Market and Technical Survey: Shea Nuts

Introduction

Shea nuts are primarily grown in West and Central Africa in the semi-arid Sahel, referred to by traders as the "Shea Belt". *Vitellaria paradoxa* and *Vitellaria nilotica* are the two main varieties. *Vitellaria paradoxa* is exported in the largest volume and grows throughout the West African region. *Vitellaria nilotica* is produced primarily in northern Uganda and southern Sudan. Shea nut products, the solid fat (butter or stearin) and the liquid oil (olein), are ideal for use as raw materials in cooking oil, margarine, cosmetics, soap, detergents and candles, but it has found its primary market niche as a substitute for cocoa butter in the chocolate and confectionery industry.

The Shea Nut Tree
(Photo Credit: KARITEA, France)

Production Method

Shea nut trees grow widely and naturally in West Africa. They only begin to bear fruit after about 20 years and do not reach maturity for 45 years. They may continue to produce nuts for up to 200 years after reaching maturity.

The long period taken to reach maturity has discouraged plantation planting, although they are used as shade trees for other crops in certain dry areas. Also the fact that supply far outstrips demand has fouled attempts to domesticate the trees.

Shea Nuts
(Photo Credit: CREDO, Finland)

The nuts, which are embedded in a soft fruit, fall to the ground during the harvesting period (typically June through August). They are then buried in pits which causes the pulp to ferment and disintegrate and produces enough heat to prevent germination. The nuts are dried for a few days and are later shelled and winnowed, usually by hand. The kernels are dried further to reduce moisture content from about 40 percent to about 7 percent.

A process called fractionation separates the oil (olein) and butter (stearin). This can be done locally and allows for the extraction of the liquid oil – which is much more valuable to West Africans because of its nutritional content – by a process involving the heating and kneading of the crushed kernels and straining the resultant oily mass.

Manufacturers in the chocolate and other food industries prefer to buy the shea nuts as opposed to the butter so that they can have as much control as possible over the processing and quality of the final product. Nuts are also preferred because they can be stored for up to five years in the right conditions, while the butter is more expensive to store and deteriorates more rapidly. Exports of shea butter from African countries tend to be unrefined.

Shea butter is produced on a commercial scale in Europe using hydraulic presses on the nuts and then placing them in hot air ovens. The product is then bleached with a hexane solvent. The butter must then be stored and transported in cool conditions and in airtight containers to avoid becoming rancid.

For a more detailed description of the production method, please refer to excerpts of a Fintrac-produced technical report in Annex A.

Supply

Shea nut supply far outstrips demand. Over 600,000 MTs of the dominant variety, *Vitellaria paradoxa*, is produced in West Africa (see Table 1 below). Most is used as a cooking oil or as a butter for the skin and hair locally. The other variety, *Vitellaria nilotica*, has a superior quality which is preferred by the cosmetics firms (see excerpts from a shea nut technical report produced by Fintrac in Annex A). Unfortunately this variety is primarily grown and processed in northern Uganda and southern Sudan, both currently states of civil unrest, and so it is generally unavailable on the market. Several other countries, including Israel and Germany, have attempted to replicate this variety without success. A contact for the project that is marketing this variety can be found at the end of this survey.

Table 1: Shea Nut Production, 1993-98 (MTs)

	1994	1995	1996	1997	1998
Benin	15,500	15,000	15,000	15,000	15,000
Burkina Faso	70,100	75,700	70,000	70,000	70,000
Côte d'Ivoire	19,785	20,000	20,000	20,000	20,000
Ghana	57,000	56,000	55,000	55,000	55,000
Mali	85,000	85,000	85,000	85,000	85,000
Nigeria	353,000	384,000	345,000	355,000	355,000
Togo	7,000	8,520	2,504	6,500	6,500
TOTAL	**607,385**	**644,220**	**592,504**	**606,500**	**606,500**

Source: FAOSTAT

FAO export statistics of major supplying countries are provided in Tables 2 and 3 below, although they are not considered to be completely accurate and are primarily estimates. Exports during the last two years of available statistics hovered around 50,000 MTs with an export value of around $10 million. Exports in 1996 and 1997 are more than double the five year low recorded in 1993, but lower than the high recorded in 1994.

Table 2: Worldwide Shea Nut Exports by Volume, 1993-97 (MTs)

HS Code 120792	**1993**	**1994**	**1995**	**1996**	**1997**
Ghana	1,793	13,988	6,000	19,654	19,654
Benin	7,870	15,266	9,504	9,504	9,504
Côte d'Ivoire	4,792	12,163	11,195	5,422	5,422
Burkina Faso	5,000	5,000	7,633	7,633	7,633
Togo	1,112	6,562	4,606	8,330	5,284
Nigeria	-	5,000	-	-	-
Mali	500	500	500	500	500
UK	-	215	182	28	-
Other	28	10	34	21	31
TOTAL	**21,095**	**58,704**	**39,654**	**51,092**	**48,028**

Source: FAOSTAT

Table 3: Worldwide Shea Nut Exports by Value, 1993-97 (US$000s)

HS Code 120792	**1993**	**1994**	**1995**	**1996**	**1997**
Ghana	340	2,590	1,500	5,846	5,846
Benin	1,071	2,223	1,400	1,400	1,400
Côte d'Ivoire	1,319	1,601	1,973	793	793
Togo	137	764	788	1,274	972
Burkina Faso	500	500	847	847	847
Nigeria	-	1,500	-	-	-
Mali	150	150	150	150	150
UK	-	45	37	9	-
Other	6	9	38	10	33
TOTAL	**3,523**	**9,382**	**6,733**	**10,329**	**10,041**

Source: FAOSTAT

Import Markets

A few companies based in Europe control the import market for shea nuts. Their main clients are chocolate manufacturers as the shea nut by-products are among the principal ingredients in cocoa butter equivalents (CBEs). Many countries, including the US, forbid the manufacture of CBEs, so the main importers tend to be in Europe with minor amounts also shipped to Japan. However, even in Europe not all countries allow CBE manufacture, but they all allow the sale of CBE products. The countries that allow its manufacture include the UK, Denmark, Sweden, Portugal, Ireland, Russia and Japan.

Accurate trade statistics are difficult to obtain. Statistics from the UN Food and Agriculture Organization (FAO) and the European Union report that European imports were in the range of 2,500-5,000 metric tons (MTs) in 1997. Based on interviews with traders, previous years' import statistics and export statistics of producing nations, the European import market is probably much larger (possibly reaching 50,000 MTs with an import value of over $13 million per year).

Major European importing companies are primarily based in Denmark, Sweden and the UK. Denmark and the UK each imported approximately 20,000 MTs last year, while Swedish imports were estimated at around 10,000 MTs. Fewer imports were recorded by France, as importers there are more interested in shea butter as opposed to nuts. The list of importers interviewed for this market study can be found at the end of this survey.

The market is not open to much speculation and trades are done in a closed circuit dominated by the Europeans. Japanese importers complain of being unable to break into the Europeans established network of clients and suppliers.

Shea butter is becoming increasingly popular as an ingredient in cosmetics and soaps, especially in France and the US. According to one importer interviewed, they have seen a threefold increase in demand for shea butter in the past year. Chocolate and confectionery products account for 95 percent of shea butter demand, with only 5 percent currently used for cosmetics and pharmaceuticals.

Prices

Over the course of the past export season (September through April/May), the price for shea nuts ranged from $240-350 per MT (CIF Europe) with $300 per MT being the average price. Ghanaian and Nigerian nuts are preferred because of their higher oil content and thus fetch a slightly better price ($275-$350) per MT. Incentives are offered for better quality nuts (see quality standards below) through premiums that are paid to exporters.

Historically the price has reached a high of $1,000 per MT, but there has been a gradual downward trend as the price of cocoa beans and butter has decreased (see Annex B). The price of shea nuts and butter follows the movement in the price of cocoa beans and butter but at a substantially lower price because it is only a substitute for cocoa butter in chocolate. The price of cocoa beans has decreased 40 percent in the past year due to increased supply at origin and lower consumption in the market.

Manufacturers add the shea butter to their CBEs in the hope that they can provide a discount on their product in order to increase sales, although they often try and convince consumers that there is a quality issue involved in their marketing decision. With lower cocoa bean prices there has been less of an incentive to purchase shea nuts. Chocolate manufacturers remain committed to CBEs, nevertheless, because their thinking is long-term and the confectionery industry has a labeling cost to contend with in Europe as they must state whether a product has CBEs in it or not.

There is a large mark-up for the various shea nut by-products: fractionated oil can fetch a price of $3,300 per MT and the refined butter from Europe trades at $1,000 per MT (all prices CIF US). The retail price for the refined butter is $6 per ounce in the US. The unrefined *Vitellaria nilotica* shea butter from Uganda is priced at $60/kg, while unrefined shea butter from West Africa is priced at $200/MT (CIF Europe).

Quality Standards

Individual companies specify their own quality standards for purchases of shea nuts. The following is a benchmark for the composition of the shea nut required for import:

- Free Fatty Acids (FFA) = ≤6%
- Moisture Content = ≤7%
- Oil Content = ≥45%
- Latex = 4-10%

The oil content is the most crucial element of the shea nut as that component is an important ingredient in the composition of the butter that goes into CBEs and other by-products. If the oil content is higher and the FFA and moisture content is lower, then the exporter will receive a price premium.

Shea butter buyers may also specify its iodine value and a melting point of between 30°C and 40°C – which signifies a minimum purity. Needless to say, the product should be free of foreign bodies. Users in the cosmetic industry want a very highly refined butter product (such as the butter of *Vitellaria nilotica*) and may require a detailed specification of the different fatty acids, the refractive index and a saponification value.

List of Importers

Loders-Croklaan
Hogeweg 1
P.O. Box 41520 AA
Wormerveer, THE NETHERLANDS
Tel. +31-75-6292911
Fax +31-75-6292421
Contact: Mr. Japp Biersteker
WWW: http://www.croklaan.com
(This office is a subsidiary of Unilever UK PLC and does all its tropical nut and edible oil buying)

Karlshamns AB
37482 Karlshamn, SWEDEN
Tel. +46-454-82000
Fax +46-454-82839
Contact: Ms. Monika Hjorth
email: mh@karlshamns.se

Aarhus Oliefabrik A/S
M. P. Bruuns Gade 27
P.O. Box 50 DK-8000 Aarhus C, DENMARK
Tel. +45 8730 6000
Contact: Mr. Soeren Laursen
email: sla@aarhus.com

Brittania Food Ingredients Ltd.
Goole DN14 6ES, UK
Tel. +44-1405-767776
Fax +44-1405-765111
Contact: Mr. Phil Nash
email: office@britfood.demon.co.uk
(Raw material supplier to Mars and Cadbury's UK)

Agritropic s.a.r.l.
Rue des Moulins
43100 Vieille-Brioude, FRANCE
Tel. +33-4-71749790

Fax +33-4-71749282
Contact: Mr. Georges Brun
(also acts as Commercial Director for Aarhus out their Abidjan office)
email: sla@africaonline.co.ci

Eurobroker
30, rue d'Astorg
75008 Paris, FRANCE
Tel. +33-1-44948787
Fax +33-1-40060313
Contact: Mr. Michael Becker, Tropical Nuts Division
email: michael@eurobroker.fr

Aarhus Olie Côte d'Ivoire
(subsidiary of Aarhus Oliefabrik A/S, Denmark)
Résidence de la Tour B.I.A.O
8-10 rue Joseph Anoma
(entrée avenue Lamblin)
Abidjan 01 BP 1730
COTE D'IVOIRE
Tel. +225-327052/53
Fax +225-327055
Contacts: Mr. Søren Laursen, Managing Director
email: ghb@africaonline.co.ci

EXA Cosmetics
112 rue de Lagny
93100 Montreil, FRANCE
Tel. +33-1-42879698
Fax +33-1-48708870
Contact: M. Philippe Monmarché
(Use refined shea butter in their line of cosmetics)

D2E
202, rue de la Croix Nivert
75015 Paris, FRANCE
Tel. +33-1-53785858
Fax +33-1-53785850
Contact: Dr. Laurent Sousselier
(Use refined shea butter in their line of beauty creams)

Fuji Oil Company, Ltd.
1-5, Nishi Shinsaibashi 2-chome, Chuo-ku
Osaka 542, JAPAN
Tel. +81-724-631364
Fax +81-724-631601
Contact: Mr. Uragami, Manager
email: 780040@so.fujioil.co.jp
(Import shea nuts, butter and oil)

Fuji Vegetable Oil, Inc.
(US based subsidiary of Fuji Oil)
120 Brampton Road
Savannah, GA 31408 USA
Tel. (912) 966-5900 x 315
Fax (912) 966-6913
Contact: Mr. Don Tanegawa
email: fvo_finance@gapcdr.com
(Imports shea butter and oil only for sale to chocolate manufacturers in Canada and S. America)

AFAJATO, Inc.
6455 E. Briar Drive
Lithonia, GA 30058 USA
Tel. (770) 482-4451
Fax (770) 413-6389
Contact: Mr. Paul Agbemashior
Email: afajato@aol.com
(Imports shea butter only for sale to health food and arts and crafts stores, primarily from Ghana)

The Shea Butter Company, Ltd.
16781 Torrence Avenue
Lansing, IL 60438 USA
Tel. 1-877-489-2700 (toll free)
Fax (708) 481-3144 or 1-877-489-9917 (toll free)
Contact: Mr. Thom Rivers
Email: trivers@naturalessence.com
WWW: http://www.naturalessence.com/company/
(Import shea butter only for soap and lotion manufacture; sells under brand name of "Natural Essence")

Terry Labs
390 N. Wickham Road, Suite F
Melbourne, FL 32935 USA
Tel. (407) 259-1630
Fax (407) 242-0625
Contact: Ms. Gail Falco or Mr. Dave Wellsley
email: aloe@terrylabs.com
WWW: http://www.terrylabs.com
(Sells refined shea butter to cosmetic companies in US)

Edible Oils Marketing Consultant
Nyland Coach House
Nyland, Cheddar, Somerset BS27 3UD, UK
Tel. +44-1934-741137
Fax +44-1934-741862
Contact: Mr. Ian Campbell CA
email: I_DCampbell@compuserve.com
(Previously worked for Unilever; excellent marketing contacts in Europe and the Americas)

Shea Nut WWW References

1. TECO Finance Export

   URL: http://www.sheabutter.com/

   Main activity is international trade of tropical raw materials. TECO collects these products in Guinea-Bissau, Ivory Coast, Mali, Burkina Faso, Togo, Benin and Nigeria. The main products are cashew nuts and shea nuts. Collection requires a strong organization with financing facilities, distribution of bags, quality control, warehousing and Export formalities from the loading port. Processing, packaging, and distribution take place in France.

   For more information: 24 rue Violet, 75015 PARIS – FRANCE, Tel : 331 45.78.92.91, Fax : 331 45.77.00.69, email : info@sheabutter.com

2. The Cooperative Office for Voluntary Organizations of Uganda (COVOL Uganda) – Shea Project

   URL: http://www.covol.org/Shea/index.html

   The Shea Project for Local Conservation and Development is an integrated, long-term effort to preserve the ecological integrity of savanna woodland in northern Uganda through reinforcement of the economic importance of the shea butter tree, Butyrospermum parkii, source of the food oil known as shea butter. Funded to 75% by the USAID Action Program for the Environment (APE), the Shea Project is a collaborative effort of COVOL Uganda and the women's farming groups of Lira District in northern Uganda.

   For technical information: Mr. Eliot Masters, Project Coordinator, COVOL, P.O. Box 833, Lira, UGANDA, Fax +256-41-543565 , email: covol@bushnet.net

   For marketing information: Ms. Alisa Puga, 4680 Portola Drive, Santa Cruz, CA 95062 USA, Tel./Fax (831) 462-2182, email: alisap@earthlink.net

3. UNIFEM – “Eradicating Feminized Poverty” (Report)

   URL: http://www.unifem.undp.org/ec_povh1.htm

4. Meeting on Karité (Vitellaria paradoxa) 15-17 April 1998, FAO, Rome, Italy

   URL: http://www.fao.org/waicent/faoinfo/forestry/NWFP/KARITE.HTM

5. Solutions Cite Case Study

   URL: http://www.solutions-site.org/cat9_sol66.htm

   The Songtaaba Women’s Group has transformed karité (shea nut) processing and made it into a substantial industry run by women, from production to marketing of a wide range of consumer products.

6. “Le vrai faux chocolat qui irrite l’Afrique”

   URL: http://www.francophonie.org/syfia/88bchoco.htm

   EU regulations on chocolate content and effects on cocoa-producing nations / vegetable oil imports, including karité (shea nut).

7. “Karité: extraction sans peine” – Centre Technique de Cooperation Agricole et Rurale ACP-EU (CTA)

   URL: http://www.agricta.org/ctafr/spore73.htm#anchor1489889
   New press for extraction that is less labor intensive. Women are responsible for much of the extraction process in the production of shea butter.

8. KARITEA

   URL: http://www.adx.fr/karitea/karitea4.html

   Beauty product producer – partner/source from Groupe Coton et Développement (Mali)

9. IDRC – Adventures in Development – Vegetable Oils (Burkina Faso)

   URL: http://www.idrc.ca/adventure/ehuiles.html

10. Mission Nature - Association for New Hope and Ideas (ANHI)

    URL: http://www.credo.fi/eko/oil.htm

11. University of Southampton – International Center for Under-utilized Crops

    URL: http://www.soton.ac.uk/~icuc

Annex A:
Excerpts from "Development of the Rural Shea Butter Industry in Uganda"

This report is an excerpt of a report prepared by Fintrac consultant Ron Harris, who visited Uganda during the period March 11-20, 1998.

Summary

This Report covers the findings of a visit to Uganda to provide technical guidance to the rural Shea Butter Project, funded by the USAID Programme and implemented by the Co-operative Office for Voluntary Organisations of Uganda (COVOL, Uganda).

The Project is based in Lira, 350kms north of Kampala, and seeks to introduce a new improved procedure for oil extraction to Women's groups in Northern Uganda and Southern Sudan in order to encourage non-destructive use of the Shea Nut Tree, *Butyrospermum parkii,* as a conservation measure.

The new procedure entails grinding and moisturising the Shea Nuts, using a simple manual Bridge Press to extract the oil, clarification of the oil by boiling with water, and allowing the clarified oil to separate into a solid fat and a liquid oil. The solid fat, termed "stearin", is sold to a "natural" cosmetic retail chain in the USA.

The overall findings of the visit, based on discussions with Project personnel and a monitored trial run of the process, are outlined, and the results of analyses subsequently carried out on samples collected from various stages of the processing procedure are reported.

Conclusions drawn from the analytical results and from observations and measurements made in the field are given, and lead to a number of specific recommendations for improving the current procedure or enhancing the yield and quality of the products.

Details of commercially available equipment that could improve control of the process are supplied but they are, in general, too costly for consideration in view of the present small scale of operations. Alternative simpler solutions, based on less expensive laboratory scale equipment, are therefore recommended.

The mission was funded via a contract awarded to the writer by FINTRAC, of Washington, DC.

Introduction

Across the North of Uganda, running into Southern Sudan, lies a semi-arid ecological zone known as "Butyrospermum Savannah", in which the dominant species is *Butyrospermum parkii, var. Nilotica* - the Shea Nut Tree. The wood of the tree is hard, heavy, and resistant to termites, and finds use in building construction and the manufacture of mortars, craft goods and charcoal. The seeds contain an oil which is traditionally used locally for both cosmetic and edible purposes.

The Shea Nut Tree is slow growing, with little, if any replanting taking place, and destructive use is on the increase. The oil is facing increasing competition, particularly from imported palm oil for edible use, and from widely advertised, more sophisticated, modern cosmetics. As a result, the tree is not so highly valued now as it has been in the past. There is concern that unless more viable non-destructive uses for the species are found, it may not survive.

Assisted by a USAID Project, a group from the Co-operative Office for Voluntary Organisations of Uganda (COVOL Uganda) have developed a strategy to encourage conservation of the species by improving the oil extraction process, making it less arduous, more efficient, and leading to a better quality product. The have, moreover, incorporated an additional fractionation step to produce a solid fat fraction, for which they have found an export market in the "natural cosmetics" field.

The writer, under contract to FINTRAC, Washington, DC, visited Uganda to provide technical guidance to the Project. The itinerary will be found in Appendix 1. This Report outlines the findings of the visit, details the results and conclusions drawn from the analyses performed on samples collected during the visit, and provides details of commercially available equipment that could further improve the process, and the yield and quality of the products.

The Current Process

Background

The extraction procedure is a specific practical application of the research finding by The Natural Resources Institute (NRI) in the late 1980's that by adjusting the moisture content of an oilseed to a critical level, generally between 12 and 15%, relatively low pressures can be used to extract the a high proportion of the oil The procedure permits the use of simple manual presses, such as a bridge press, in place of expensive powered high pressure expellers requiring complex adjustment and maintenance, and is therefore ideal for small operations in the rural areas of developing countries. The procedure can be used, *inter alia*, for sunflower, groundnuts, rapeseed, and coconuts.

During a sabbatical year in England, Dr Peter Donkor, from The Technology Consultancy Centre of The University of Science and Technology (UST), Kumasi, Ghana worked at NRI on the process. He identified the potential application of the procedure for the extraction of oil from Shea Nuts and this has been the subject of a collaborative project in Ghana between NRI and UST. After unsuccessful attempts to apply the IRHO and KIT/GTZ hydraulic presses and the CEPAZE/ATI centrifuge methods for Shea Nut processing, COVOL Uganda learnt of the work in Ghana and arranged for Dr Donkor to visit Uganda as a consultant to the Shea Project in early 1996. He described the extraction procedure to COVOL personnel, and developed a working prototype of the bridge press used in the work at NRI and Ghana with SAIMMCO, Ltd., Soroti, who have subsequently manufactured units for the Project.

Eight presses have now been installed by the Shea Butter Project at project sites used by member Groups of the Northern Uganda Shea Processors Association (NUSPA). A further twelve have been sent to Southern Sudan for similar projects sponsored by JB Drilling, Ltd. and The Norwegian Peoples' Aid Programme. Their placement is shown in Appendix 2. There are several additional presses in store awaiting decisions on new Groups being considered for membership of NUSPA.

The traditional process for extracting shea butter in the area entails roasting the nuts, pounding them in a wooden mortar, and grinding with stones. The ground mass is boiled with water, allowed to cool and the oil skimmed from the surface. It is laborious, inefficient and produces a highly coloured and flavoured oil.

The objective of the Shea Butter Project has been to replace this traditional process with the new improved technique giving higher yields of a better quality product suitable for export markets, whilst remaining a small-scale rural industry. To this end, following the NRI procedure, the moisture content of the nuts is adjusted to the critical level and oil extraction is carried out with the Bridge Press. After extraction, the oil is clarified by boiling with water, skimmed off, and then allowed, over a period of time, to separate into a solid fat and a liquid oil. The solid fat has found a market with a natural cosmetic company in the USA, whilst the liquid oil is sold locally as an edible oil.

Processing Steps

The fruit matures between April and June, is allowed to fall, and is **harvested** by collection from the ground around the tree. The fruit **pulp** is eaten or removed by allowing to rot or dry. The fragile shell is similarly easily removed by cracking and winnowing. After sun drying the nuts will keep for more than a year if placed in a suitable **store.** It is important not to let the nuts begin to germinate, since this generates a bitterness which passes into the oil.

Nuts approved for processing by the Project are selected on a quality basis as being largely free from insect damage and mould attack. They are washed in a dilute solution of household bleach and sun dried before **grinding**. At the Project Field Office site this is accomplished by passing twice through a diesel powered plate mill of Indian manufacture, but at sites lacking such facilities, grinding is still carried out in the traditional manner by pounding in a wooden mortar. A comparable plate mill has now been designed locally and at the time of the visit, three units were being manufactured by SAIMMCO. These are scheduled for installation at Abim and Amuria during the forthcoming processing season, with the third possibly going to a new site at Gulu.

In the traditional process, the ground oilseed would then be roasted over a fire for a period, but this results in a highly coloured and flavoured oil unsuitable for export markets. Roasting is therefore not encouraged, and the new procedure omits this traditional step.

Boiling water is added to the ground material until the mass is at that **critical moisture content** where oil extraction becomes easy. This point is judged by the texture and appearance of the material.

The ground moisturised seed mass is then transferred into fabric bags which are placed, two at a time, in the cage of the press, with separator plates between each pair. Pressure is applied by winding down the screw. Oil emerges from the apertures in the cage and is collected in a suitable container. When the **pressing** is complete and no more oil can be extracted without undue force, the screw is raised and the residual presscake is unloaded. The presscake is low in protein and high in tannins, and of little value as a livestock feed, but finds a local use as an inhibitor of termite attack and is buried around wooden structures.

The crude oil is then poured into an aluminium **clarification** vessel, water equivalent to half the volume of the oil added, and the mixture boiled for up to half an hour. During this process much of the colour is destroyed, whilst seed particles, gums and mucilage are hydrated and migrate to the interface, or pass into the water layer and collect at the bottom of the vessel. At the end of this operation, after cooling, the oil layer, now a light greenish yellow in colour, is transferred into 20 litre plastic buckets.

The clarified oil from all processing sites is transported to the Project House in Lira where it is allowed to stand for four to five days in a cool sheltered spot and slowly separates into a solid fat (termed "stearin") and a liquid oil ("olein"), a process known technically as **fractionation**. The two fractions are separated by filtering though muslin. Using these procedures, between 25 and 30% of the clarified oil can be recovered as stearin.

The stearin is transported to the United States, dispensed into small jars and sold to "Body Time" - chain of retail natural cosmetic stores in California. The olein is packed locally and sold as a cooking oil.

Results of Analysis

During the visit samples were taken of nuts, presscake and oil at various stages of the process and subjected to analyses to determine the characteristics of the raw material nuts and their processing products, to assist in calculating the efficiency of oil extraction, assess the levels of deterioration, and provide specifications for marketing purposes. Additionally, since some batches of stearin had developed mould growth during display at retail outlets, the COVOL Project Co-ordinator had requested a basic microbiological screening ("total viable count") to determine whether the responsible micro-organisms had entered the processing stream in Uganda, and, if so, at what stage, or resulted from contamination during packaging in the USA. The analyses were carried out by Salamon and Seaber of London E1, a Full Member Analyst accredited by FOSFA (Federation of Oils, Seeds and Fats Association), and the results are shown in Appendices 3 and 4.

Composition of Shea Nuts

In addition to the sample of nuts collected during the visit to Uganda, the writer was able to obtain, from NRI, a sample of Shea Nuts of Ghanaian origin. It is commonly reported that the oil from the Uganda *variety Nilotica*, differs from the West Africa *variety Mangifolia*, and this was confirmed by their compositions which will be found in Appendix 3.

The oil contents of the two varieties are comparable but oil from the Ugandan variety is significantly more unsaturated and has a considerably lower level of stearic acid and is higher in oleic acid than that from Ghana. Although the precise ratio of stearin to olein found during fractionation depends primarily on how the fatty acids are distributed between the three positions of the triglyceride molecules (which is known not to be random) and the temperature at which the fractionation takes place, one would expect a significantly lower yield of stearin from the Uganda variety than from the Ghana variety under all normal fractionation conditions.

The characteristics of the Shea Nut sample collected in Uganda indicates that the batch used for the demonstration and trial runs during the visit were of high quality, showing low levels of both moisture (3.4%) and free fatty acid (3.5%). Free fatty acid (ffa) content is the standard indication of deterioration in an oil or oilseed - indicating hydrolysis of the triglyceride molecules to produce un-esterified fatty acids - and appears in trading specifications for these commodities. The visit took place at the very end of the processing season before the new crop had been harvested. Nuts were thus in very short supply and only one batch could be located. It was considered by visual inspection to be of excellent quality and this has now been confirmed by these analyses.

Efficiency of Extraction

A comparison of the compositions of the raw material oilseed and the presscake residue remaining after oil extraction can be used to estimate the Oil Extraction Efficiency (OEE) and thus the quantity of oil to be expected from pressing a given quantity of seed. The analytical data from the nut and presscake samples collected from trial run carried out during the visit are given in Appendix 3.

During the trial run 1,500ml (1.5kg) of water were added to 13kg of ground nuts to bring the moisture content up to the level judged by the processing personnel to be suitable for the process. Now that the moisture content of the raw nuts has been determined, calculations show that this level of addition brings the moisture content of the ground nuts up to about 13.4%, which is within the 12 to 15% shown by NRI to be the optimum. The addition of 1.5kg of water to 13kg of nuts equates to 11.5kg per 100kg of nuts. This changes the composition of the nut mass as shown in columns B and C in the Table below:

	A	**B**	**C**	**D**
	Nuts before water addition	**Nuts after water addition**	**After water addition (%)**	**Presscake (%)**
Moisture	3.4	14.9	13.36	12.5
Oil	53.7	53.7	48.16	37.3
Fibre/Protein/CHO, etc.	42.9	42.9	38.48	50.2
Total Weight	100	111.5	100	100

The percentage composition of the material placed in the press is thus as shown in column C above. During processing oil and moisture are extracted (or lost through evaporation in the case of the latter) whilst the Fibre/Protein/Carbohydrate components remain unchanged. Therefore, if 100kg of moisturised ground nuts are pressed, the Fibre/Protein/Carbohydrate component (38.48kg) becomes 50.2% of the presscake (as shown in column D above), from which the total weight of presscake can be calculated to be 76.65kg. Since the oil content of the presscake has been shown to be 37.3%, the quantity of residual oil in the presscake is 28.59kg, and, as the original seed mass contained 48.16kg, it can be concluded that 19.57kg have been extracted. Similar calculations show that 3.78kg of water would also be lost during the process.

Extraction of 19.57kg of oil from a raw material originally containing 48.16kg is equivalent to an OEE of 40.6%, i.e. 40.6% of the available oil in the raw material loaded into press has been extracted. This agrees well with the observations and measurements made at the trial during the visit, when 9.5kg of moisturised nuts (equivalent to 8.52kg of original nuts) produced 2 litres (1.84kg) of oil. Since 8.52kg of the original nuts contained 4.58kg of oil, the OEE can be calculated as a similar 40.2%. Using these data, one would expect to extract 33kg of oil from 150kg of Nuts (the quantity used by the Project Staff as indicating the normal daily throughput of a single Press).

This figure is, however, considerably lower than the 45kg of oil from 150kg of nuts claimed in the Project Handbook, which implies an OEE of 56%. However, the calculations above relate only to a single series of samples taken from one day's operation on a single batch of Nuts at one site. A practical average level of oil extraction can only be determined by considering the results from a number of sites over a number of processing seasons, provided that adequate accurate records have kept. It should nevertheless be noted that this trial carried out in Uganda produced results and conclusions comparable to the reported oil yield in Ghana, where, on average, about one gallon (imperial - 4.19kg) of oil is produced from 25kg of Shea Nuts, which is equivalent to an OEE of 36% and can be extrapolated to 27kg of oil from 150kg of nuts.

Deterioration of Oil Quality during Clarification and Fractionation

The procedure used in Uganda exposes the oil to water and air - both agents for deterioration - at several stages. The Nuts are ground, releasing lipase enzymes which accelerate hydrolysis; water is added before pressing; further water is added at the clarification stage; there is the danger of contamination with water on transferring the oil into the fractionation vessels; and fractionation is carried out in open vessels at a relatively high ambient temperature, with a large surface area exposed to the air. To monitor any deterioration, moisture and ffa determinations were carried out on the original nuts and the oil after extraction, clarification, and fractionation.

The results (Appendices 3 and 4), show that deterioration has taken place during the processing procedure with an ffa of 3.5% in the nuts rising to between 5.0 and 6.3% in the various oil samples. The results also indicate that the largest rise in ffa appears to occur in the period between grinding and clarification. Although the ffa levels found in the olein and stearin fractions would be unacceptable for an edible product - the oil would require neutralisation before consumption - cosmetic use would not be ruled out.

Microbiologically, the clarified shea butter and its fractions have very low total viable counts, indicating that, if these samples are typical of routine production, the moulds encountered in retail packs in the USA are introduced at the packaging stage. This is carried out in California.

Characteristics of Fractionation Products

Appendix 4 provides details of the standard analyses, used for specification purposes, performed on the clarified oil, and the olein and stearin fractions - Iodine Value, Slip Melting Point and fatty acid composition. These confirm, as expected, the separation of a solid more saturated stearin (with lower Iodine Value and level of unsaturated fatty acid, and a higher Melting Point) from the whole oil, leaving a more unsaturated, lower Melting Point liquid olein. The unsaponifiable matter shows a slight tendency to remain in the liquid fraction. These data will be useful to the Project as specifications for marketing purposes.

The fatty acid compositions of the two fractions, particularly the distribution of stearic and oleic acids between them, compared with that of the whole oil, can normally be used to calculate the theoretical ratio of stearin and olein that can be expected at the fractionation stage. However, if such calculations are carried out on the figures shown in Appendix 4, they indicates a 63% yield of Stearin. This is not in accordance with observations during the visit, nor with the views of the Project Staff who report a 25 to 30% yield of stearin. This anomaly arises almost certainly because the two samples were not strictly comparable, having been derived from different oil fractionation batches. It was, in fact, reported later that the oil produced during the visit (from which the olein sample was derived) had failed to fractionate satisfactorily, an effect undoubtedly due to the high ambient temperatures pertaining at that time of year, and the stearin sample supplied for the analysis was from an earlier batch. This confirms the view that the stearin produced by the current "natural" fractionation and simple separation procedures will show considerable variations in composition and characteristics from batch to batch.

Conclusions and Recommendations

Owing to the seasonality of the crop, no **harvesting**, **depulping** or **drying** operations could be observed during the visit.

No survey of Shea Nut **storage** facilities was possible during the visit since it took place at the end of the processing season, before a new season's crop had been harvested. The one batch of nuts purchased during the visit appeared, from cursory observation, to be of excellent quality and this has now been confirmed by analysis. It had been stored in a well constructed and maintained traditional granary, close to the Project Field Office site at Adwari Corner. The Project personnel are planning to use its design and construction as a model for training purposes.

Pre-treatment

(a) Washing the nuts with a dilute solution of household bleach to remove surface moulds is a wise precaution in view of the microbiological contamination that has been found in some batches of stearin during retail display. The low "total viable count" found in samples of oils collected during the visit, if these are typical of routine production, indicates that the steps taken in Uganda to limit contamination are successful, and suggests that the infection is introduced at the packaging stage in California. To overcome this the jars and their closures should be sterilised before filling.

(b) A plate mill is a well proven grinding method for seed of the size of shea nuts. The unit currently in use at the Project Field Office site is of Indian design and manufacture but comparable units are soon to be manufactured locally, and when available will be installed at other processing sites. In the meantime, traditional manual pounding of the nuts in a mortar is likely to remain the method used at the more remote extraction sites. This would not be expected to have any adverse effect on yield or quality but does increase the time and arduous nature of the operation.

(c) The analytical results have suggested that the major fall in oil quality, and rise in ffa levels, occurs between grinding and clarification. Damage to plant tissue is known to result in the release of lipase enzymes, which accelerate lipid hydrolysis, so the oil in the ground Nuts will be particularly susceptible to deterioration. To minimise this, there should be as few delays as possible between grinding, extraction, and clarification. On no account, for example, should the Nuts, after grinding, be left for long periods, e.g. overnight, awaiting pressing. This caution should be added to the Project Handbook.

(d) The value of water addition to the ground Shea Nuts before pressing to facilitate oil extraction is well understood by the Project personnel. Determination of the moisture content of the Nuts processed during the visit, together with the measurements of water addition made during the trial run, show that this particular batch was raised, by the Project personnel, to 13.4% - near the mid-point of the optimum range. A table indicating the quantity of water that needs to be added per kg of ground oilseed at different initial moisture contents to bring it up to the optimum level is given in Appendix 5, and this Table should be incorporated into the Project Handbook. However, in view of the virtual impossibility of accurately determining the moisture content of a batch of Shea Nuts in the field without specialised equipment, this Table should be considered as for general guidance only. As illustrated by the performance of the Project personnel during the trial run, it is not difficult to judge from the appearance and texture of the ground seed mass when the correct moisture content for pressing has been reached, providing mixing has been thorough. When a handful of seed mass is squeezed in the hand, oil will quite clearly emerge from between the fingers when the moisture content is correct. This area should be covered in more detail and emphasised more strongly in the Project Handbook.

Pressing

(a) Analyses carried out subsequent to the visit show that the trial run achieved an oil extraction efficiency of 40.6% and this would be considered disappointingly low in most oilseed processing ventures. It could easily be increased by urging processing staff to increase the pressure in the press. However, extraction efficiency using mechanised equipment in rural areas of developing countries is always a balance between increasing yield and revenue by working the equipment harder against the difficulties of maintenance, repair and spares availability if equipment components should wear badly or break. It is clear from the emphasis given in the Project Handbook to “screwing down the press plate only until turning becomes difficult”, and to “never use your full strength against the push bar or you will cause damage to the screw”, that the Project staff have opted to minimise equipment wear and maintain operations rather than seek maximum oil extraction levels, and this is understandable in the circumstances. The project personnel appreciate this, and also the benefits of applying pressure in a gradual, intermittent manner, waiting for oil flow to virtually cease before tightening the screw further - a point well stressed in the Project Handbook.

(b) The 56% OEE claimed in the Project Handbook (45kg of oil from 150kg of Nuts) is not impossible -it is routinely achieved using the method on coconuts and groundnuts in other countries - but it should be noted that the lower figure achieved during the trial run in Uganda (just over 40%) is similar, in fact higher, than that obtained on a regular basis in Ghana. An accurate estimate of the routinely attainable yield of oil will be required if any future investment in Shea Nut processing ventures based on the method is be considered. For this to be achieved, detailed data on the processing activities from many sites over an extended period will be required. A data collection system will need to be established. At its simplest, this could consist of Processing Record Sheets that are distributed to all processing sites accompanied by training for the operators in their completion. Basic Processing Record Sheets would cover, at least, the following items: Date; Weight of shea nuts processed; Volume of water added before pressing; Weight (or volume) of crude oil extracted; Volume of water added at clarification stage; Final weight (or volume) of clarified oil produced. It may also be necessary to provide additional measuring equipment, for weights and volumes, to processing sites.

(c) There is a problem with bag breakage in the press, which can lead to an excess of seed particles finding their way into the extracted oil. A heavier duty fabric with stronger stitching should be sought.

(d) It was noted both during assembly of presses for the trial extraction runs, and whilst measuring the dimensions of the other presses for comparison purposes, that there is considerable variation between individual units manufactured by SAIMMCO, Ltd., to the extent that many parts were not interchangeable. This could cause difficulties and delay in assembly and if spare parts are required. It is recommended that a draughtsman be employed for a short period to prepare detailed precise engineering drawings to ensure that future presses have identical dimensions. Alternatively, copies of the engineering drawings of the original press used in the pioneer work on the method at NRI on which the Ghana design was based, should be sought from the Institute at the following address:

Food Science Department,
Natural Resources Institute,
University of Greenwich,
Central Avenue,
Chatham Maritime,
Kent, ME4 4TB,
England.

Telephone: (+44) (0)1634 880088.
Fax: (+44) (0) 1634 880066.

Clarification

(a) The analytical results have suggested that the major fall in oil quality and rise in ffa level occurs between grinding and clarification. Although the period between grinding and pressing could account for this, delay between extraction and clarification could also be responsible. The crude oil has a high moisture content, water having been added to the nuts before pressing, which, coupled with the inevitable presence of damaged nut tissue particles containing lipases, can result in rapid deterioration. This period should therefore be as short as possible since both these factors are eliminated by heating the oil to 100ºC. Clarification and heating of the oil should thus be commenced immediately after extraction. The crude oil should not, for example, be left overnight to await further batches merely to ensure that the clarification vessel is adequately filled. This point should be incorporated into the Project Handbook.

(b) Clarification removes colour, mucilage, and seed particles from the oil, but, if the decanting procedure is not carried out with extreme care, there is the risk of reintroducing water into the oil. As a precaution, it is recommended that the clarified oil, scooped from the surface of the water, should be reheated to around 110^{o}C for 10 mins, to ensure that all traces of moisture are removed. It should then be allowed to cool again before filling the fractionation vessels. This additional step should be put in hand immediately, and the Project Handbook amended accordingly.

(c) For a possible longer term improvement to the procedure, tests on a small-scale should be carried out to examine whether the addition of small amounts of phosphoric acid or sodium hydroxide (caustic soda) to the water used for clarification, leads to any benefits. The former causes mucilaginous phosphatides to form heavier and more granular sediments which are less likely to contaminate the oil, whilst the latter will remove any free fatty acids that have developed in the oil during storage of the nuts, or in the period between grinding and clarification.

(d) It may be possible to avoid the use of water for clarification by heating the oil with bleaching earth and activated carbon, and passing the mixture through a filter press. The bleaching earth and carbon will remove the colour and provide a filter aid that will take out the seed particles and mucilage. Such a procedure should be tested on a small-scale before being considered for introduction into the field. Appendix 6 gives details of a suitable edible oil filter press.

Fractionation

(a) The quantities, compositions and characteristics of the olein and stearin fractions depend primarily on the temperature at which the separation occurs. Each of the various triglyceride species present in shea butter (more than 26 different species have so far been identified) has a specific solidification point at which it will crystallise, so the fractionation temperature will determine whether it appears in the liquid or solid phase. With the diurnal and seasonal variations in ambient temperatures found in Uganda, product yields and characteristics are likely to be very variable, and this is illustrated by the anomalous compositions of the two fractions analysed as part of the present study. It is considered essential that the fractionation procedure be put on a more reliable, consistent, carefully controlled footing. Ultimately, if both production and the market expand sufficiently, a mechanised fractionation unit which would control cooling, crystallisation and separation of the two fractions, may be justified, but at present the cost puts this out of the question - details of commercial fractionation plants will be found in Appendix 7. A much simpler and less costly solution suitable for the current scale of production would be to establish a thermostatically controlled air-conditioned room in Lira (possibly at the Project House) in which the fractionation vessels could be placed. Such a facility would also permit experimentation to ascertain the most effective fractionation temperature, maximising the yield of a stearin fraction acceptable to the buyer.

(b) The current separation method, filtration through muslin, is also unsatisfactory, with a portion of the stearin fraction passing through into the olein, and olein being retained in the stearin. Exposure to air at this stage was also thought by Project personnel to be responsible for the introduction of fungal contamination, but the microbiological tests carried out on the fractions indicate that these fears are probably groundless. A simple but relatively inexpensive method of separating the two fractions more effectively would entail use of a Büchner Filter Funnel and Flask, paper filters, with suction derived from a water operated vacuum pump. Installed in the temperature controlled air conditioned room referred to above, this simple filtration system could be used both for production runs and for experimental purposes investigating different fractionation temperatures.

Quality Control

As more Women's Groups are supplied with Bridge Presses, and Shea Butter production using the new procedure increases, the Project staff will find it increasingly difficult to monitor and supervise all production activities. The Project should be provided with a means of detecting batches of poor quality oil which may be produced by Groups who do not scrupulously follow the Handbook recommended procedures. This could be achieved by equipping the Project with suitable laboratory glassware, reagents and other equipment to enable it to routinely monitor incoming clarified oil from the Women's groups. Additionally, a small laboratory would enable stearin characteristics to be examined to ensure quality before export. The most important simple tests required would be free fatty acid content, which would permit unacceptable quality oil to be rejected, and Iodine Value, a measure of unsaturation and melting point as a check on both the incoming oil (to detect adulteration) and the stearin fraction. The facility would also be used during the recommended investigations into improved clarification, fractionation, and separation procedures.

Markets

The export market for the stearin fraction is at present limited to a single retail natural cosmetic chain in California and its total potential volume is unknown. It is recommended that additional markets for the specific Ugandan product be sought in other countries. The olein fraction could also be included in this exercise. Marketing of the olein fraction locally could also be pursued more positively, by, for instance, selling it to a Lira Market stallholder.

General

The financial status of the project appears superficially to be favourable; shea nuts purchased for UgSh 375 (US$ 0.38) per kg and stearin selling for US$ 60 per kg, but the yields of oil and stearin have not been clearly established, and operational costs have, in effect, a large element of subsidy from COVOL e.g. transport of nuts and oil locally, and shipment and packaging of the stearin. It is felt that the financial aspects of the venture have not yet been adequately examined, and this should be carried out before any major investment in production equipment, such as filter presses or fractionation plant, is made. Provision of laboratory scale equipment would, however, be warranted as a development and quality improvement initiative.

APPENDIX 1 - Itinerary

10 March - Depart London Gatwick Airport.
11 March - Arrive Entebbe Airport. Travel to IDEA HQ in Kampala,
- Briefing with IDEA Staff (Steve New) and COVOL representatives (Eliot Masters, Alisa Puga, Michael Kay, and Karmen Jaquez).

12 March - Perusal of relevant documents and earlier Reports on Project,
- Travel to Lira (352 kms north of Kampala).

13 March - Travel to Project HQ in Lira, then to the Project Field Office site at Adwari Corner, Otuke County (60 kms east of Lira),
- Visit two other processing sites to inspect equipment,
- Visits to potential suppliers of Shea Nuts for processing trials.

14 March - Travel to Project Field Office site,
- Demonstration of the process by Project Staff to a Women's Group visiting from Gulu,
- collection of samples from processing runs.

15 March - Travel to Project Field Office site,
- carried out fully monitored trial processing run, assisted by Project Staff (Anna Owia and Ester Adur),
- further samples collected,
- clarified oil set aside to fractionate.

16 March - Discussions on Project at Project House in Lira.
- Commenced drafting of Field Report.

17 March - Visited Lira Office of Appropriate Technology International who are sponsoring rural small-scale sunflower oil

extraction using a "Ram Press",
- Visited Cotton Ginnery to discuss local cottonseed processing,
- Completed first draft of Field Report.

18 March
- Visited Project Office in Lira to inspect and take detailed measurements of Presses,
- Travel to Project Field Office site,
- Inspected fractionation vessels and transported them back to Project House in Lira,
- Discussions with Project Staff on first draft of Field Report.

19 March
- Final visit to Project Field Office site, to discuss future prospects,
- Return to Project House, for final discussions and amendments to Field Report,
- Collection of sample of Olein Fraction.

20 March
- Travel to IDEA HQ, Kampala,
- Presented Field Report to IDEA HQ Officers,
- Debriefing with IDEA Staff (Clive Drew and Kaggwa Umran),
- Travel to Entebbe Airport, Depart for London, Gatwick.

1 April - Met Project Staff (en route to the USA) at London Gatwick Airport, and received sample of Stearin Fraction for analysis,

APPENDIX 2 - Placement of Bridge Presses

Location	Details
(a) Northern Uganda	
Adumara Village -	1 Press for Adumra Kuk Dura and Opeta Tworo Groups
Barjobi Village -	1 Press for Can Onotowa Group
Opejal Village -	1 Press for Aero Nyero Group
Cikke Village -	1 Press for Alok Abalo and Nyeko Abalo Groups
Anep Moroto Village -	1 Press for Note en Teko Group
Adwari Corner -	3 Presses for Training and Demonstration purposes at the Project Field Office Site
(b) Southern Sudan	
Akot -	2 Presses installed by JB Drilling, Ltd.
Akot -	5 Presses installed by Norwegian Peoples' Aid
Kato Keji -	5 Presses installed by Norwegian Peoples' Aid

APPENDIX 3 - Composition of Shea Nuts and Presscake

Component (%)	Uganda *Variety Nilotica*	Ghana *variety Mangifolia*	Presscake *(Uganda)*
Moisture Content	3.4	-	12.5

Oil Content (as is)	53.7	51.5	37.3
Fibre/Protein/CHO, etc.	42.9	-	50.2
ffa content of oil *	3.5	-	-

[* **ffa** (free fatty acid) content is an indication of deterioration in an oilseed or oil - hydrolysis of the triglyceride to produce un-esterified fatty acids - it is a standard measure used in commodity trading specifications]

Fatty Acid Compositions (%).

Fatty Acid	*	**Uganda** *var. Nilotica*	**Ghana** *var. Mangifolia*
Palmitic Acid	(16:0)	4.4	3.9
Margaric Acid	(17:0)	tr.	tr.
Stearic Acid	(18:0)	30.7	43.2
Oleic Acid	(18:1)	57.4	44.3
Linoleic Acid	(18:2)	5.8	6.3
Linolenic Acid	(18:3)	0.4	0.4
Arachidic Acid	(20:0)	0.8	1.2
Eicosenoic Acid	(20:1)	0.3	0.4
Docosanoic Acid	(22:0)	0.1	0.2
Tetracosanoic Acid	(24:0)	0.1	0.1
Total Saturated Acids		36.1	48.6
Total Mono-unsaturated Acids		57.7	44.7
Total Poly-unsaturated Acids		6.2	6.7
Total Unsaturated Acids		63.9	51.4

[* By convention, the number before the colon indicates the number of carbon atoms, whilst the number after the colon indicates the number of double bonds]

<u>APPENDIX 4</u> - Characteristics of Shea Butter and Fractions

	Crude Shea Butter	**Clarified Shea Butter**	**Shea Stearin Fraction**	**Shea Olein Fraction**
Moisture (%)	-	0.2	0.09	0.08
ffa content (%) *	5.4	5.0	5.4	6.3
Iodine Value **	-	64.5	63.0	69.5
Melting Point (Slip Point)	-	30.0ºC	31.9ºC	23.3ºC
Unsaponifiable Matter (%)	-	3.0	2.7	3.1
Total Viable Count (3 days at 30ºC)	-	less than 10	less than 10	less than 10

[* **ffa** (free fatty acid) content is an indication of deterioration in an oilseed or oil - hydrolysis of the triglyceride to produce un-esterified fatty acids - it is a standard measure used in commodity trading specifications]
[** **Iodine Value** is a measure of unsaturation also used in commodity trading specifications]

Fatty Acid Compositions (%).

Fatty Acid	*	**Shea Butter**	**Stearin Fraction**	**Olein Fraction**
Palmitic Acid	(16:0)	4.4	4.4	4.63.9
Margaric Acid	(17:0)	tr.	tr.	tr.
Stearic Acid	(18:0)	30.7	33.0	26.1
Oleic Acid	(18:1)	57.4	55.2	60.8
Linoleic Acid	(18:2)	5.8	5.7	6.8
Linolenic Acid	(18:3)	0.4	0.4	0.4
Arachidic Acid	(20:0)	0.8	0.8	0.8
Eicosenoic Acid	(20:1)	0.3	0.3	0.4
Docosanoic Acid	(22:0)	0.1	0.2	0.1
Tetracosanoic Acid	(24:0)	0.1	tr.	tr.
Total Saturated Acids		36.1	38.4	31.6
Total Mono-unsaturated Acids		57.7	55.5	61.2
Total Poly-unsaturated Acids		6.2	6.1	7.2
Total Unsaturated Acids		63.9	61.6	68.4

[* By convention, the number before the colon indicates the number of carbon atoms, whilst the number after the colon indicates the number of double bonds]

<u>APPENDIX 5</u> - Table for Addition of Water to ground Shea Nuts.

[To bring Bridge Press charge up to Optimum Moisture Content for new procedure]

Target Moisture Content (%)	**Initial Moisture Content (%)**				
	3	**4**	**5**	**6**	**7**
12	102	91	80	68	57
13	115	103	92	81	69
14	128	116	105	93	81
15	141	129	118	106	94

in mls (g) of water per kg of ground Shea Nuts

<u>APPENDIX 6</u> - Details of Filter Press

Available from **Johnson Progress, Stoke on Trent, Staffordshire, England.**

Specification assumes a nominal throughput of 250 litres per 8 hour day of Vegetable Oil containing about 1% w/v of suspended solids.

Model S 250 Type REBI Side Bar Filter Press.

Capacity 5.25 litres, having five Chambers, 25 mm deep.

Consisting of:-

Fabricated Mild Steel framework (7 bar),
Polypropylene recessed Plate Pack, Centre Feed, Bib Outlet, manual movement,
Hand operated hydraulic Closing, with spring assisted Return and Locknut,
Polypropylene Connection Plate and Feed Liner,
Polypropylene flat Drip Tray and Trough,
Woven polypropylene Filter Cloths,
Mild steel round Side Bars with stainless steel Sleeves,

Diaphragm Pump, complete with delivery pipework, valves and fittings
[Note: requires compressed air at 7 - 8 bar]

Painted, Assembled and Tested before dispatch.

Price, ex works, before packing: £ 2,898 (Approx. US$ 4,800)

APPENDIX 7 - Details of Fractionation Plants.

The two major Companies operating in this field:

- s.a. Fractionnement Tirtiaux (Fleurus, Belgium)
- N V Extraction de Smet, s.a. (Edegem, Belgium) - were approached for quotations for a fractionation plant with a throughput of 250 litres per 8 hour day, operating on Ugandan Shea Butter.

s.a. Fractionnement Tirtiaux

This company have installed over 150 fractionation plants over the past 20 years mainly operating on milk fat, beef tallow, hydrogenated soya bean and fish oils, and palm oil, and ranging in capacity from 12 to 600 tonnes per day. Their plants are fully automated with sophisticated control systems.

However they have very recently supplied a 1 tonne per day palm oil fractionation plant (which they described as a “Bush Plant”) to a West African country, designed to operate in a rural area, omitting the automated control systems, and using a standard vegetable oil filter press instead of the more complex continuous “Florentine” vacuum filters employed in the conventional larger plants. This plant had been priced at about US$150,000.

The Company spokesman considered that the cost of a similar, simple, even smaller plant of 250 litres per hour throughput, would be about US$ 75,000, but stressed that this was a rough estimate, not a quotation. They would require a sample of the Shea Butter (5kg) for investigative work before they would be prepared to issue a quotation for a customised plant with guarantees of performance.

N V Extraction de Smet, s.a.

This Company have installed 12 fractionation plants over the past 4 years ranging in capacity from 250 kg to 450 tonnes per day, operating mainly on palm oil, beef tallow, hydrogenated soyabean oil, and for the production of "specialty fats".

The Company's 250 kg per day fractionation plant is designated a "pilot plant" and is designed primarily for research and development purposes. Although the Company could give no guarantee of performance, it was felt to be suitable for the scale of operations envisaged, and would be flexible enough to allow the Project staff, after experimentation, to select the optimum conditions to maximise the quantity of stearin. A description of the plant, including specifications of the individual equipment components is given on the following pages.

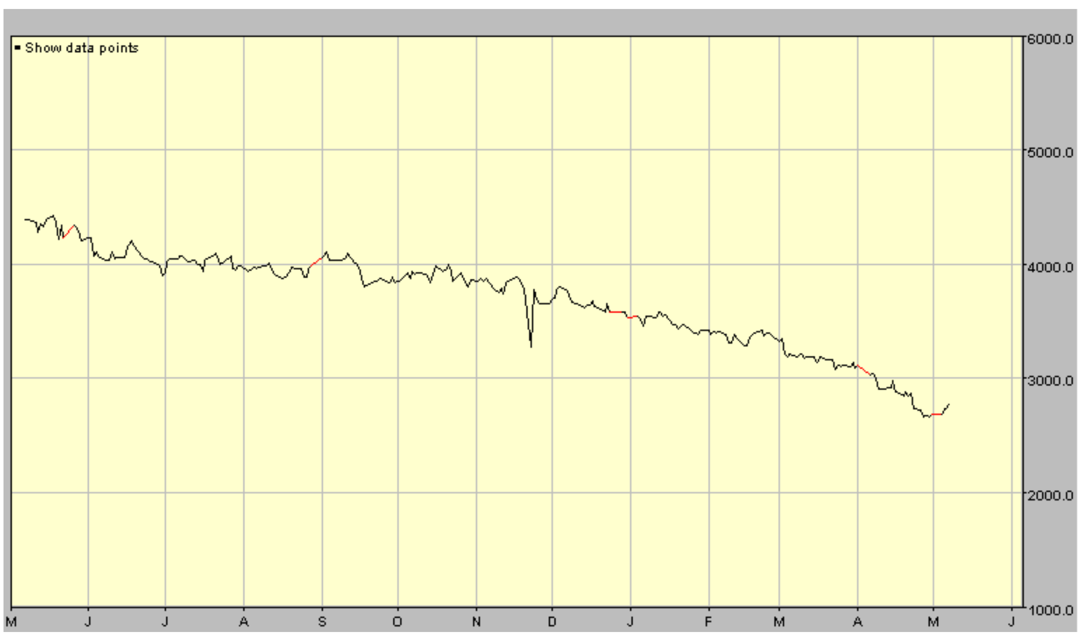
Price, ex works, before packing: BFr 4,000,000

(Approx. US$ 110,000)

Annex B:
Historical Trends in Cocoa and Cocoa Butter Prices

Table C1: CSCE Cocoa Futures ($/MT), May 98 – June 99

Table C2: Cocoa Butter, African type ($/ton), May 98 – June 99



Source: Public Ledger Online