg oil produced	**$0.89**	**$0.79**	**$0.40 (approx)**
Minimum capital investment/ Processor	$160 **K12,000**	**$4,000 K300,000**	**$240,000 (est) K18,000,000**

The typical Moringa (or Sterculia) oil production *direct* cost with a ram press is upwards of K270/kg (about $3.60/kg) oil including the cost of seeds, and *before overheads*.

11.4 Conclusions Drawn

Motorized extraction systems always achieve a higher extraction ration than manual methods but they depend upon a minimum throughput for economic operation. The partners considered in 2001 that respective expellers should not be imported for trial on tree seeds in Malawi until:

oils and their by-products had been characterized and their 'quality' determined;

their market potential and likely prices had been assessed; and

the available seed resources had been quantified.

[84] One complete expeller with a spare set of cones and worms, plus tools and 8 h.p diesel drive motor costs $4,572 ex-works (2001).

Discussions with NTE (April 2002) suggest an attempt should be made to run available tree seed samples, specially Moringa, through one of the Estate's Macadamia Nut oil expellers to compare extraction efficiency with that achieved by BCA on the Sundhara Sayari in Tanzania.

11.5 Professional Filtration Technical Notes

In April 2002, MAFE and EDETA made arrangements with NTE to filter a batch of BCMMORA crude oil; NTE Macadamia oil had previously been certified by MBS as fully complying with *Edible Oil Standard 51* (Phakamea, E. personal communication). This was the first time that oils from the MEP partnership had been professionally filtered. The service was charged at K10/input kg ($0.13/kg). The process was witnessed by Tendayi Pafupi and Fatuma Bonomali on behalf of BCMMORA. MBS, and later LFRA, tested samples of the output for insoluble impurities. LFRA reported nil presence of insoluble impurities after MAFE challenged an MBS report of some 1% insolubles.

For the foregoing filtration program, NTE's *Rosedown* filter unit (*flushable with compressed air*) was configured to comprise 21 *cloth+ paper filters*[85]. Filtering *pre-heated* oil, the unit typically can handle 120 liters/hour. At our request, the BCMMORA oil was not pre-heated so the lower viscosity made progress slower. Paper filters were changed after the first 40 liters of output, since the feed pump was heating up (it reached 64°C) and the flow was reducing. The unit is ideal for small batches of oil. The compressed air flushing system enables as little as 50 liters to be processed at a time; the *dead* loss is about 10 liters. December is the best time for seeking use of this equipment.

A similar filter system was inspected by MAFE at Hua Feng Company (Photo Gallery; Annex 5, Volume 2), Blantyre. This was offered to MAFE for experimental purposes at no charge. Hua Feng also has a small refining vessel that has a batch load of about one tonne.

[85] Optima reports using disposable paper filters for its Moringa oil (Sutherland, J.P. personal communiocation)

12 FILLING THE OIL PRODUCTION QUALITATIVE AND QUANTITATIVE DATA VACUUM

12.1 Production Research Required

Notwithstanding a comprehensive literature search and consultations with MIRTDC and the other organizations listed (during the 4-month *Inception Phase* of the MEP) secondary data was lacking from Malawi and abroad on

?? *input-output economics* of village-scale extraction of seed oils of Moringa and Jatropha and
?? respective *qualitative/compositional data* (see Section 9.9 and Table 7) for the output.

Such information was considered vital for determining feasibility of any respective enterprise development and for justification of any related project/investment proposal. In addition, program sponsors needed to be satisfied that the 'products' and production processes were not a danger to the environment or human health. These aspects are examined in Annex 9, Volume 2.

For supporting *business planning*, MAFE was unwilling to rely on manufacturer's 'rated performance' statistics for oil extraction equipment; it was felt necessary to develop such information from empirical trials under 'normal' field conditions. With regard to Moringa, Coote et al (1997) had recommended:

"

(i) information is sought on low-tech oil processing methods …………. In areas such as Salima, Mangochi or Nsanje …………. To determine economic feasibility of *small or commercial scale* production.

(ii) a supply of fresh *Moringa* oil is obtained and sensory evaluation ……….. is re-run …… also … in Nsanje and Mangochi districts which have a high concentration of *Moringa oleifera* trees …"

Machell, K. (1997) recommended setting up a trial to process at least 5 tonnes of Moringa seeds to enable test marketing of about 1 tonnes of oil but in the period up to 2001 there was no new work in Malawi that acted on his or the Coote recommendations. In addition to commissioning BCA to address engineering questions, it was agreed between LRCD and MAFE early in 2001 that a village-based program should be organised to act on the Coote recommendations and to address MAFE's needs for qualitative and quantitative data. The program would:

1. Explore availability and prices of tree seeds for processing;
2. Accurately monitor economics of Moringa and Jatropha oil production from ram presses;
3. Conduct laboratory assay of the respective output for Moringa, Jatropha and "competing" oils such as Sunflower and Groundnut; and
4. Include other tree species' oilseeds within *the cluster at that time targeted* by MAFE under 2. and 3. as this would impose little extra cost and could reveal interesting information beyond that stated in available literature.

Mirroring the pattern of exploitation of traditional oilseeds for both oil *and by-product* uses, it was decided that the MEP research and development program should include efforts to identify subsistence and commercial applications for tree seed oil by-products, i.e. presscakes, hulls, etc.

While it was hoped that some of these by-products could be used for nutritional, livestock feeding, industrial or manurial purposes, MAFE started investigation of the scope for manufacture of fuel briquettes from by-products. A quotation for supply of briquette-making equipment was obtained from MIRTDC (Annex 13, Volume 2).

Inevitably, through running this work in parallel to the *BCA mechanical investigations* and related adaptive research there was some duplication of mechanical performance results but the former contributed significantly to 'fine tuning' carried out on the latter. Through being conducted simultaneously they saved the MEP some 2 work months of program time.

12.2 Oil Extraction Trials And Assay Of Samples: Plant Oils Stage 1

12.2.1 Sites and roles of partners

Following the decisions made with LRCD, monitoring of production trials – using ram press and aqueous extraction[86] methods - was organised by MAFE and EDETA at a site close to Blantyre commencing February 21, 2001. This was termed *Plant Oils Program Stage 1*. Staff of LRCD, PROSCARP and WSU-IP visited the production site to familiarize[87] with the methods employed. Trials were carried out on Manketti with communities at Bolero, Mzimba North during May, 2001.

The commercial partner in all of the trials was Khumbo Oil Refinery (KOR) and the institutional partners were EDETA and (at Blantyre) MIRTDC. EDETA's principal task was to monitor physical inputs and outputs while MIRTDC would calibrate the equipment and appraise physical performance of the various processes including operating temperatures. Excepting work in Bolero, all production activities took place at the premises of KOR. Oil was extracted using KOR's MIRTDC (1997) ram press.

All the original Registers of this and other KOR (and BCMMORA) work up to April 2002 are held in the Resource Center Library. See also Annex 7, Volume 2.

12.2.2 Seed Procurement

KOR took responsibility for procurement of seeds for processing. Respective costs ex-farm, excluding transportation, were:-

	K/kg
Castor – Madziabango (only 14 kg)	25
Neem – Ngabu (unshelled)	45
Moringa – Chikwawa	30[88]
Local Groundnuts – *purchased in Blantyre*	49

MAFE additionally procured the following seeds ex-farm (2001 crop) specifically for processing[89]:

CG7 Variety Groundnuts – Chitedze	not priced
Natal Mahogany[90] - Karonga (requiring further sun-drying)	20
Jatropha – Nkuka, Lilongwe West	15
Manketti – Bolero (defruited[91] kernels)	91
African Star-Chestnut[92] - Mtakataka	25

[86] This method was brought to MAFE Project attention by KOR.
[87] USAID NATURE staff werealso invited but were committed on other activities.
[88] This purchase was made late in the harvest season, in February.
[89] The prices normally paid by MAFE for seeds of planting quality are higher.
[90] Samples of aril paste were washed from the undried seeds and placed in chilled storage beofore assay by MBS.
[91] Whole fruit cost was K7.50/kg, including cracking expenses; kernel yield was 8.2% on whole fruit.
[92] Not included in *Stage 1* production. This appeared to be an edible nut similar in taste to groundnut.

KOR's previous experience with groundnuts indicated that groundnut oil extraction would be economic but the trials needed to demonstrate that the negotiated purchase prices of the tree seeds would be low enough to leave a *potential profit* from tree seed oil extraction operations.

12.2.3 Assay of Production Samples

MBS and CCCD agreed to conduct comprehensive analysis of production samples and took delivery of duplicated samples accordingly. It was decided that (triplicate) samples would also be retained for any necessary further analysis and possible international characterization and certification (see below). The schedules of some 120 (mostly triplicate) samples is presented in the respective reports of MBS and CCCD that accompany this document. Sampling was done on seeds, crude oil, refined oil and cake, also some other extracts.

CCCD provided a Research Assistant, John Kamanula[93], to assist production monitoring and verify the manner of preparation of samples. He is in an excellent position to provide 'project continuity'[94] with support from Dr John Saka.

12.2.4 Lessons and challenges from Production Trials

Much was learnt over the initial 5 weeks of *Stage 1* and the observations and initiative of the team at KOR led to modifications to approach and technology that were incorporated into 2 further weeks' work. The preliminary report from MIRTDC (see Dossier), which included remarks on the lack of uniformity of cage bar spacing, influenced BCA investigations on how to improve ram press performance with tree seeds.

Inevitably there were teething problems in starting the trials. These included inadequate output of sample material in some cases, e.g. too little crude oil produced from the very small amount of seeds. In such cases only one sample was prepared and sent to one institution. In addition, there were occasions of oversight on the part of the researchers to separate each seed batch into a sample of 5 - 10 kg (purely for laboratory solvent/soxhlet extraction of oil) from the balance intended for the ram press and aqueous floatation oil extraction trials.

There were some batch tracking difficulties, i.e. in relating the oil refined to the amount of seed processed since part of the crude oil from a particular amount of seed was withheld from refining and sent out as samples for assay. However, although some data were lost, economic profiles included at Annex 8, Volume 2 cover actual measurements taken.

12.2.5 Producers Request a Motorized Expeller

By April, KOR's proprietors (principally interested in groundnut oil extraction) were agitating to start trials with a motorized expeller. MAFE agreed to investigate possible sources (see Sundhara report in *Dossier*).

12.2.6 Delays in Getting Results and Deferral of Purchase Decisions

In July 2001, detailed results of analysis by CCCD on the tree seed product samples were awaited, overseas laboratories had not yet been 'instructed', detailed market research and market probing had not yet started *and* comprehensive economic analysis still had to be completed. The results of these various strands of investigation would be needed *before* a decision could be made on the commercial potential of the oils (and thus the economics of using expellers). It was therefore agreed at the Stakeholders' Review (25/07/01) that decisions on purchase of an

[93] Mr Kamanula has the additional advantage of being Sena-fluent.
[94] Dr Henry is taking up a one-year Fulbright Resident Tutor Scholarship at the University of Alabama in August 2002.

expeller for demonstration purposes would need to be deferred until late 2001 or early 2002 when the results of all the investigations were known and pooled.

12.3 Social Factors in MAFE Small Scale Oil Production

12.3.1 <u>The family and its business associates</u>

KOR is a family venture that employs all members of an extended family according to need. There are direct financial returns to the children who work outside school hours at specific or peak periods. Most of the income from the enterprise goes directly into general sustenance of the extended family, to include groceries, school fees, clothes, medicines, etc. Each child has a specific area of expertise although generally they can also do other work. One child has carried out (secret) applied research into formulation of poutry feeds from tree seed presscakes, with some success.

12.3.2 <u>Peer groups and training offered</u>

There are a number of women friends of the proprietor of KOR who are involved in oil production of KOR, particularly the defruiting and seed dehusking/winnowing stages which need more labour (see below). Formal payments like MK150 – 200 per person are sometimes given after working for 2 to 4 days (K50 – 70/person day). The character of the activities is more social than business and includes shared meals. There are no contracts for targets and no specified piecework payment. In certain cases this has bred minor disputes.

Sometimes agreement is reached between KOR and ‘employees’ where payment would be in kind rather than cash. An example of such cases is a woman who has been trained in oil extraction by simply offering her services to KOR in return.

For the last 5 years KOR has provided training in ram press operation to various communities in Central and Southern Malawi through arrangement with IEF, EDETA and other organizations. Usually groundnut is the raw material. Often Mr Cosmas Chigwe has been involved.

12.3.3 <u>Linguistic Barriers, Traditional Beliefs and Taboos</u>

Sometimes Chichewe does not serve all communication purposes. Program R&D has taken the partners to Tumbuka speaking communities in Mzimba North and Sena speakers in the far South. When working in such areas it is advisable to work with and through speakers of the local language.

There is a belief that Castor oil can be produced traditionally using only an earthen pot. In this method the ground castor seeds are boiled until oil sits on top of the castor material and the oil is separated by continuously dipping a chicken feather (which repels water) to absorb oil which is dripped into a receiving jar. But, clearly KOR is able to extract oil using other utensils.

Although the vegetable uses of Moringa are well-known, uptake of the initiative of IEF to promote Moringa oil extraction has not properly taken off. As suggested in Section 9.8 and Section 12.4 below, the ratio of very high effort to low output and low (oil) nutritional benefit is the likely cause.

After carrying out a preliminary field visit and seed collection, MAFE has not completed in-depth investigation of *traditional uses (including witchcraft)* and management of Natal Mahogany. This work needs to be done mostly in Karonga and should be compared with information from Mozambique (Macucule, A. personal communication).

12.4 Methods and Labor Required

A detailed Narrative of events is set out in Annex 7, Volume 2.

This Section summarizes the events and the observations. A diary of respective activities and persons involved is presented at Annex 7, Volume2.

12.4.1 Technology and production system

Established extraction technologies, including ram pressing, and their characteristics and constraints were discussed in Chapter 11. Subsections of Chapter 11 describe design/configuration flaws in ram presses and expellers used by MAFE and its partners. They also report on the progress achieved by BCA in addressing identified constraints and describe unresolved challenges - such as problems with motorized expelling of Natal Mahogany. Full details are set out in the BCA Reports in the *Dossier*.

12.4.2 Special characteristics of KOR operations

KOR has been involved in ram pressing for 6 years and, unlike many families/communities in Southern Malawi who have acquired presses, the KOR family works its press regularly throughout the year. MAFE has not succeeded in finding a small-scale partner who works a ram press on a full-time basis, although Northern communities such as those assisted by PI are thought to be active. There are numerous groups who work presses seasonally.

All the operators of the KOR press are necessarily physically fit and have developed an appropriate, economical 'stroke' technique.

KOR was an ideal private sector, village-based partner for MAFE's initial MEP experiments and the only processor met that used its press in all seasons.

12.4.3 Aqueous extraction method

KOR introduced MAFE to aqueous extraction of oilseeds. After shelling by pestle and mortar, and winnowing, kernels are pounded to a flour and then gently simmered in boiling water for 2 to 3 days. Evaporation requires that water be topped up from time to time.

Under trial a Moringa kernel flour[95] sample (28.3 kg) yielded 19.1% refined oil extraction (5.4 kg) which, although not matching 14.7% achieved from *whole seeds* by Sundhara Sayari, exceeded all performances achieved with unimproved ram presses. The oil produced by this method tends to have relatively low free fatty acids, through these contaminants dissolving in the water. The method prompts suggestion (Pratt, J.H.) of investigating *diffuser* technology.

Disadvantages of this method include:

> High dependence on forest-based fuel: recorded charcoal consumption was approximately 4.4 kg[96] for every litre of refined oil produced;
>
> Possible denaturing of natural anti-oxidants that does not arise with cold-pressing (unless high refining temperatures are applied);

[95] 56% of whole seeds, so effective aqueous extraction yield on whole seeds was 10.7%.
[96] The Lilongwe urban price of charcoal is about K300/sack of some 30 kg (July 2002) so 'aqueous' production of 1 kg of oil consumes nearly 5 kg of charcoal costing some K50. It involves some supervision.

Possible solutions that could be examined are:

- *As already tried by KOR, substitution of charcoal/firewood by fossil fuel, and*
- *Vacuum vessel boiling: low-temperature aqueous extraction.*

At MAFE's request KOR began to use bottled cooking gas in refining[97] but KOR kept no records of gas consumption. This work needs to be repeated.

An advantage of this method is its suitability to be done concurrently with other household activities since – if located in a safe and secure place - only spot-checking of the process is required. In contrast, using a ram press is a full-time activity. Labour cost (Section 12.5) for manual extraction (K10/hr indicated) is calculated at about K60/kg and seems to match the overall cost of aqueous extraction. Including returns to wood gatherers, charcoal burners and respective transporters, overall *returns to labor* of both methods may be the same.

Manual pressing is an environmentally benign activity while the aqueous method (at 3 kg wood for 1 kg charcoal) uses forest timber at the rate of about 15 kg wood for every 1 kg of oil produced and should be discouraged.

12.4.4 Seed preparation

12.4.4.1 Drying

Groundnuts are purchased pre-shelled but often need several days' sun-drying to bring moisture down to acceptable levels. Sometimes they are adulterated with water by vendors. Wet nuts will not compress adequately; they extrude through cage bars.

Natal Mahogany seed harvesting usually coincides with the height of the rainy season. While this is acceptable for *aril aqueous rubbing*, it makes for difficulty in drying of the aril-extracted seed for oil extraction. Further work is required to determine the feasibility of high-volume drying (sun radiation or other methods) of this seed, also Neem, for oil extraction. Due to collection and shipment during the rains, none of the Natal Mahogany seed samples used in MAFE trials was mould-free. However, Grundy and Campbell (1993) reported that mould was not a serious impediment to using Natal Mahogany for production of soapstock.

12.4.4.2 Shelling

All extraction methods employed by KOR on *sun-dried* tree seeds required shelling, typically using a pestle and mortar followed by winnowing of (lightweight) shells from a shallow basket/tray. Before the experimentation of BCA, KOR was maximizing the shelling process to leave virtually shell-free kernels. BCA's recommendations suggest that part-shelling is more productive, and less labor intensive.

[97] This costs K116/kg from BOC Gases (16/11/2001).

EDETA's records of labour usage for manual (pestle & mortar) seed shelling with 100% winnowing indicate the following:

Seed	Person hours/kg seed		Person hours/kg winnowed mix
Moringa (1)	0.19		0.36
Moringa (2)	0.10	(large batch of 146.8 kg)	0.17
Moringa (3)	0.30		0.54
Moringa (4)	0.07		0.12
Jatropha	no data (kernel yield was 80.9% of seed)		
Natal Mahogany[98]	0.12		0.16
Dry Neem fruits	0.19		0.51
Manketti	2.74	(extraction of kernel from fruit)	33.3[99] (kernels only)

It is thought that for a part-shelled *'mix'* of Moringa as recommended by BCA, the pestle & mortar/winnowing process could be reduced to around 0.11 person hours/kg (i.e. 0.09 person hours/kg whole seed).

12.4.4.3 Effects of depodding /shelling on existing domestic workload

Depodding / shelling fitted well in the every day activities since most of this work was done by less busy persons – children, outside school hours.

Owing to the nature of the task, there was increased interaction between individuals during dehusking. This was because this stage is best done as a team which becomes a forum for some discussions.

For Natal Mahogany the precise traditional seed pre-treatment method and the uses to which the kernels are put need to be ascertained since the seed shell is poisonous. Uses of the shell need to be determined.

12.4.4.4 Pre-heating

Pre-heating is required to improve oil release from the kernel, typically in industry at some 60°C (Gondwe, K. & Taulo, J. personal communication). KOR applies this by heating seeds with charcoal (or gas) either by stirring in a shallow pan or by bathing a kernel pan in a simmering water 'jacket'. The latter avoids the risk of scorching.

During trials, before the purchase of a probe thermometer, several batches of dry-heated kernels/seeds were overheated. This can be avoided by experience and specially by ensuring that one person always takes full-time charge of the process.

EDETA recorded typical dry-heated kernel/seed temperature reaching up to 101°C (too hot), with 50 – 80 °C being 'normal'.

The Sundhara mechanical expeller does not require seed preheating since, typically after one hour's operation it has generated its own heat by friction – possibly too much heat in the case of Moringa.

[98] Natal Mahogany hand-shelling required much more time (we doubt the accuracy of the "recorded" figure: 2.65 person hours/kg).

[99] R&D into rapid fruit splitting methods is required; KOR developed a quicker method than the inverted-axe method of the suppliers.

Typical labor usage recorded by EDETA from trials with a hand-held dry-heating pan ranged from a minimum of 0.06 person hours/kg of mix to 0.32 person hours/kg, with several samples in the range of 0.10 - 0.14.

For planning purposes it is suggested that a pre-heating output of 7 kg of mix/person hour (0.14 person hours/kg mix) is taken. On the projection for ram press throughput for Moringa (6.5 kg of mixture/hour), this implies that one ram press could require one full-time person to preheat the material that is processed. The tasks of press operation (tiring) and preheating (relaxed) can thus be shared by alternating between two persons.

In a multiple press production facility, seed pre-heating could be centralised possibly using a number of immersion pans in a single 'boiler' or by a using a direct-heated continuous flow system. Valmore and Hua Feng might be able to give advice on a suitable system.

12.4.5 Extraction

Compared with Groundnuts, all the tree seed samples required more pressing effort/kg of oil output. Moringa however initially required less effort/input kg. This probably reflected incorrect setting of the cone or inefficiency of the press but there was also occasional clogging of the press.

A replicated statistical trial was not undertaken at KOR (BCA trials however involved 3 replicates). Pressing labor inputs were recorded as follows:

Seed	Person hours/input kg mix or seed		Person hours/kg crude oil
Groundnut (local)	0.25	kernels	1.30
Groundnut (CG7)	0.22	kernels	0.97
Moringa (1)	0.17	mix	2.43
Moringa (2)	0.13	(large batch of 82.5 kg of mix)	1.44[100]
Moringa (3)	0.20	mix	3.55
Moringa (4)	Floatation: n.a.		
Jatropha	0.29	(large batch of 113.65 kg of mix)	1.71
Natal Mahogany (1)	0.21	(unshelled)	1.27
Natal Mahogany (2)	0.69	(pounded, shelled)	3.67
Natal Mahogany (3)	0.32	(hand-shelled)	2.57
Manketti	0.36	(kernel)	1.98
Neem	0.33	seeds in shell	4.74

MAFE concluded that in the case of Moringa probably a press operator output of some 1.7 person hours/kg crude oil would be feasible.

12.4.6 Labor requirements for ram pressing systems

Further work was planned for late 2001 to accurately determine benchmark input and output data/unit of labor effort for commercial pressing of tree seeds. MAFE has tentatively relied on the BCA press data (0.6 kg crude oil/hour from 6.5 kg of pressing mixture) for planning purposes.

[100] A maximum production rate of 0.6 kg crude oil/hour, i.e. 1.66 person hours/ kg crude oil, was achieved in commissioning trials of the Bunda College cylinder-cage ram press. A higher labor requirement was recorded under the College's own experiments but this is attributed to inexperience.

Taken with existing methods of seed preparation and winnowing the foregoing observations imply that the typical labor requirement for producing 1 kg of crude Moringa oil (at 9% extraction from 11 kg of mixture) could be:

	Person hours
Shelling	1.2
Pre-heating	1.6
Extraction	1.7
TOTAL	4.5

To this figure should be added set-up and equipment cleaning time. All of these processes might thus require 5 or 6 person hours of work/kg of crude oil produced.

Moringa
For Moringa, 1 kg of crude oil is conservatively estimated to require collection of some 17 kg of whole seeds. Labor required for harvesting and depodding/defruiting of this quantity could amount to at least one person day, possibly more. We have used a collection/depodding rate of 12 kg per person day in our calculations (see also Footnotes to Section 10.7.1, where 14 kg/person day is indicated for Tanzania)

The total labor requirement from harvesting through to crude oil production could thus be about two person days/kg crude oil[101].

Labor requirements for production of Jatropha and Trichilia oils (if seeds are shelled by pounding and winnowing) are expected to be lower.

Groundnuts
Labor requirements for processing of groundnuts are significantly lower. No shelling is needed and pressing labor needed is not more than 1.3 person hours/kg crude oil. Overall, processing of groundnuts probably requires in the region of 2.5 to 3 person hours/kg crude oil.

[101] The plans at Annex 11, Volume 2 to produce a batch sample of 400 litres of filtered crude Moringa oil over a period of 6 weeks (5-day week) implied that this would require some 6 tonnes of seeds and up to some 800 person days of labor, i.e. the equivalent of 27 persons working on a full-time basis, and the operation of at least 4 ram presses.

12.5 Economic Analysis of Stage 1 Trials

12.5.1 <u>Production economics</u>

Annex 8, Volume 2 presents spreadsheets of analysis of input-output data from the trials as follows:

<u>Groundnuts</u>

Local Groundnut 2000:	refined oil (& butter)
CG7 Groundnut 2000:	refined oil (& butter)

<u>Moringa</u> (dehusked by pounding)

Salima 2000:	refined oil
Salima 1997:	refined oil
Chikwawa 2000:	refined oil (sample not tested due to scorching)
Salima 1997 aqueous floatation:	*refined oil*

With CAMARTEC Ram Press at Bunda College of Agriculture

Moringa Salima 1997:	*crude oil from unmodified bar cage*
	crude oil from cylinder cage with 3.2 mm perforations
	crude oil from cylinder cage with 2.5 mm perforations
	crude oil from cylinder cage with 1.5 mm perforations

<u>Jatropha</u>

Jatropha 2000:	crude oil

<u>Natal Mahogany</u>

Karonga 2001 unshelled:	refined oil
Karonga 2001 shelled (pounding):	refined oil
Karonga 2001 hand-shelled:	refined oil

<u>Manketti</u>

Manketti 2001:	refined oil (*in Bolero*)

<u>Neem</u>

Neem 2000:	crude oil

Sunflower 1996 aqueous floatation refined oil

For Sundhara Sayari Expeller in Tanzania: see Bunda College of Agriculture report in the *Dossier*

12.5.2 <u>Kernel/seed extraction ratios</u>

The following extraction ratios were achieved:

Table 13: Kernel Extraction Rates (%) For Various Seeds against extraction methods

SEED	EXTRACTION METHOD	
	POUNDING & WINNOWING	HANDSHELLING
Moringa (Salima 2000)	52.94	
Moringa (Salima 1997)	56.12	
Moringa (Chikwawa 2000)	56.47	
Jatropha	80.87	
Natal Mahogany	80	62.5
Manketti	Not applicable	8.2[102]
Groundnuts	Supplied shelled: 100	Not applicable
Neem	32	

12.5.3 <u>Seed procurement considerations</u>

For all of the seeds the kernel extraction rate is low enough to warrant consideration by processors to purchase shelled seed, i.e. at a slightly higher cost than to buy the bulky unshelled seed. This reduces transport costs as well as processor's labor costs. Moreover this would add value to the seed, meaning more money to the farmer. If processing is organized away from seed production sites, this arrangement could be specially important in more remote seed production sites. Empirical research of this topic is required along the lines proposed by international Moringa specialists in Table 11 under the sub-heading *Processing Technologies*.

[102] During the shelling process, an inverted axe and a hammer were used to crack the Manketti fruits that contained the kernels. The percentage indicated <u>is percentage of whole fruit</u>.

12.5.4 Summary of crude oil yields

Yields are presented below:

Table 14: Crude oil yield (% of kernels) obtained from ram press

Species	Moringa (see note below)			Jatro-pha	Natal Mahog-any[103]	Manketti	Groun-dnuts (CG7)	Groun-dnuts (local)	Neem
Provena-nce:	Chikwawa 2000	Salima 2000	Salima 1997						
Oil%	5.48	6.80	9.16	16.79	18.75	18.31	22.7	19.6	7

N.B. For Pajaroya 2000 Moringa whole seeds (Tanzania), the Sundhara Sayari expeller gave a maximum sustained extraction of 14.7% crude oil from whole seeds, equivalent (at 56% kernels) to *26 % crude oil from kernels* (see Dossier).

12.5.5 Lessons learnt

Data have been collected in several stages during the MEP. The presentations below include data collected during the Stage 1 production trials, additional data generated in partnership with Bunda College up to 30/09/01 and modifications made in 2002 on the basis of further experience. The following conclusions can be drawn in respect of Moringa:

12.5.5.1 Processing Labor

Projected labor utilization is: Person hours/kg crude oil

Sundhara Sayari motorized expeller	0.5
Bunda College ram press	5 - 6

12.5.5.2 Equipment Costs (Capital Repayment) Over Projected Life

Costs excluding fuel and lubricants, where applicable: K/kg crude oil

Sundhara Sayari motorized expeller	20
Imported ram press	14
Bunda College ram press	7

[103] In one trial at KOR with undecorticated Trichilia/Natal Mahogany seeds, a crude oil yield of 16.67% was achieved. The trials with the Sayari Sundhara on this species in Tanzania ran out of time and were inconclusive.

12.5.5.3 Projected Operating, Capital Repayment and Seed Cost of Crude Oil

	Total cost K/kg crude oil
a. ***Sundhara Sayari motorized expeller*** (see Dossier) at 14% extraction on whole seeds bought in at K15/kg	
(100% dedicated to Sunflower, all-year at 25% extraction	*67)*
100% dedicated to Moringa, 6 months annually at 14% extraction	160
b. ***November 2001 Projection for Manual System:*** Moringa, at 6% extraction on whole seeds costing K6/kg, with actual extraction 9% on part-decorticated seeds:	
Imported ram press	184
Bunda College ram press[104]	177
c. ***Revised projection, July 2002 for Manual System:*** Moringa, at 6% extraction on whole seeds (oil ratio 1:17) costing K12/kg[105], with actual extraction 9% on part-decorticated seeds:	
Imported ram press	278 ($3.70)
Bunda College ram press	271 ($3.60)

12.5.6 <u>Overall Results of Economic Analysis</u>

Experience gained in late 2001 and early 2002 with BCMMORA enabled the opportunity cost of Moringa seeds to be realistically determined. Including an allowance for transport costs at about 15%, whole seeds can be bought for about K12/kg ($0.16/kg), cash-on-delivery. This may be one half of the prevailing price for Moringa seeds in Tanzania but clearly is attractive for several communities.

This then enables presentation of a like-for-like comparison of Moringa oil productivity of the two mechanical extraction systems[106] studied:

[104] Processing at 6 person hours/kg oil priced at, say, K10/hour = K60. Seed collection and de-podding estimated at 11 person hours: K110; Press capital repayment: K7/kg. Total: K177. Purchasing of seed at an effective cost of more than K6/kg increases costs proportionally.
[105] This price appeared to be feasible on a larger procurement scale as demonstrated by BCMMORA.
[106] For commercial planning purposes a seed/crude oil ratio of 1:17 has been taken.

Table 15: Overall Comparison of Productivity of Mechanical Production Systems and Total Labor Required

Extraction System:	**Ram Press (*Bunda* design)**	***Sundhara Sayari* Expeller**
Total cost/kg crude oil (seed, operating and capital repayment) before management charges	**K280/kg ($3.70/kg)**	**around K180/kg ($2.40/kg)**
Capital cost of machine	**K10,000 ($135)**	**K375,000 ($5,000) approx.**
Seed processed/hour	**8.5 kg**	**28 kg**
Crude oil output/hour	**0.5 kg**	**4.0 kg**
Ratio of oil: seed by weight	**1:17**	**1:7**
No. of presses to equal expeller output	**8 these will process 68 kg of seeds/hour**	
Cost of 8 presses:	**K80,000 i.e. less than 25 % of expeller capital cost**	
Extraction efficiency relative to expeller:	**41% i.e. most *extractable* oil stays in the seedcake**	
Technical sophistication, need for periodic maintenance; risk of mechanical failure	**Very low**	**Very high**
Equipped for the same oil output, what is the output when one machine fails?	**87%**	**NIL**
Labour required (all processing operations) for 4 kg crude oil/hour	**40 – 48 persons**	**2 expeller operators**
Whole seeds required/hour	**68 kg**	**28 kg**
Anticipated number of full-time harvesters required to sustain this output (to be verified) at 7 working hours/day & 1.7 kg/harvester/hour	**40 persons**	**17 persons**
Total direct labor required to sustain output at 4 kg crude oil/hour	**80 - 88**	**19**
Total person hours/kg crude oil	**21 approx.**	**5 approx.**

12.5.7 Conclusions for Application (Moringa oil)

The following conclusions were drawn by the partners in November, 2001 and circulated in the respective draft Mid-Phase Report:

- In an enterprise dependent upon oil as the sole marketable output, the oil extraction ratio is critical to profitability. The ratio is much less critical where presscake also has a market.

- Cost of seed procurement is THE major determinant of oil production costs.

- Where capital is not limiting and the supply of seeds is assured, the cost of oil extraction equipment is not a major factor in determining the viability of Moringa oil production.

- Motorized expelling captures at least double[107] the amount of oil that can be extracted by ram pressing.

- Although it requires skilled operatives, motorized extraction requires about one twentieth of the personnel in manual systems. This possibly offers simpler management and, for season-dependent work, less risk associated with casual labor recruitment.

- Ignoring (*partly verified in 2002)* quality factors attributable to extraction methods, oil extraction on ram presses is not financially competitive with motorized expelling *if seed raw material is priced at the same level*.

- Financial viability of oil extraction by ram press will depend upon seed acquisition costs being 'negotiated' below the price which (potential) commercial expeller operators will be willing to pay.

- In a free market, expeller operators (with machines correctly configured for Moringa) would probably be in a position to provide rural producers with more value added at the farm from purchasing their seeds than the producers themselves could generate from owning and operating ram presses.

- Expeller operators need to be fully supplied (with Moringa seeds) to recover their investment in plant and equipment or alternatively should also handle traditional oilseeds, especially sunflower, to obtain adequate plant utilization.

Seed transport costs have not been investigated but are thought to make no material difference to these conclusions.

At July 2002, further experience has reinforced these conclusions.

[107] This statement is partly applicable to Jatropha but BCMMORA/MAFE trials suggested it is not applicable to Natal Mahogany; however BTP has successfully expelled Natal Mahogany.

13 CHEMISTS' RECOMMENDATIONS: CCCD

13.1 General Remarks

The CCCD Report highlights limitations of laboratory capacity in Malawi and frustrations from unexpected campus disruptions and poor access to computing facilities.

At Chapter 14 of its report, CCCD persists with its 2001 recommendation for comprehensive bio-chemical analysis of the selected tree seeds, suggesting that this be included under appropriate postgraduate research.

Scholarly publications (i.e. for *Journals*) are being prepared as follows:

- ?? **Aqueous extraction of oil from seeds of *Moringa oleifera;***
- ?? **Preliminary characterizationof oil from seeds of *Sterculia africana;***
- ?? **Phytochemical screening of some Malawian tree seeds;**
- ?? **Characterization of oil from seeds of *Schinziophyton rautanenii;* and**
- ?? **Characterization of oil from the seed kernel of *Trichilia emetica.***

CCCD provides recommendations for improving seed pre-treatment before oil pressing and means of improving oil quality (Chapter 12) and explains (Chapter 11) what steps should be taken if the market required seed oils to be *refined* before export.

13.2 Specific recommendations

The following were submitted:
"

a. Immediate application of the results of MAFE/CCCD/EDETA research to peri-urban and rural development by arranging training of *small-scale* oil producers. The training must include *social organization* and *quality control.*

b. Collaboration between EDETA and CCCD on a *total quality management system* for small-scale oil producers to ensure their product meets the *buyer's specifications*.

c. Further study of the *aqueous extraction of Moringa oil* and in particular the detailed chemical composition of the oil for comparison with other methods.

d. Investigation of *Manketti oil* for *modified atmosphere packaging* (MAP) and *anti-tumour activity.*

e. Study of the variation of the quantity and quality of *conjugated linolenic acids* (CLNs) of Manketti provenances.

f. Study of the chemical constituents and of the seed and seed coats of *Trichilia emetica*: Headspace gas chromatography of the seeds show release of hydrigen cyanide and acetonitrile, CH_3CN on heating. The seeds reportedly are used as a mosquito repellent. The seeds and seed coats should be investigated for potential pharmaceutical products.

g. Investigation of the nutritional values of the milky extract of *Trichilia emetica arils* reportedly eaten with spinach.

h. Uses and chemical composition of various seed coats.

i. Publication of scientific and socio-economic aspects of the commercialization of the tree seed oils in Journals such as *Economic Botany* that specialize in *disseminating holistic information linking the scientific and socio-economic aspects of plants* so that international development stakeholders can benefit from the information.

j. Exploitation of the *leaf proteins* of *Moringa oleifera* to alleviate protein deficiency and other nutritional problems of vulnerable groups such as young children and lactating mothers as has been done in other countries.

k. Investigation of the *barriers* to establishment of *quality analytical services* in *the University of Malawi* for local analysis of Malawi's natural resources, including

?? **governance,**

?? **institutional recognition of the technical profession and reward for technical expertise and**

?? **qualifications such as a *technician's diploma,***

?? **good laboratory management,**

?? ***quality assurance* (QA) programs including back-to-back partnerships with other *reference laboratories* and covering other *total quality management* (TQM) issues.**

l. Collaboration with WSU on investigating the chemical and pharmaceutical properties of these and other oil seeds. Malawi would benefit from the expertise and equipment of WSU, and WSU academics would benefit from original natural resources developmental and environmental research.

m .*Capacity building* in Malawi in the important specializations of *food science* and *food processing* especially in *lipids* by supporting *postgraduate training* of students, involving *split programs* between University of Malawi, *University of Botswana* and WSU. Such programs would help alleviate Malawi's many recurring *severe nutritional problems*, heavy dependence on natural resources and limited human and institutional capacity in these important specializations.

n. Institutional support and linkages with WSU for the University of Malawi *Natural Resources and Environment Center* (NAREC) in sustainable utilization of Malawi's natural resources such as *indigenous foods* and *herbal medicines.* Such linkages could involve students from WSU being attached to the Center for *short and long-term research projects*.

o. Collaboration of the Chemistry and Physics Department s of Chancellor College with the Agricultural Engineering Department of our sister college, Bunda.

"

PART IV: CONCLUSIONS AND RECOMMENDATIONS

14 VALIDATION OF EXPERIENCES AND IDENTIFIED POTENTIAL

14.1 Main Tasks

The principal MEP task under the Scope of Work was to **"identify products from natural resources management practices and natural woodlands that demonstrate high potential for *commercial production and marketing* in Malawi, with special emphasis on non-wood and non-food products."**

The last major MEP task set in the 2001 – 02 Annual Workplan was as follows:

- **Small-scale investment planning:** Develop one or more plans[108] *appropriate to specific localities* for management, investment, start-up and operation of pilot production, processing and marketing of *two or more products*, determining the resources required, and the manner of their procurement and commitment.

Extent of fulfilment
The MEP partners have developed two plans for the pilot commercialization of *one product*. Several other possible products may be identified by further research but none is yet ready for commercial launch.

The partners have met the agreed objective (*stated in the draft Mid-Phase Report*) of acquiring enough market intelligence and knowledge of physical and financial feasibility for Moringa oil production for export to determine that under Malawi conditions it can, without ascribing a value to any by-product, be a viable business.

14.2 Subsistence Considerations

Owing to the Scope of Work, investigation of subsistence uses was initially given little attention. But, consideration of subsistence and the related importance of trees to food security eventually came into the program after nine months, i.e. in June 2001, when detailed product/species selection criteria were agreed at the WSU/USDA/USAID Washington Meeting.

14.3 Infant Markets

The Scope of Work implied that that the principal challenge would be to *identify suitable* natural resource-based *products* in Malawi to exploit local or international markets that already existed. MAFE investigations revealed that there were few established markets for the respective plant species and products under consideration and this observation was reinforced by the conclusions of the USDA/USAID Review of Current Knowledge.

[108] Include in each plan guidelines for determination of crop ripeness, harvesting methods, post-harvest handling, and respective storage procedures for each type of product.

14.4 Species and their uses

Agroforestry species cited in the Scope of Work as warranting special attention were:

Neem *(Azadirachta indica)*,Jatropha *(Jatropha curcas)*, Moringa *(Moringa oleifera)*,Tephrosia *(Tephrosia vogelii)*, and Jujube *(Ziziphus mauritiana)*. As agreed with LRCD, work on Jujube and other indigenous fruit species was soon 'delegated' to SADC-ICRAF. The initial strategy of the program was to collate all available information on the other indicated species and to seek advice from local and international sources/potential partners on what *commercial potential* they might have.

Internet searching got underway upon the arrival of a suitable computer in December 2001, two months after the start of the program. It has contributed appreciably to the knowledge built up by the MEP partnership.

One of the best uses of Neem is as a source of wood in subsistence especially for burning. Indicated by other organizations to be relatively localized and not significantly commercialized, this species was given low priority in MEP investigations.

Apart from use as a living fence, Moringa was best known as a subsistence food crop but previous research suggested that it had commercial potential in several respects.

On the advice of MAFE Field Assistants, wild species from *natural woodlands* such as African Star Chestnut *(Sterculia africana*), Manketti *(Schinziophyton rautanenii)* and Natal Mahogany *(Trichilia emetica)* became a second theme of investigation from March 2001 onwards, several months after the foregoing species. *Poorly documented*, all three of these species have been found to require empirical, pure research and then, if promising from a commercial perspective, a period of adaptive research into feasible means of extracting their products. It has already been demonstrated that it is technically feasible to extract oils from both African Star Chestnut and Natal Mahogany.

Although not in the initial 'menu' of species, Marula *(Sclerocarya birrea)* became a target of general investigation during the formulation of the USDA/USAID regional market study. Excepting a reported kitchen-based extraction[109], no experience has yet been gained in Malawi of extracting Marula oil. MAFE has no experience of oil extraction from this species.

14.5 Effectiveness of the MEP Partners

All of the production and nearly all of the technical results achieved by the program are attributable to MAFE's local collaboration partners. For a MAFE outlay of some $30,000 they have provided very good 'value'. MAFE's contribution has been mostly in market assessments, economic analysis/feasibility determination and program coordination.

The promptness of delivery of inputs and results by EDETA, KOR, BCA and MBS was excellent. Some institutions that were expected to take a strong interest in collaboration withdrew due to either staff or funding constraints. Blantyre Polytechnic could not participate because of key staff being away on study leave. One of its former water engineers[110] was traced to Northern Water Board. CCCD suffered from over-commitment of its teaching staff and some

[109] R. Hartley, personal communication.
[110] Mr Anderson Mtwali

campus disruptions. Future work could include drawing on the analytical capacity of Chancellor College Department of Economics (Ngwira, N[111]. personal communication).

The principal *strengths of the current MEP partnership* and *MAFE's wider partnership* lie in:

a. Adaptive research, development and practical use of oil extraction technologies for tree seeds, suited to small and medium scale use;
b. development of empirical economic analysis of the supply chain from farm through to sale of final product;
c. guidance for preparation of business plans and preparation of respective financing plans;
d. product characterization and supervision of quality control (see h. & j. below);
e. assistance to mobilization of producers in rural areas, building of trust between producer and processor and respective project implementation;
f. with NGO and other partners, extension support to promotion of new planting of (proven) commercial species and supply of germplasm.
g. real-time market intelligence and dissemination of respective information;
h. development of products to the specification demanded by the marketplace;
i. assistance to market probing and building of confidence between processor and buyer; and
j. support, as necessary, to compliance with market regulatory/safety procedures and product certification.

14.6 Overseas service providers

SCRI-LAU gave very prompt analytical services at a reasonable price. LFRA fulfilled its contractual obligations but, excepting the idea for food machinery lubricants, did not volunteer any commercial hunches although it is known to have serviced Southern Africa Marula oil exporters.

14.7 Potential Identified

14.7.1 <u>Commercial potential</u>

The range of identified established *non-wood and non-food commercial products* that the foregoing species could supply to satisfy international markets was as follows:

Cosmetic oils from Marula and Moringa
Soap oils, Medicinal extracts and pesticides/antifeedents from Neem

Food uses identified[112] were:

Vegetable pods and, possibly, processed leaves of Moringa

14.7.2 <u>The special attributes of Moringa</u>

Literature and advice from previous workers in Malawi and elsewhere all beckoned establishment of an R&D program to determine whether Moringa oil from trees on Malawi farms could meet international standards at the right cost of production. An international market for the oil has been found at a price in the region of K600/kg ($8/kg), moreover a supplier from within the region cannot satisfy demand. Locally, Malawi Pharmacies Ltd (Annex 5, Volume 2) may be able to use raw or degummed Moringa oil as an olive oil (K400/kg; $5.30/kg) substitute. The partnership settled on Moringa oil as the principal target product from on-farm species. It

[111] e-mail: economics@chanco.unima.mw ; naomingwira@yahoo.com
[112] Excluded from the MEP Scope of Work.

was the only product to complete a full round of R&D that, within the 18 months available, rendered it ready for commercialization.

Having set up a program of Moringa oil R&D, the partnership used its assembled resources to commence building new knowledge about the means of extracting oils from other species of interest and to get them characterized but further work is required (see CCCD Report) to determine their commercial suitability.

Moringa offers significant NRM and food security benefits[113]. It was found unrealistic to ignore the subsistence uses of Moringa when considering its potential as a source of commercial oil, especially in the poorest communities that were encountered. Subsistence/food security dependence on this species simply served to reinforce the argument for promoting it especially in the South. Two main areas of cultivation of Moringa have been identified: Lower Shire and Salima District. It also occurs throughout the Lakeshore and is found from Mangochi to Balaka.

14.7.3 <u>Immediate Potential for Project Implementation</u>

14.7.4 <u>Moringa Oil Project</u>

14.7.4.1 Manual system

The partners have determined that for small-scale producers extraction of Moringa oil by Ram Press for export is economically feasible. This appears to be the mechancial extraction system causing the least 'damage' to oil natural anti-oxidants. Crude oil can be produced to an acceptable standard ready for export sale at a cost of about K280/kg ($3.70/kg) excluding costs of packing, filtering, inspection, repacking, forwarding and management/quality control and other overheads. Oil extraction rates and profitability can probably be improved by fitting the press with the improved *Bunda Cylinder Cage*. This system has a low fixed cost, has a low physical efficiency, is labor-intensive and needs a lot of personnel and good organization. Although it does not need high levels of technical expertise it needs extremely good management and social organization. It also needs a system of seed pre-treatment that avoids scorching.

14.7.4.2 Motorised system

The partners have also determined that extraction of Moringa oil at a larger scale[114] (but in output terms still at a medium/small scale) by Sundhara Sayari Expeller is economically feasible[115]. Crude oil can be produced ready for sale at a cost of about K180/kg ($2.40/kg) excluding costs of packing, filtering, inspection, repacking, forwarding and management/quality control and other overheads[116]. The partners consider the Sundhara likely to give by far the best value of all expellers suited for Moringa. Compared with the ram pressing system, the main considerations for the Sundhara are its capital cost, technical complexity and risk of breakdown. This system can achieve indicated profitability only if seed supply can be sustained – preferably at levels enabling the plant to work continuously.

[113] Until the point when the true state of the Jatropha oil market was revealed (USDA/USAID Study) Jatropha also enjoyed R&D attention.
[114] At some 4kg oil/hour and 28 kg seeds/hour this is one seventh of the output that is suggested for 'medium scale' industrial R&D in Table 11 (Tanzania).
[115] There are still some questions over the extent to which this system denatures the natural anti-oxidants in the oil.
[116] Although it appears to be potentially more profitable than a system based on ram presses (8 ram presses have the same output as one Sundhara), this system should preferably be compared with other motorised extraction systems such as the Komet (in Tanzania) to determine its efficiency relative to capital and operating costs.

14.7.5 <u>Other potential requiring research</u>

14.7.5.1 Markets

Export specifications of Moringa oil have been obtained from a 1997 source and need to be checked.

Unfinished investigations of MAFE include:

Past and present uses of Sperm oil, respective chemistry and its implications;

Specifications of vegetable oils required in lubrication of food and drink preparation machinery and in high-temperature/high-stress lubrication applications;

Specifications of oils required in leather-making;

Commercial uses of Sterculic and Malvalic acids;

Commercial uses of Isomers of Conjugated Linolenic acid;

Demand for natural anti-oxidants (see Bibliography No. 109e.)

14.7.5.2 Empirical bio-chemical research

Manketti *(Schinziophyton rautanenii)*, African Star Chestnut *(Sterculia africana)* and Natal Mahogany *(Trichilia emetica)* contain seeds with oils and other components that can be extracted and may have commercial potential as suggested in the respective Chapter 10 Species and Products Sections and in the CCCD Report. As MAFE was unwilling to sponsor a total characterization of their seeds by LFRA, all three species require further pure research, preferably under a postgraduate research program of CCCD, ideally, as requested, in partnership with WSU and University of Botswana.

As agreed in the Mid-Phase Review in July 2001, Malawi provenances of Marula *(Sclerocarya birrea)* need to be tested for their kernel oil quality, ideally under the intended program coordinated by CRIAA, Namibia. This will indicate whether Malawi should try to join SAMOPN and avail SAMOPN technology and its regional and international market access.

It should be noted that SANProTA will probably sponsor R&D into Manketti and Baobab *(Adansonia digitata)* in the near future. Duplication with regard to Manketti research needs to be avoided.

WESM clients at Kam'wamba and in the lakeshore area may be able to supply Marula and Baobab kernels as a by-product of their other activities.

14.7.5.3 Empirical engineering research

BCA's experiments with the *Spindle Press* gave uninspiring results and the respective MEDI machine was underdesigned. Before discounting this type of press, other manual screw-operated and hydraulic presses should be investigated, specially in Namibia's Marula oil industry.

First-hand experience should be gained of Komet and other small-scale motorised expellerrs.

14.8 Species no Longer under MAFE Consideration for Commercial Development but Still of Interest to MAFE's Partners

Optimism within the partnership about the scale of the regional Jatropha *(Jatropha curcas)* industry and the strength of the market for Jatropha oil in soap manufacture proved to be unfounded. Moreover, because of the known presence of certain toxins, formal checks need to be run to determine whether this oil is safe to human health. University of Hohenheim, Germany has some experience in this field.

Neem *(Azadirachta indica)* and Tephrosia *(Tephrosia vogelii)* both contain principles with medicinal and pesticide possibilities. Much further research is required to determine their local suitability for commercialization. Such work was beyond the reach of MAFE. These species present a number subsistence pesticide/anti-feedent and traditional medicinal uses that might be promoted. More information is required and could be accessible from literature and from ADDs. Neem can definitely be promoted as a woodlot species for firewood and for crop storage. Within Malawi, MEP and FRIM investigations identified a relatively high cost of neem seeds for processing and the conflict of harvesting and seed drying with the rainy season. Much new work would be required to determine the economics of local neem oil extraction for commercial use.

Investigations of WSU's Linda Robison (Annex 2, Volume 2) revealed limited use of plant materials for medicinal and pesticide products from all the above species and, as asserted by MAFE, found there was very modest formal commercialization of such products. For reasons outlined in Section 8.3 MAFE itself did not pursue investigation of medicinal products.

14.9 Publishing Results

Both BCA and CCCD respectively need to publish in respective subject matter Journals the results of their own pioneering research accomplished during (and in some cases before) the MEP, particularly:

Bunda Ram Press perforated cylinder;
Reconfiguration of the Sundhara Sayari expeller for *Moringa oleifera*;

Vaccenic acid in *Moringa oleifera* and its commercial significance;
Aqueous oil extracts of tree seeds;
Characterization of oil from seeds of *Schinziophyton rautanenii;*
Characterization of *Sterculia africana* oil.

15 KEY RECOMMENDATIONS AND SUGGESTED STRATEGY

The identified potential falls into three distinct categories.

15.1 Immediate Potential for Project Implementation

A 'Model' pilot commercial Moringa oil production and marketing project is proposed to apply the findings under Section 14.6.4 on two sites at small and medium/small scale respectively. At a cost of some K2.4 million ($32,000), it will create 40 jobs for up to 4 months and add value to existing plant resources. Supervised by existing partners[117], it is ready to be rolled out and features capacity-building and rural income enhancement without jeopardizing subsistence/food security[118]. Moreover *seasonality of the proposed activities coincidentally gives the potential to put cash in producers' hands at a time when they may face acute scarcity of subsistence foods.*

The project is thought capable of utilizing some 50% of available raw material in the targeted areas; the raw material is abundant and has no alternative commercial use. Provided that fixed investment, raw material procurement and employment of process workers can be funded, this will immediately improve rural livelihoods, build producer capacity and empower producer groups. It is considered an initiative eligible for support by a donor that targets rural livelihood and food security issues. The fixed investment required is far below the threshold established in the *Selection Criteria.*

Fob export revenue from the first season of production is forecast at just over K2.0 million ($27,000) from the shipment of some 4,500 kg of crude, filtered Moringa oil. The *fob value* of oil is projected at K450/kg ($6/kg), i.e. after allowing for shipment and dealer expenses. Most of the production would come from Lower Shire Valley.

Operations should start no later than September each year, making the most of the dry season. Two months' previous preparation and mobilization are recommended. The year 2002 leaves insufficient time for proper preparation. The project should start up in mid-2003.

15.1.1 <u>Pilot Production Sites</u>

15.1.1.1 Salima South

The small-scale production unit should be in a 'focus area' of Moringa that could be in parts of the Districts of Chikwawa (East or West of Shire River), Nsanje or Salima. Because of extensive previous experience of MAFE and its partners working in Salima and of producers there already being sensitized by MAFE and EDETA, it is recommended that this zone be selected for the ram pressing program. Producers in Salima estimated about 5 tonnes of seeds to be available annually. This work would need high inputs of management and social organization, preferably from EDETA.

Up to four ram presses held at the *Resource Center* are already available for the work in Salima and (see Table 16 below) are considered more than sufficient to cope with one season's forecast production in the focus area.

[117] MAFE would not be involved but overall coordination would be required.
[118] Plant resources utilized will be the residue after normal subsistence use has been completed.

15.1.1.2 Bangula, Nsanje District

The larger production unit[119], i.e. using a Sundhara Sayari expeller, should be stationed in the densest Moringa zone which is considered to be the EPAs around Bangula, Nsanje District/RDP, Lower Shire. Production could be organized either as a development project, possibly as part of an income generating initiative to help communities survive the critical season of food shortage, or as a purely commercial initiative of private enterprise, e.g. Cheetah.

The Sundhara should be ordered from Tanzania. Suitable technicians who can assist start-up and development of correct operating and maintenance procedures may be contacted through VYAHUMU: John Wariuba &/or Eliamini Kateh.

Ordering of the expeller should be made at least 3 months before operations are intended to commence to allow time for manufacture, shipment, installation and commissioning.

Complementarity, if any, with COMPASS's plans for commercialization of Marula oil in Lower Shire (Section 6.2.2) – including social organization elements for the Community Trust - needs to be ascertained.

15.1.2 Assumptions, Outputs and Costs of Implementation

Table 16 projects the costs and expected outputs of the two production programs that have been advocated.

Employment generated over the production period and the forecast cash to be received directly in the production communities (i.e. during 4 months September – December), before division of processing profits is projected as follows:

	Salima Ram Pressing Program	Bangula Expeller Program
Full-time jobs established	10	30 (excl. technicians)
Community cash earned K	94,000	468,000

Based on MAFE's recent experience, working capital is vital to sustain operations throughout the production period, i.e. before product consolidation and marketing. In particular, until the market for Moringa products becomes formally established, it is necessary *to pay cash-on-delivery for seeds*. It is therefore recommended that implementation plans be based on the provision of *working capital to sustain the entire production program*. In addition there will be a need to fund intial fixed investments.

It should be noted that this is intended essentially as a project to demonstrate the commercial viability of Moringa oil production for export. Careful coordination and program supervision are not only justified but also evidently vital in the light of recent experience of the partnership.

[119] Mr Yacubu Osman and Mr Ibrahim Osman, adjacent Bangula Transmission Station could be consulted.

Table 16: Outline Financial Projection for Pilot Moringa Oil Extraction for Export

Respective expenditure contemplated for one full season's production of 90 days (net) over 4 elapsed months up to the onset of rains is:

	Salima Ram Pressing Program	Bangula Expeller Program
	K million	K million
Direct costs/working capital	0.13	0.94
Fixed investment	0.03	0.60
Total project outlay	0.16	1.54

Project cost: K1.70 million

On the basis of experience in 2001 – 02, support services from the institutions involved are (assuming no entrepreneur comes forward to develop the Bangula program) projected tentatively by MAFE to be as follows:

Salima Ram Pressing Program	Bangula Expeller Program
K million	K million
0.27	0.40

Support services: K0.67 million

As % of total project cost: 28%

15.1.3 <u>The Proposed Project Support Team</u>

For new work to be undertaken on the two sites in the proposed manner, the following five organizations should continue collaboration, retaining the same division of responsibility as at present:

EDETA;

BCA Agricultural Engineering Department, supported by the **Resource Center**;

CCCD[120]**,** with analytical/regulatory compliance support from **Malawi Bureau of Standards** (MBS).

If an entrepreneur comes forward to take up the suggested motorized extraction program in Lower Shire Valley, involvement of existing partners there would probably be limited to supply of technical support services.

Overall project coordination has not been separately budgeted as it is hoped that EDETA could fulfil this role as part of its *Site Supervision.* At least for Salima, EDETA would have to widen its role to project management and marketing support and, if there is no interest from entrepreneurs in Lower Shire, take on project leadership and coordination in both sites. Through **EDETA**, the group could benefit considerably from information sharing arrangements with **SANProTA**.

The emerging collaboration with **USAID/USDA** and **A-SNAPP** might be included above and the partners might continue to draw on economics-and-marketing backstopping and database retrieval services of **WSUIP**.

[120] Possibly assisted by Economists from Chancellor College.

The technical and social organization partners should maintain close dialogue with the **Resource Center** keeping it briefed regularly on the stage reached in development of production systems an commercialization. The Resource Center would in turn be expected to respond with measures to support germplasm supply and promotion of new planting.

Partner support to the Moringa oil project would include implementation of CCCD's specific recommendation:
"Collaboration between EDETA and CCCD on a *total quality management system* for small-scale oil producers to ensure their product meets the *buyer's specifications*."

A collaboration agreement through CCCD with **SCRI-LAU**, or renewal of **LFRA membership** ($1,242/year 2002-03) might be considered *if laboratories in Malawi cannot be upgraded* to meet the exacting requirements of product development and quality control advocated in the accompanying CCCD Report.

The authors are confident that this project[121] is feasible.

15.1.4 Models for other oilseeds

The system that is found to be the most sustainable and profitable could provide a model for future exploitation of other tree seeds, including Marula after the respective species have gone through their own round of R&D alongthe lines indicated in Section 14.6.5.2.

15.2 Other Potential

15.3 Recommendations for Further Market Research and Market Probing

Further checks to identify the **ideal export specifications of Moringa oil** should be carried out by consulting a wide audience in the trade.

The following should be investigated internationally:

Past and present uses of **Sperm oil**, respective chemistry and its implications and opportunities for Malawi tree seeds;

Specifications of vegetable oils required in **lubrication of food and drink preparation machinery** and in **high-temperature/high-stress** lubrication applications;

Specifications of oils required in **leather-making**: implications and opportunities for Malawi tree seeds;

Commercial uses of **Sterculic and Malvalic acids**;

Commercial uses of **Isomers of Conjugated Linolenic acid**;

Demand for **natural anti-oxidants** (see Bibliography No. 109e.)

[121] Discussed in principle with Danielle Typinski, USAID at MAFE 05/05/02. E-mail dtypinski@usaid.gov

It is recommended that this work be let as a Contract Research project either to specialists experienced in the respective trades or to an international market research organization, possibly under the auspices of A-SNAPP.

15.3.1 <u>Recommendations for Pure and Applied Research</u>

As discussed earlier, MAFE is sceptical of the possibilities of Malawi developing on its own new plant-based medicines for international sale. These might best be developed through international support such as a direct **Partnership with the WSU College of Pharmacy**, as suggested by CCCD, and/or the Plant Resources of Tropical Africa Program of the National Herbarium (Annex 3, Volume 2).

Freed from the constraint of *agroforestry species* imposed by MAFE, it is proposed that University of Malawi engage in a systematic program **of pure and applied research on five native farm and wild tree species** principally to isolate products with industrial, nutritional and cosmetic potential. Unless suitably re-equipped, CCCD should establish a **partnership with SCRI – LAU or CSIR, South Africa** to avail specialized laboratory services. BCA would need to join in engineering and animal nutrition aspects of the work.

Manketti *(Schinziophyton rautanenii)*, African Star Chestnut *(Sterculia africana)* and Natal Mahogany *(Trichilia emetica)*, which are best known as wild trees, require further research, principally by CCCD. It is strongly recommended that the agenda be widened to include other species of national and regional interest, i.e. **Marula *(Sclerocarya birrea)*, and Baobab**[122] ***(Adansonia digitata)***. Once their properties and commercial potential have been identified a pilot project for commercial exploitation in each case can be established.

In the case of seed oils/fats commercialization, experience from the pilot model of Moringa oil commercialization would shed a lot of light on how to proceed.

Great care needs to be taken to **avoid duplicating the research work of SAMOPN, CRIAA and SANProTA** on the foregoing species. It is strongly recommended that CCCD channels respective inquiries to these organizations with the assistance of SANProTA's local member, EDETA and that CCCD offer services as an R&D partner

The research agenda of CCCD should include:

15.3.1.1 Characterization of five poorly documented species:

Total characterization of the seeds (and specific seed parts) and oils of five species:

African Star Chestnut *(Sterculia africana)*
Baobab *(Adansonia digitata)*
Manketti *(Schinziophyton rautanenii)*
Marula *(Sclerocarya birrea)*
Natal Mahogany *(Trichilia emetica)*[123] including phenotypic variation, investigation of the nutritional values of the milky extract of *Trichilia*

[122] KOR reports conducting trial extraction of Baobab oil in 2002 on a ram press in association with WESM-assisted communities at Kam'wamba.
[123] Refer also to possible uses as a polish in Section 10.8.8.

emetica arils and traditional uses of sub-types of this plant in Mozambique and Tanzania.

15.3.1.2 Moringa oleifera specialised research

a. Desk research on the exploitation and **commercialization in West Africa of the *leaf proteins* of *Moringa oleifera*** to alleviate protein deficiency and other nutritional problems of vulnerable groups such as young children and lactating mothers; adaptive research if the results are promising.

b. Chemical **analysis on oils and seeds from various Moringa provenances**, to determine variation and, if significant, to be followed up by investigation by **FRIM, t**he **National Herbarium** and contracted specialists of species/varietal variation as suggested in Section 10.7.1.

c. Further study of the ***aqueous extraction of Moringa oil*** and in particular the detailed chemical composition of the oil for comparison with other methods.

d. Research **with BCA** into:

d1. the feasibility of applying ***aqueous extraction* and/or *diffuser technology*** to Moringa seed processing (Department of Agricultural Engineering, BCA).

d2. the progress of commercial development **of Moringa-based water-treatment products in Tanzania**, and respective **animal-feed by-products** (Department of Agricultural Engineering, BCA);

d3. the **digestibility of Moringa press cakes and aqueous extracted seed cakes** (Department of Animal Nutrition[124], BCA), preferably with collboration of KOR;

15.3.2 Detailed bio-chemical investigations (including medicinal possibilities advocated by CCCD)

a. Following the work of Allam, S.S.H. 2001, investigation of the scope for **Moringa oil blending with other edible oils**, including Macadamia oil, to improve their **stability/shelf life**.

b. Quantification of the **natural anti-oxidants in Manketti kernel oil** and determination of its potential as an anti-oxidant additive to commercial oils.

c. Study of the variation of the quantity and quality **of *conjugated linolenic acids* (CLNs) of Manketti** provenances; Investigation **of *Manketti oil* for *modified atmosphere packaging* (MAP) and *anti-tumour activity***.

d. Study of **the chemical constituents of the seed and seed coats of *Trichilia emetica*:** Use as a mosquito repellent; identification of potential pharmaceutical products.

[124] Safalaoh, A.C.L. personal communication. E-mail: andys@bunda.sdnp.org.mw ; andysafalaoh@yahoo.co.uk

e. Detailed literature review of **toxicity of *Jatropha curcas* oil** and, if required, investigation and experimentation in partnership with University of Hohenheim, Germany.

f. **Bio-chemical explanation** of the universal use **of Neem leaves to cure 'stomach ache'** in Lower Shire.

g. **Bio-chemical explanation** of the use **of *African Star Chestnut seed pod hair ash* as an *eye ointment***, and wearing of a ***bark rope necklace*** as an *evil spirits* remedy.

Each of the foregoing subjects of research should be carefully planned, with determination of verifiable indicators and the timetable to completion, and costed. None of this research should be undertaken by *teaching staff* directly. It should all be sub-contracted as postgraduate research and be sponsored accordingly. Many person-years of research are foreseen. The information is required to determine the commercial and (in some cases) subsistence suitability of the species as a condition of establishing whether they can be better utilized.

To support such work, the possible funding window indicated under Section 10.5.3 should be followed up and the Association of Professional Chemists and Chemical Engineers of Malawi (APCCEM) (Chisala, D.P. personal communication; Annex 5, Volume 2) should be periodically briefed.

15.3.3 Further engineering research suggested for BCA

a. BCA should investigate **the cost of operation and maintenance and the performance of the Komet**, bench-mounted 2-stage expeller for *Moringa oleifera*, consulting Optima and testing one of the machines of either Valmore, the Kafora Group or Naming'omba. The manufacturer should also be consulted to ascertain prices and claimed performance.

b. Efforts should be made through EDETA and SANProTA to secure comprehensive information on the performance, price, and operating and maintenance costs of **the *Hydraulic Press* system used by Marula oil producers in Namibia and South Africa** (CRIAA; SAMOPN). Its suitability for other tree seeds, specially *Moringa oleifera* should be determined.

c. BTP, Zimbabwe should be consulted for detailed guidance on **efficient oil extraction from *Trichilia emetica*** and efforts should be made to trace **the technology formerly used by the Kyela soap industry in Tanzania** to extract Malawi *Trichilia* oil. Archives on the history of this topic in Mozambique should be traced in Maputo and Lisbon.

d. BCA should continue to network with tree seed engineering researchers internationally and within the region to support the **improvement of *seed storage, pretreatment/conditioning* and *extraction technologies*** in Malawi.

15.3.4 Assignment for FRIM

It is recommended that FRIM be engaged to investigate ***household/hedgerow/live fence* production costs, inputs and outputs for Moringa**.

15.3.5 Networking

The suggested research for Moringa will contribute considerably to addressing issues identified by the international *Moringa Network* in November 2001 (Table 11). All researchers involved above are advised to keep the Ministry of Agriculture and Irrigation, the *Resource Center*, *NRCM* and *Forestry Department/FRIM* updated on progress and problems encountered. They should maintain contact with the international Moringa Network**,** *A-SNAPP, SANProTA and SADC-ICRAF* and periodically verify that they are not duplicating research of other workers. Efforts should be made to keep work in progress posted on websites. The sites of A-SNAPP, SANProTA and the Moringa Network are recommended.

JULY 16, 2002

BIBLIOGRAPHY

Note: References labelled *** are in the Resource Center Library (02/07/02)

1. Agribusiness in Sustainable Natural African Plant Products – A-SNAPP. June 2000. Progress Report***

2. Agribusiness in Sustainable Natural African Plant Products – A-SNAPP. Sept 2001 (postponed Feb 2002). Roundtable Program and Abstracts. Accra. TechnoServe, Rutgers University, University of Stellenbosch & USAID.***

3. Allam, S.S.H. 2001. Utilization of some untraditional sources of high oleic acid oils for improving vegetable oils stability. Food Technology Research Institute, Giza. La Revista Italiana de Sostanze Grasse. Vol LXXVIII. Giugno 2001.***

4. Anbarassan, P., Sreeja, K.V., Kalaiselvi, S., Prvatham, A. and Vedamuthu, G.B. 2001. Our Moringa Experience … An Overview. Presentation at the Moringa Products Workshop, Dar Es Salaam. Horti Nursery Networks, Erode.***

5. Anon., 1904. The nature and commercial uses of Ben oil. Supplement to the Board of Trade Journal, Bulletin of the Imperial Institute, pp. 117 – 120.

6. Becker, K. 1998. Investigation of the Roles of Lectin and Phorbol Esters in Causing *Jatropha Curcas* Toxicity, and Detoxification of Jatropha Meal from a Toxic Variety Using Heat and Chemical Treatments. University of Hohenheim Institute for Animal Production in the Tropics and Subtropics. Stuttgart.***

7. Becker, K. 1998. Some Analyses of Jatropha, Moringa and Algai Samples to Understand their Potential as Animal Feed. University of Hohenheim Institute for Animal Production in the Tropics and Subtropics. Stuttgart.***

8. Bennett, R. 2001 & 2002. personal communication: glucosinolates in *Moringa oleifera.*

9. Bennett, R. 2002 Reports ……………..

10. Binns, B and Logah, J.P. 1972. Dictionary of Plant Names in Malawi. The Government Printer, Zomba.***

11. Bunderson, W.T., Bodnar, F., Bromley, W.A. and Nanthambwe, S.J. 1995. A Field Manual for Agroforestry Practices in Malawi. Malawi Agroforestry Extension Project. Publication No. 6. Lilongwe.***

12. Bunderson, W.T., Jere, Z.D., Hayes, I.M. and Phombeya, H.S.K.(2001. Land Care Practices in Malawi, Malawi Agroforestry Project (MAFE) Publication 42, Lilongwe. Funded by US Agency for International Development (USAID)***

13. Burger, A.E.C., de Villiers, J.B.M., & du Plessis, L.M. (1987). "Composition of the kernel oil and protein of the marula seed." *South African Journal of Science* Vol. 83 November / December, 733 - 5.***

14. Burgess, S.A. 2002. personal communication: wild tree seed harvesting in Zambia.

15. Childs F.J., Chamberlain J.R., Antwi E.A., Daniel J., Harris P.J.C. 2001. Improvement of Neem and its Potential Benefits to Poor Farmers. HDRA, Coventry, UK. ISBN 0 905343 29 8. 32p.

16. COMPASS. 2002. Directory of CBNRM Organizations. Internal Report 4. Third Edition. USAID Contract: 690-C-00-99-00116-00. Activity: 612-0248.***

17. COMPASS. 2002. Directory of COMPASS ListServ Members. Internal Report 9. Second Edition. USAID Contract: 690-C-00-99-00116-00. Activity: 612-0248.***

18. Coote C, Stewart M, Bonogwe 1997. . The Distribution, Uses and Potential for Development of *Moringa Oleifera* in Malawi *Forestry Research Record No. 67.* Forestry Research Institute of Malawi, Zomba.***

19. Demeulenaere, E. 2001. *Moringa Stenopetala*, a Subsistence Resource in the Konso District. Presentation at the Moringa Products Workshop, Dar Es Salaam. Museum National d'Histoire Naturelle, Paris ***

20. Du Plessis, L. 1988. Fruitful future for marula oil. Scientiae 4: 15 – 16

21. ECHO Plant Information Sheet 1999: Fish Bean. *Tephrosia vogelii.* ECHO, Fort Myers.*** p:\seedbank\plant info sheets-full page\tephrosia vgelii, fish bean.doc.

22. Eckey, E.W. 1954. Vegetable Fats and Oils. Reinhold Publishing Corp.

23. Faizi, S., Siddiqui, B.S., Saleem, R.,Siddiqui, S., Aftab, K. and Gilani, A.H. 1994. Isolation and structure elucidation of new nitrile and mustard oil glycosides from *Moringa oleifera* and their effect on blood pressure. J Nat Prod. 1994 Sep;57(9):1256-61.

24. Faizi, S., Siddiqui, B.S., Saleem, R., Aftab, K., Shaheen, F. and Gilani, A.H. 1998. Hypotensive constituents from the pods of *Moringa oleifera*. Planta Med. 1998Apr;64(3):225-8.

25. Foidl, N., Makkar, H.P.S. and Bekker, K. 2001. The Potential of *Moringa oleifera* for Agricultural and Industrial Uses. Presentation at the Moringa Products Workshop, Dar Es Salaam. PROPAGE/CWS/CDE/CTA.***

26. Foidl, N. 2001 & 2002. personal communication.

27. Folkard, G.K. and Sutherland, J.P. 1996. Moringa oleifera – a multipurpose tree and a litany of potential. Agroforestry Today, Vol 8, No. 3, pp 5 –8.***

28. Fuglie, L.J. ed. 2001. The Miracle Tree. The Multiple Attributes of Moringa. Technical Centre for Agricultural and Rural Cooperation (CTA: ACP-EU) and Church World Service, Dakar.***

29. Fuglie, L.J. 2001. Combating Malnutrition with Moringa. Presentation at the Moringa Products Workshop, Dar Es Salaam. Church World Service, Dakar.***

30. Gaydou, A.M., Menet, L., Ravelojaona, G. and Genetse, P. 1982. Vegetable energy sources in Madagascar: ethyl alcohol and oil seeds (French). Oleagineux 37(3):135-141.***

31. Golbitz, P. ed. 2000. 2001 Soya and Oilseeds Bluebook. Soyatec Inc., Bar Harbor. ISBN 0-57067-107-9***

32. Government of Malawi, 2001. Malawi's National Forestry Programme. Priorities for Improving Forestry and Rural Livelihoods. Department of Forestry NFP Co-ordination Unit, Lilongwe. ISBN 1 899 825 762.***

33. Green, C.L., Steele, R.J.G. & Willemse, J. 1995. R2274 (C): Minor Industrial Crops in the Southern Africa Region: An appraisal of developmental potential with special reference to interregional trade (June-July 1995). World Bank, Washington (unpublished). Natural Resources Institute, Chatham & Agro-economic Research, Fouriesrus. NRI Contract No. C0757.*** (three copies)

34. Grundy, I and Campbell, B.M. 1993. Potential Production and Utilisation of oil from Trichilia spp. Economic Botany 47: pp148 -153. ***

35. Gubitz, G.M., Mittelbach, M. and Trabi, M. (Eds.) 1997. Biofuels and Industrial Products from *Jatropha curcas.* Dbv – Verlag fur die Technishe Universitat Graz.***

36. Harper, A.F. 1999. Livestock Update. Feeding Phytase to Growing Pigs: A Preliminary Cost/Benefit Assessment. Virginia Tech Tidewater AREC.***

37. Heller, Joachim. 1996.Physic Nut. *Jatropha curcas L*. Promoting the conservation and use of underutilized and neglected crops. 1. Institute of Plant Genetics and Crop Plant Research, Gatersleben/International Plant Genetic Resources Institute, Rome. ISBN 92-9043-278-0.***

38. Henning, R. 2000. The Jatropha Booklet. A Guide to the Jatropha System and its Dissemination in Zambia. GTZ-ASIP Support Project Southern Province. bagani GbR.***

39. Henry, E.M.T., 1996. *Preliminary Chemical Investigation of Seeds and Leaves of Moringa oleifera Growing in Malawi* presented at the 5th University of Malawi Research And Publications Conference, 2nd – 5th September 1996 at the Sun and Sand Holiday Resort, Mangochi.***

40. Henry, E.M.T., Makiyi EF, Masamba WR 1999. *Report on Extraction, Purification and Stability of Oil from Moringa Olifera seeds.* Zomba: University of Malawi.***

41. Hilditch, T.P. 1949. The Chemical Composition of Natural Fats. Chapman and Hall Ltd.

42. Hyman, E.L. 1994. Oilseed Production and Processing in Malawi. Appropriate Technology International, Washington, DC.***

43. Jahn, S.A.A. 1981. Traditional Water Purification in Tropical Developing Countries- Existing Methods and Potential Application. Publ **117** Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) GmbH, Eschborn

44. Jahn, S.A.A. 1989. Uso Apropiado de Coagulantes Naturales Africanos para el Abastecimiento de Agua en el Medio Rural. Investigacion realizada en el Sudan y guia para nuevos proyectos. GTZ, Eschborn.***

45. Jahn SAA 1991. The Traditional Domestication of a Multipurpose Tree *Moringa stenopetala* (Bak.f.) Cuf. in the Ethiopian Rift Valley. *Ambio* **20**: 244 – 247

46. Jere, P., Varela, K. and Voysey, B. 2000. Malawi National Forestry Programme. Working Group on Co-Management of Forest Goods and Services. Synthesis study of initiatives in co-management of natural resources in Malawi. Final Report. Government of Malawi National Forestry Programme.

47. Jones, N. and Harris, P.J.C. 1995. Jatropha curcas L. A Potentially Economic Perennial for Marginal Frost-Free Lands. A biological and economic evaluation. A proposal for a Research Support Budget. Henry Doubleday Research Association. ***

48. Koné, S. (undated). How to Make Better Soap. GTZ, Eschborn.***

49. Kunkwezu, E.P.H. and Chilembwe, D.B. 1998. Preliminary Evaluation of the Performance of the Ram Press Using Moringa and Jatropha Seed. Farm Machinery Team. Chitedze Agricultural Research Station/PROSCARP Project Management Unit, Lilongwe***

50. Le Poole, H.A.C. 1996. Behen Oil: A classic oil for modern cosmetics. Cosmetics and Toiletries Magazine, January, pp 77 – 79./ 1995 report to Jan Dekker International, 10p.

51. LFRA Limited. 2001. Food Information on the Internet – An Essential Guide. Fourth edition. LFRA Limited.***

52. Lombard, C. 2001 & 2002. personal communication.

53. Lowore, J. 2001. Natural Resource Based Enterprises in Malawi. COMPASS Document 29. USAID Contract: 690-C-00-99-00116-00; Activity 612-0248***

54. Lowore, J. and Wilson, J. 2000. Grass-roots Advocacy for CBNRM Policy Reform. . Community Partnerships for Sustainable Resource Management in Malawi (COMPASS). Document No 14.***

55. Lyyra, M., Jalkanen, L. and Sarkkinen, E. 2000. Legislation for Novel Food Products – All you need to know about placing novel foods on the EU market. LFRA Limited.

56. Machell, K.. 1997. The Extraction, Properties and Potential of Oil of Moringa – Behen Oil. Presentation at The World Bank Workshop on Development of the Multi-Purpose Tree – *Moringa oleifera.* Blantyre 17 – 18 June 1997.***

57. Machell, K. 1994. Report on extraction of Moringa Oil from *Moringa oleifera* Seeds. Intermediate Technology Zimbabwe. Leicester University.***

58. Machell, K.. 1997. Final Report. The Promotion and Utilisation of *Moringa oleifera* in Zimbabwe and Malawi. Intermediate Technology Zimbabwe.***

59. Makkar, H.P.S., Becker, K. and Schmook, B. 2001. Edible provenances of *Jatropha curcas* from Quintana Roo state of Mexico and effect of roasting on antinutrient and toxic factors in seeds. Institute for Animal Production in the Tropics and Subtropics (480), University of Hohenheim, Stuttgart***

60. Mander, M. 1998. Marketing of Indigenous Medicianl Plants in South Africa – A Case Study in Kwazulu-Natal. FAO, Rome.***

61. Mauambeta, D.D.C. 2000. Wildlife Society of Malawi. Strategic Plan 2000 to 2005. The Wildlife Society of Malawi, Blantyre.***

62. MBS 1988. *MBS 51:1988 Edible Oils General Standard*. Blantyre: Malawi Bureau of Standards.***

63. McConnachie, G.L., Warhurst, A.M. and Pollard, S.J.T. 1996. The Production of Activated Carbon for Water Treatment in Malawi from Waste Seed Husks of Moringa Oleifera. Water Sci. Technol., Vol. 34, No. 11, pp 177 – 184.***

64. Mekonnen, Y., Yardley, V., Rock, P. and Croft, S. 1999. In vitro antitrypanosomal activity of *Moringa stenopetala* leaves and roots. Pytother Res. 1999 Sep;13(6):538-9.

65. Mkamanga, G and Chimutu, P. 2001. Sustainable Management of Indigenous Forests. Project under GTZ – SADC/Forest Sector Technical Co-operation Unit: Mwanza East Community Based Natural Resources Management. Final Evaluation Report. Gil Enterprise Consultants and USAID, Malawi *includes cost-benefit analysis.****

66. Mukumbwa, J. 2000. The Kafora Group Oil Mill at Chitipa. Horticulture in Malawi. Vol. 2, No. 3. 2000, pp. 32 – 33. Horticultural Development Organisation of Malawi.***

67. Mwamba, C.K. 2002. Photo-documentation on the Promotion of Soap and Fuel Production from *Jatropha curcas* Oil. National Institute for Scientificand Industrial Research. Lusaka***

68. Mwanyambo, M.L. and Nihero, D.A. 1998. Medicinal Plants and Biodiversity (Malawi) Project. Final technical Report. International Development Research Centre, Canada***

69. National Research Council USA 1992. *Neem a Tree for Solving Global Problems. A Report of an Ad-hoc Panel of the Board on Science and Technology for Technology for International Development.* Washington: National Academy Press. (Ed: Vietemeyer, N.D.)***

70. National Statistical Office. 2000. 1998 Malawi Population and Housing Census. Report of Final Census Results. Zomba

71. Ndabigengesere, A., Narasiah, K.S. and Talbot, B. 1994. Active Agents and Mechanism of Coagulation of Turbid Waters using *Moringa oleifera. University of Sherbrooke, Quebec****

72. Palgrave, K.C. 1997. Trees of Southern Africa. Capetown: Struik publishers (Pty) Ltd.***

73. Peralta, J.G., Zarzuelo, A., Cobbaert, C. & de Witte, P. (1992). "(-)-Epicatechin-3-galloyl Ester: A Secretagogue Compound from the Bark of *Sclerocarya birrea*." *Planta Medica* 58, 174-5.***

74. Potts, K.H. and Machell, K.. 1995. The Manual Screw Press *for small-scale extraction.* Intermediate Technology Publications.***

75. Pratt, J.H., Henry, E.M.T., Mbeza, H.F. and Mlaka, E. 2002. On-farm and wild trees: Prospecting for Commercial Products. A paper in Proceedings of the Southern African Agroforestry Conference, May 20 – 24, 2002, Pretoria. ICRAF, Harare.***

76. Pretorius, V., Rohwer, E., Rapp, A., Holtzhausen, L.C. and Mandery, H. 1985. Volatile flavour components of marula juice. Z. Lebensm. Unters. – Forsch. 181, 458 – 461.***

77. Rakotonirainy, A.M., Wang, Q. and Padua, G.W. 2001. Evaluation of Zein Films as Modified Atmosphere Packaging for Fresh Broccoli. Journal of Food Science. Vol. 66. No. 8, 2001, pp 1108 – 1111.***

78. Ranjangam, R.S., Azahakia Manavalan, R.S., Thangaraj, T., Vijayakumar, A. and Muthukrishan, N. 2001. Status of Production and Utilisation of Moringa in Southern India. Tamil Nadu Agricultural University.

79. Rossell, J.B. (Ed.) 1999. Oils and Fats Volume 1. Vegetable Oils and Fats. LFRA Limited.***

80. Southern Alliance for Indigenous Resources. 2000. Regional Natural Products Development Initiative. Discussion Paper. SAFIRE, Harare.***

81. de Saint Sauveur, A. 2001. Moringa Exploitation in the World: State of Knowledge and Challenges. Presentation at the Moringa Products Workshop, Dar Es Salaam. PROPAGE/CWS/CDE/CTA.***

82. De Silva, T. and Raina, K. 1996. Fact Finding and Preparatory Assistance to Assess the Potential and Prepare a Plan of Action for the Industrial Utilization of Medicinal and Aromatic Plants. Malawi. UNIDO.***

83. Schäfer, G. & McGill, A. E. J. (1986). "Flavour Profiling of Juice of the Marula (*Sclerocarya birrea* subsp. *caffra*) as an Index for Cultivar Selection." *Acta Horticulturae* 194 (Fruit and Vegetables for Processing) 215 - 222.***

84. Schmutterer H, Ascher KRS 1987. Natural Pesticides from the Neem Tree (*Azadirachta indica* A. Juss) and other Tropical Plants.***

85. Simon, J.E., Phippen, W.B. and McCaleb, R. 2000. Directory of Companies in the Botanical Products Industry (update to work of Duke, J.). Agribusiness in Sustainable Natural African Plant Products – A-SNAPP.***

86. Simon, J.E., Phippen, W.B. and McCaleb, R. 2000. Directory of Companies in the Flavor/Fragrance/ Essential Oil Industry. Agribusiness in Sustainable Natural African Plant Products – A-SNAPP.***

87. Sutherland JP, Folkard GK and Grant WD 1989. Seeds of Moringa Species as Naturally Occuring Flocculants for Water Treatment *Science, Technology & Development* **7** (3) 191-197.

88. Sutherland JP, Folkard GK and Poirier, Y.L. 2001. *Moringa oleifera.* The Constraints to Commercialisation. Presentation at the Moringa Products Workshop, Dar Es Salaam. Optima Environnement, Nyon & University of Leicester.***

89. Suzuki, R., Noguchi, R, Ota, T, Abe, M., Miyashita, K. and Kawada, T. 2001. Cytotoxic Effect of Conjugated Trienoic Fatty Acids on Mouse Tumor and Human Monocytic Leukemia Cells. Lipids, Vol. 36, No. 5, 2001, pp 477 – 482.***

90. Trick, P. 1999. Policy Frame work for Community-based Natural Resources Management in Malawi: A Review of Laws, Policies and Practices. Community Partnerships for Sustainable Resource Management in Malawi (COMPASS). Document No 7.***

91. Tsaknis, J., Spiliotis, V., Lalas, S., Gergis, V.and Dourtoglou, V. 1999. Quality Changes of *Moringa oleifera*, variety Mbololo of Kenya, seed oil during frying, *Grasas Y Aceites*, **59** (**1**), 37-48.***

92. Tsaknis, J., Lalas, S., Gergis, V., Dourtoglou, V. and Spiliotis, V. 1999. Characterization of *Moringa oleifera* Variety Mbololo Seed Oil of Kenya, *J. Agric. Food Chem.*, **47**, 4495-4499.***

93. Tsaknis, J. 1998. Characterisation of *Moringa Peregrina* Arabia seed oil, *Grasas Y Aceites*, **49** (**2**), 170-176.***

94. Tsaknis, J., Lalas, S., Gergis, V., Dourtoglou, V. and Spiliotis, V. 1998. Quality Changes of *Moringa oleifera* variety of Blantyre, seed oil during frying. *La Rivista Italiana Sostanze Grasse.* **75** (**4**), 181 – 190.***

95. Tsaknis, J., Lalas, S., Gergis, V. and Spiliotis, V. 1998. A Total Characterisation of *Moringa oleifera* Malawi seed oil, *La Rivista Italiana Sostanze Grasse*, **75** (**1**), 21-27.***

96. USDA. 1972. *TEPHROSIA VOGELII:* a Source of Rotenoid for Insecticidal and Piscicidal Use. Technical Bulletin No. 1445. Agricultural Research Service. US Department of Agriculture.***

97. van't Riet, S. 2000. The Moringa Tree – a Miracle Tree. Horticulture in Malawi. Vol. 3, No. 3, 2001, pp. 12 – 15. Horticultural Development Organisation of Malawi.***

98. Von Teichman, I. (1982). "Notes on the Distribution, Morphology, Importance and Uses of the Indigenous Anacardiaceae: 1. The Distribution and Morphology of *Sclerocarya birrea* (the Marula)." *Trees in South Africa*, Oct. - Dec., 35 - 41.

99. Von Teichman, I. (1983). "Notes on the Distribution, Morphology, Importance and Uses of the Indigenous Anacardiaceae: 2. The Importance and Uses of *Sclerocarya birrea* (the Marula)." *Trees in South Africa 35:* Apr. - Sept., 1 - 7.

100. Walker, J. 2001. personal communication.

101. Walters, P.R., Macfarlane, N. and Spensley, P.C. 1979. Jojoba: an assessment of prospects. Tropical Products Institute. Publication G128. London.

102. Warhurst, A.M., McConnachie, G.L. and Pollard, S.J.T. 1996. "The production of activated carbon for water treatment in Malawi from the waste seed husks of Moringa oleifera". Water Sci. Technol., Vol. 34, No. 11. Pp.177 – 184.

103. Warndorff, J. and T. 2001. personal communication.

104. Watt, J.M. and Breyer-Brandwijk, M.G. 1932. medicinal and poisonous plants of southern and eastern Africa. Second edition, E. and S. Livingstone Ltd, Edinburgh.***

105. Wegmersghaus, R. and Oliver, G. 1980. *Jatropha curcas* L. In Zimbabwe. Grower's Handbook. Plant Oil and Engineering Development Group Pvt Ltd (POEDG), Harare.***

106. Weinert, I.A.G., van Wyk, P.J., & Holtzhausen, L.C. (1990). "Marula" in "Fruits of tropical and subtropical origin" Eds. S. Nagy, P.E. Shaw & W.F. Wardowski. Lake Alfred, Florida Science Source.***

107. Williamson J. 1975. *Useful Plants of Malawi*. Zomba: University of Malawi.***

108. Wyeth, P., Burgess, S.A., Karaan, M. et al., Le Breton, G & Chunda, P. and Pratt, J.H., (2002). An industry and market study on six plant products in Southern Africa: A Summary Review of Current Knowledge. Volume II: TREE CROPS. Washington State University. USDA & USAID. Washington.***

109. Websites with bibliographies –

109a. http://www.asnapp.org

109b. http://www.jatropha.org/malawi/index.html (features MAFE and EDETA)

109c. http://www.naturalhub.com/natural_food_guide_nuts_uncommon_Ricinodendrin_rautanenii.ht (accessed 23/10/2001)

109d. Duke, J.A. 1983. Handbook of Energy Crops (unpublished). *Jatropha curcas L.* at http://newcrop.hort.purdue.edu/newcrop/duke_energy/Jatropha_curcas.html (quotes Gaydou et al, 1982)

109e. http://www.chipsbooks.com/novelcos.htm for "Culinary and Hospitality Industry Publication Services" new publications not yet ordered by MAFE:

Ching, K.C. (Ed.) 2000. Fatty Acids in Foods and Their Health Implications. 2nd Ed. 1,045 pp. $249.
Includes:- *Craig-Schmidt, M.C.and Holzer, B.M. Fatty Acid Isomers in Foods.*
Cohen, M., Robinson, R.S. and Bhagavan, H.N. Antioxidants in Dietary Lipids

Gunstone, F.D. and Padley, F.B. (Eds.) 1997. Lipid Technologies and Applications. 834 pp. $234.

Harborne, J.B. and Baxter, H. 1999. The Handbook of Natural Flavonoids. 2 volumes. 1,800 pp. $1,289.

Hui, Y.H. 1996. Bailey's industrial Oil and Fat products. 5 volumes. 2,778 pp. $899.

Kabara, J.J. and Orth, D.S. 2002? Preservative-Free and Self-Preserving Cosmetics and Drugs Principles and Practices. 284 99. $149.

Magdassi, S. and Touitou, E. (Eds.) 1998. Novel Cosmetic Delivery Systems. 376 pp. $174.

Salunkhe, D.K. et al. 2002? World Oilseeds Chemistry, Technology and Utilization. 554 pp. $150.

110. Trichilia emetica undergraduate student theses available from Eduardo Mondlane University, Maputo:-

110a. Machai, T.E. 2000. Diagnostico dos sistemas agroflorestais tradicionais do distrito de Maxixe, Provincia de Inhambane. Tese de Licenciatura em Engenharia Florestal, Universidad E. Mondlane, Maputo.

110b. Michaque, S. 2000. Levantamento de uso de plantas nas comunidades de Gala, Puza e Zitundo no distrito de Matutuine. Tese de Licenciatura em Engenharia Agronomica, Extensao Rural, Universidad E. Mondlane, Maputo.

110c. Mudanisse, F.C.E. 1998. VariabilidadeFenotipica das Maffurreiras (*Trichilia emetica*) dos Arredores da Cidade de Maputo. Tese de Licenciatura em Engenharia Agronomica, Producao e Proteccao Vegetal, Universidad E. Mondlane, Maputo.

110d. Chiocho, J. 1999. Ensaios de Sementeira e Armazenamento da Semente de Mafurra (*Trichilia emetica* Vahl.). Tese de Licenciatura em Engenharia Agronomica, Extensao Rural, Universidad E. Mondlane, Maputo.

Note: Dr Alberto Macucule reports (July 2002) that no earlier *Trichilia emetica* documentation could be located in the library of Eduardo Mondlane University.

Useful E-mail Contacts (see Acknowledgements)

Authors:

John H. Pratt E-mail: JohnPratt1@compuserve.com ; prattjhox@hotmail.com ; pratt@malawi.net
Dr Elizabeth M.T. Henry E-mail: emhenry@chirunga.sdnp.org.mw ; methhenry@Africa-Online.net
Henry F. Mbeza E-mail: hfmbeza@bunda.sdnp.org.mw
Emmanuel Mlaka/EDETA E-mail: edeta@sdnp.org.mw
Leonard Satali E-mail: c/o EDETA; Tel: (c/o CABUNGO 01636295)

MAFE Resource Center:

Mr N.J. Mulenga E-mail: landcons@malawi.net
Dr Henry S.K. Phombeya E-mail: resourcecenter@malawi.net

National Research Council of Malawi:

Dr C.N. Mwiyeriwa E-mail: psnrcm@sdnp.org.mw

Washington State University:

Dr Trent Bunderson E-mail: tbunderson@yahoo.com
Dr Jan Noel E-mail: noel@wsu.edu
Jo Bonner E-mail: jobonner@wsu.edu
Asst.Prof. Linda Robison E-mail: lrobison@wsu.edu
Dr Peter Wyeth E-mail: pwyeth@wsu.edu
Prof David Sclar E-mail: sclar@mail.wsu.edu
Prof Gary Meadows E-mail: meadows@mail.wsu.edu

Total Land Care

Malawi E-mail: tlc@malawi.net
Zambia E-mail: tlcz@zamnet.zm

A-SNAPP, Zambia

Noah Zimba E-mail: nbzimba@zamnet.zm

Collaborators:

Armelle deSt Sauveur E-mail: asauveur@wanadoo.fr
Yvonne de Lange E-mail: delangey@avroyshlain.co.za
Arch Personal Care E-mail: archinfo@archpersonalcare.co.za
Richard Hartley E-mail: hartley@sdnp.org.mw
Lars Moeller E-mail: lars.moeller@optimaworld.com
Susie Burgess E-mail: susie@organic.org.zm
Nikolaus Foidl E-mail: biomasa@ibw.com.ni
Lowell Fuglie E-mail: fuglie@telecomplus.sn ; fuglie@sonatel.senet.net
Marian McKenzie-Ross E-mail: gonebananas@mweb.co.za ; mwsansom@mweb.co.za
Dr Clinton Green E-mail: clinton.green@btopenworld.com
Reinhard.Henning E-mail: Reinhard.Henning@t-online.de
Keith Machell E-mail: kmachell@zol.co.zw
Charles K. Mwamba E-mail: nisiris@zamnet.zm
Jan & Titia Warndorff E-mail: jan-titia@hetnet.nl ; binga.trees@zol.co.zw ; gwarndorff@healthnet.zw
Traidcraft Malawi E-mail: traidcraft@sdnp.org.mw
Uta Gottschalk GATE E-mail: uta.gottschalk@gtz.de
Dr David Odee E-mail: dodee@africaonline.co.ke
Dr Tony Simons E-mail: t.simons@cgiar.org
Jo Chamberlain E-mail: jo.chamberlain@green.oxford.ac.uk
Duncan Macqueen E-mail: d.j.macqueen@greenwich.ac.uk
Patrick Hardcastle E-mail: PDHARDCASTLE@compuserve.com
Dr Andrew Watson E-mail: Andrew_Watson@dai.com
Sander Donker E-mail: sanderdonker@cheetah.malawi.net
Dr Augustine Chikuni E-mail: Augustine@sdnp.org.mw ; herbarium@chirunga.sdnp.org.mw
SHOGA E-mail: shoga@malawi.net
June Walker E-mail: junewalker@Africa-Online.net
Stacia Nordin E-mail: nordin@eomw.net
Prof. John Tsaknis E-mail: jtsaknis@teiath.gr
Cyril Lombard E-mail: cyril.lombard@virgin.net ; criaawhk@iafrica.com.na
Gus Le Breton E-mail: safire@ecoweb.co.zw ; GUS@safire.co.zw ; info@sanprota.co.zw
Alois Sander E-mail: asander@sdnp.org.mw ; (now Tanzania c/o Tel: 022-2150761)
IFR
Prof Sue Fairweather-Tait E-mail: sue.fairweather-tait@bbsrc.ac.uk
Richard Bennett E-mail: richard.bennett@bbsrc.ac.uk
MBS E-mail: mbs@malawi.net ;
Dr Austin Khulumula E-mail: askhulumula@malawi.net

Davlin Chokazinga E-mail: davlin@MBS.malawi.net
Fred Sikuesi E-mail: fred@MBS.malawi.net
LFRA E-mail: info@lfra.co.uk
Mike Marrs E-mail: mmarrs@lfra.co.uk
Rachel Burch E-mail: RBurch@LFRA.co.uk
SCRI: Claire Reid E-mail: creid@scri.sari.ac.uk
Charlie Scrimgeour : cscrim@scri.sari.ac.uk
For CSIR: Lourens Du Plessis: ldplessis@csir.co.za
Steketee, Richard E-mail: ris1@cdc.gov
Mount, Dwight L. E-mail: dlm2@cdc.gov
Calafat, Antonia M. E-mail: aic7@cdc.gov
Dr John P Sutherland E-mail: JohnPSutherland@aol.com
Prof. Geoff Folkard E-mail: gkf@leicester.ac.uk
Prof. Victor H Chipofya E-mail: vchipofya@yahoo.com
Blantyre Polytechnic E-mail: hchibwana@sdnp.org.mw
Dr Christine Witte E-mail: ief@malawi.net
MIRTDC E-mail: mirtdc@malawi.net
Valmore Paints E-mail: valmore@malawi.net
Evangelical Lutheran Church in Tanzania (for VYAHUMU): elcthq@ELCT.or.tz
Intermech Engineering LtdE-mail: pchisawillo@yahoo.com
Lawrence Cheyo E-mail: optimadar@raha.com
William Creighton (consultant) : wpcreighton@twiga.com
FRIM E-mail: frim@chirunga.sdnp.org.mw ; frim@clcom.net
Gerald Meke E-mail: gmeke@frim.clcom.net
National Tree Seed CenterE-mail: ntsc@frim.clcom.net
Naming'omba Tea Estates Ltd: namingomba@malawi.net
Dr Alberto Macucule E-mail: macucule@agronomia.uem.mz ; macucule@yahoo.com
Dr Andreas Boehringer E-mail: aboehringer@malawi.net
Dr Festus Akinnifesi E-mail: fakinnifesi@sdnp.org.mw
Dr Freddie Kwesiga E-mail: fkwesiga@africaonline.co.zw
Daulos Mauambeta E-mail: wsm@malawi.net
SADC FSTCU E-mail: sadcfstcu@malawi.net