FINAL TECHNICAL REPORT

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(NRI Project A0524)

April 1996 - March 1997

IMPROVED PROCESSING OF SHEA NUTS IN NORTHERN GHANA

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Executive Summary

The improvement of agroprocessing is a key feature of the Government of Ghana's National Agricultural Strategic Plan. Shea nuts have been identified as a second priority commodity. This research project aimed to work with local NGOs and the Technology Consultancy Centre (TCC) of the University of Science and Technology (UST) in Kumasi to carry out field tests on an improved method of shea processing in villages in the semi-arid region of Northern Ghana. The objectives were:

- To carry out studies into technical, social and economic factors of the shea butter extraction process and marketing systems
- To examine the marketing system for shea butter in Ghana
- To arrange local manufacture of the press
- To develop a strategy to facilitate the uptake of the technology

Shea nuts play an important part in income generation in semi-arid regions. Traditional processing is carried out by women and children and involves lengthy, arduous processes requiring large quantities of fuelwood and water which often have to be carried long distances from source to village. The improved process offers a reduction in processing time for 25kg shea kernels from 9.5 to 3.25 hours, water requirements are reduced from 90 litres to 1.7 litres and the need for fuelwood is completely eliminated. These savings will provide benefits to the villagers and conserve scarce resources.

The project started in April 1996 and ended on 31 March 1997 with funding totalling £46,690. Specific activities included:

- Identifying suitable villages for the field trials
- Arranging local manufacture of bridge presses and monitoring their performance
- Training women processors in the use of the press
- Monitoring of field trials to evaluate yield and acceptability of both process and product
- Carrying out an economic evaluation of the process
- Carrying out laboratory analysis of shea kernels, oil and cake samples
- Studying the domestic market for shea butter
- Preparing workshop drawings for construction of a bridge press
- Organising a workshop to discuss project findings

Background

Shea trees grow wild in the semi-arid parts of the equatorial belt of Central Africa in a region stretching from The Gambia in the west to Sudan in the east. Ripe fruit is collected by women and children and taken to the village for immediate processing. Firstly the green pulp is removed to expose the nut which is parboiled and sun dried. The nuts are then lightly crushed with a stone or wooden paddle to remove the outer shell and expose the oil-bearing kernel. The separated kernels are either sold immediately or stored for local processing, using traditional methods, into shea butter which is used for cooking or cosmetic purposes.

The production of shea butter is an important income earning activity for many women in rural areas of Northern Ghana and for some women it is their only source of independent income.

The Traditional Process

The traditional method of extracting shea butter is a time consuming, arduous process using large quantities of water and firewood, as shown below:

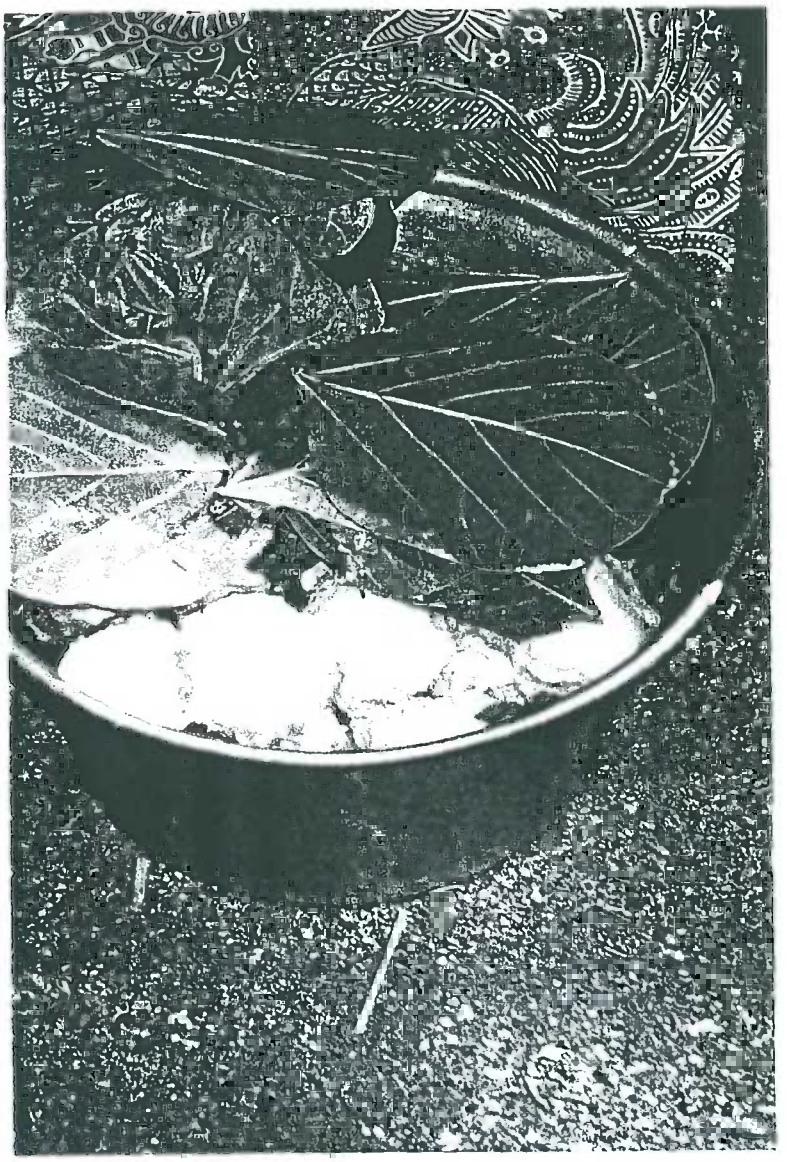
Process	***Time taken/25kg***	***Resources required*** **
Shea kernels		
↓		
Pounding	60 minutes	
↓		
Roasting	60 minutes	Fuelwood (0.5 headload)
↓		
Milling	60 minutes	
↓		
Kneading	180-240 minutes	Water (0.25 headload)
↓		
Rinsing	60 minutes	Water (2.75 headloads)
↓		
Boiling	90 minutes	Fuelwood (0.5 headload)
Total	**8.5-9.5 hours**	**4 headloads**

** 1 headload = approx. 30kg

Women processors complain that roasting the pounded kernels and boiling the extracted cream are hot, arduous tasks and that the kneading stage causes pain in the back and shoulders.

In the traditional process the residue after shea processing is dispersed in the rinsing water and thrown to waste. Anecdotal evidence indicates that the washing liquid may sometimes be used to paint the walls of houses as it is believed to have insecticidal properties.

Pats of shea butter on sale in Tabiase market

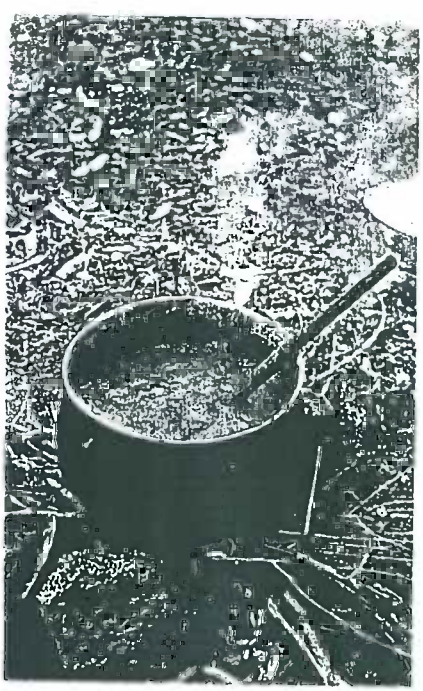


Stages in the traditional processing operation

Pounding

Roasting

Kneading



Boiling

Stages in the operation of the Bridge Press

Water is added to the milled paste

The paste is wrapped in cotton cloth and placed in the press

Pressure is applied and oil is extracted

The residue is removed as a solid block

Improved process - bridge press method
Collaborative work on shea nut processing between NRI and TCC in 1993 indicated the potential for using the bridge press to extract shea butter. This work showed, that the bridge press, used in conjunction with shea nut paste of an intermediate water content (between 11 and 13%), was efficient in the extraction of shea butter. The bridge press method offers considerable savings in time, fuel, water and labour as shown below:

Process	*Time taken/25kg*	*Resources required*
Shea kernels		
↓		
Pounding	60 minutes	
↓		
Milling	60 minutes	
↓		
Mixing /bagging	15 minutes	Water (2.5 litres)
↓		
Pressing	40 minutes	
Total	**2 hours 55 minutes**	**2.5 litres water**

In order to use the bridge press the dried kernels are pounded as for the traditional method. There is, however, no need to roast the pounded nuts before milling thereby saving time, fuel and labour. After milling there are no kneading or rinsing stages therefore removing the steps which cause pain. A small quantity of water is worked into the paste which is then wrapped in cotton cloth and placed in the press. Pressure is applied and the oil is extracted. The press has a capacity of 15kg, is operated manually and requires minimal effort to operate.
After the oil has been extracted the residue is removed from the press as solid blocks which can be sun-dried and used as a fuel. No further processing of the oil is necessary.

Project Purpose
To improve traditional agro-processes and by-product utilisation and to develop a strategy to facilitate the introduction of processing improvements for shea butter in Northern Ghana.

The country focus was Ghana, however, shea nuts are grown in sixteen African countries, Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Ghana, Mali, Guinea, Ivory Coast, Niger, Nigeria, Senegal, Sudan, The Gambia, Togo and Uganda.

Research activities

Identification of suitable villages for the field trials
Initial field trials carried out during 1995 (Swetman *et al* 1995) were discontinued due to problems encountered in monitoring the use of the press. In July 1996 the project leader and an NRI food technologist met with the staff of the Tamale Archdiocesan Agricultural Programme (TAAP) which works with village groups to develop agricultural activities. TAAP indicated their willingness to collaborate in field trials of the bridge press operation as this work was complementary to their development strategy and they had the resources to monitor presses regularly. Two villages in the Tamale area, Chanzegu and Kanfehiyili, were identified as possible sites for the location of presses as they had existing women's groups producing shea butter by traditional means for sale in local markets. Each village is regularly visited by a TAAP field worker, who agreed to undertake additional monitoring visits and to provide advice on the operation of the press.

In January 1997 a third press was installed in Tabiase near Wa. In this case the press was to be operated on a custom basis by a Farmer's Co-operative and will be managed/monitored by Technoserve (an American NGO) with the assistance of a Peace Corps volunteer based in Tabiase.

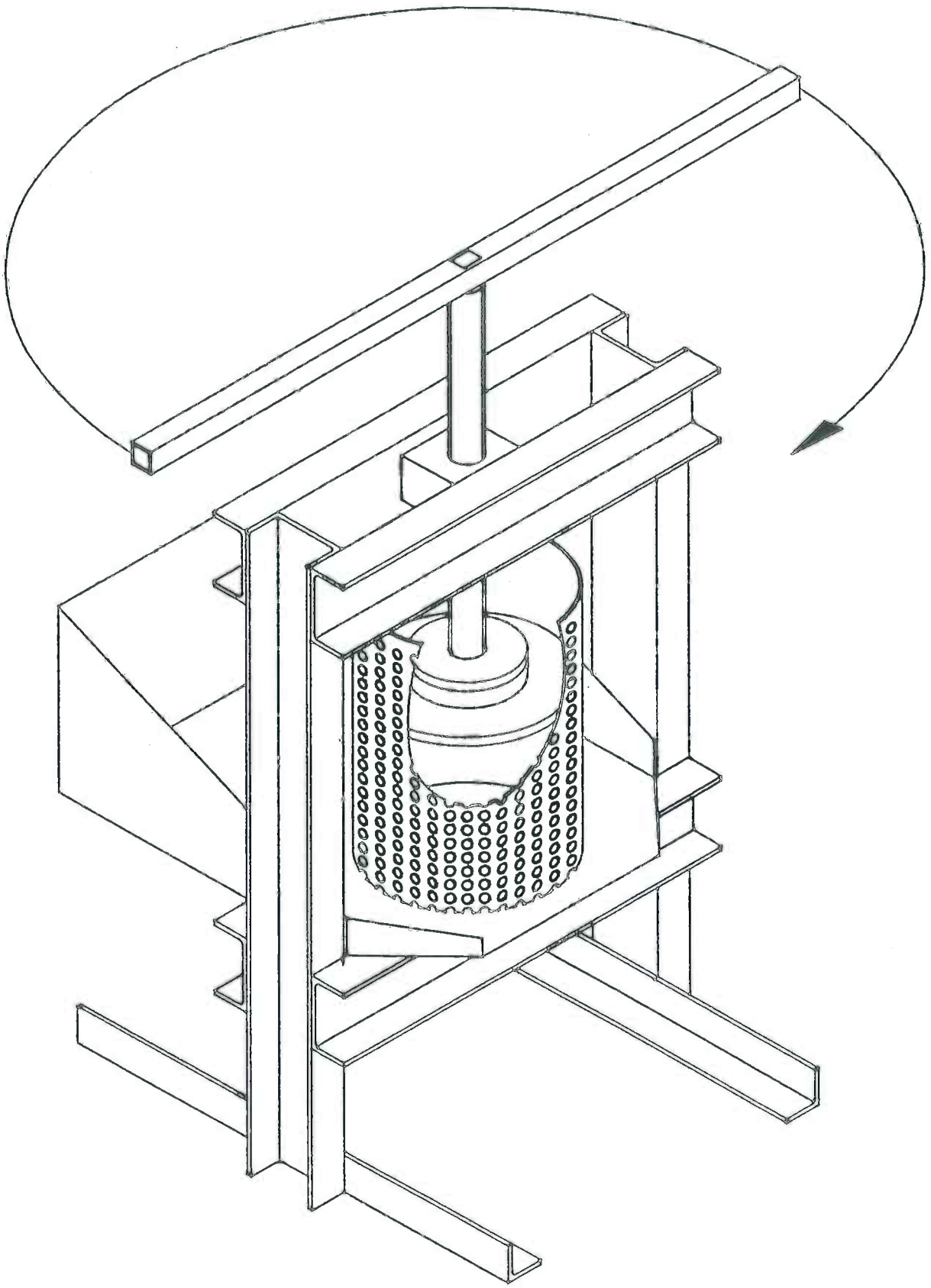
Preparation of design plans for construction of a bridge press
TCC constructed the first press using the original NRI plans drawn up as part of the collaborative research programme in 1993. This press was used as a pattern by the local manufacturers. NRI have designed, and prepared plans for, a modified press which requires no welding (it is designed to be assembled using bolts) and features a device to aid the removal of the press cake (Anstee 1997). An outline drawing of the press is shown below.

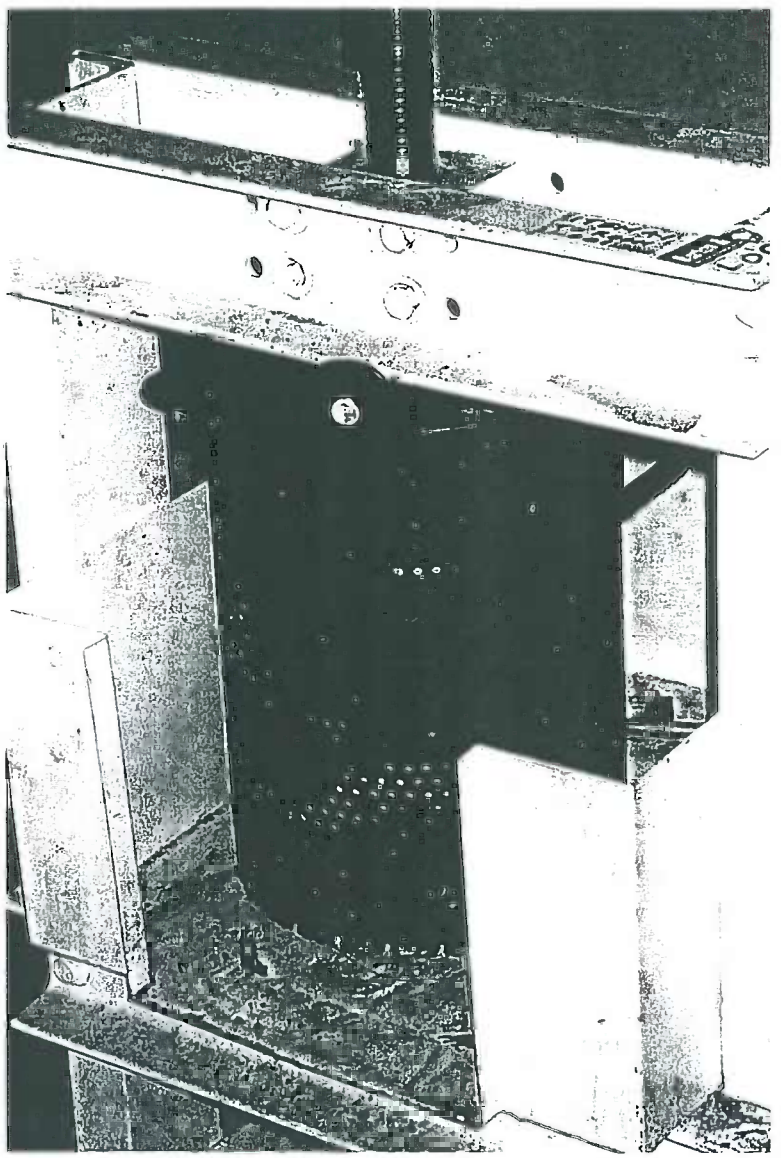
Local manufacture of bridge presses
The workshop of the Intermediate Technology Transfer Unit (ITTU) in Tamale was commissioned to produce two bridge presses based on a prototype produced by TCC. Minor modifications were made to the design to take account of locally available materials and to keep the cost as low as possible. Subsequently TAAP commissioned a third press to be made by an independent engineer.

Training women processors in the use of the press
In October 1996 a processing specialist from TCC and an NRI food technologist supervised the installation of the presses in two villages near Tamale and trained a group of the women processors and the TAAP field worker in their operation. NRI later repeated this exercise in Tabiase.

Monitoring of field trials to evaluate the acceptability of process and product and to determine the yield of oil obtained.
A simple monitoring system based on the number of bowls of nuts (average weight of each bowl 2.5 kg) and using easily available containers for volume (for example a gallon bucket and soft drink bottles) was devised. Each of the villages was regularly visited by the TAAP extension officer who recorded details of any processing carried out since his previous visit. No processing was carried out during November and December as the women travelled away from the villages to help with the cassava harvest. A summary of the results is presented overleaf.

NRI STANDARD BRIDGE PRESS





Date of monitoring visit	Number of bowls* processed since previous visit	Volume of oil obtained (litres)**	Yield of oil %
Chanzegu			
20/10/96	15 (38 kg)	13.6	33.5
29/10/96	22 (55 kg)	19.5	32.6
16/10/96	20 (50 kg)	20.5	44.5
8/1/97	40 (100 kg)	22.7	20.9
15/1/97	34 (85 kg)	31.8	34.1
11/2/97	55 (138 kg)	50.0	33.4
2/3/97	4 (10 kg)	4.5	41.9
Kanfehiyili			
17/10/96	15 (38 kg)	13.6	33.5
22/10/96	26 (65 kg)	24.3	34.5
30/10/96	32 (80 kg)	29.5	34.0
5/1/97	20 (50 kg)	18.2	33.4
14/1/97	20 (50 kg)	18.2	33.4
11/2/97	44 (110 kg)	40.9	34.2

* Average weight of 1 bowl = 2.5 kg
** 1 litre oil = 0.92kg

The results from the monitoring programme show similar yields to those recorded during more detailed studies carried out by the NRI/TCC team. Results indicated that the monitoring exercise was successful and that the women were able to operate the press efficiently.

Oil yield from NRI/TCC trials

Trial number	Weight of paste (kg)	Weight of oil (kg)	Yield (%)
1*	12	4.1	34.2
2*	11.1	3.75	33.3
3*	12	4.0	33.3
4*	13.4	4.3	32.1
5*	10	3.3	33.0
6*	9.3	3.0	32.2
7*	10	2.83	28.3
8*	10	3.01	30.1
9**	13.2	4.2	31.8
10***	12.4	3.8	30.6
11***	12.7	3.9	30.7
12***	15.8	4.9	31.0

* Chanzegu October 1996
** Kanfehiyili October 1996
*** Tabiase January 1997 - the women indicated that the nuts had been badly dried and would therefore be expected to give a lower yield.

Despite initial reservations about the process, the women reported that they found the press time-saving and easy to operate. Collection and carrying of fuel and water for processing was no longer required.

Satisfactory yields of oil were obtained from the press. Women reported that yields were equal to, or more than, they would have expected to obtain from traditional processing. When it was explained that the nuts did not have to be roasted, the women expected the shea butter from the bridge press to have a bitter flavour. However they did not find this to be the case and all stated that they preferred the flavour of the bridge pressed oil.

When the process was introduced to the villages, the shea nut paste for pressing was packed into cotton bags. These were initially supplied by NRI but were later manufactured locally from used flour sacks. Initially it was found that the bags were easily damaged by the press. Subsequent experimentation indicated that, instead of using cotton bags, the paste should simply be wrapped into a square of cotton material with an overwrap of woven polypropylene sacking. This practice was successful and welcomed by the women processors.

TAAP were very enthusiastic about the process and plan to install presses in three other villages in more remote areas. They also began a training programme to instruct the women in soap-making, using the shea butter, as a means of adding value to the product and to extend the marketing opportunities.

At the start of the trials (October 1996) the market price of kernels was relatively low at 700 cedis per bowl but by February 1997 the price had risen to 1100 cedis. This caused a cash-flow problem and may have restricted the women's usage of the press. This was particularly applicable to Tabiase where the women reported that few nuts were being traded. The women plan to store extra nuts when the during the July 1997 harvest to enable them to produce more butter with the press, particularly during the lean season when the market price of butter is increased.

Economic evaluation of the process

Financial analysis of the bridge press technology was undertaken and showed that the profitability of producing the shea butter with the traditional process is extremely low. While substantial increases in returns per woman hour can be gained by using the bridge press, the women must accept a reduced income per batch of nuts processed. This reduced income is especially significant during the repayment period, but also once the press is repaid the cost of the bags reduce the income gained per batch compared to the traditional process. The costs of the two processes were compared, assuming that the bridge press has a life of 10 years, and assuming an hourly labour rate of 90 cedis per hour. This analysis showed that the processing cost using the bridge press, at 469 cedis per kilogram of nuts, is not significantly lower than the processing cost of the traditional method of 471 cedis per kilogram of nuts. Nonetheless, for an annual turnover of 5 tonnes of nuts, the NPV of the bridge press is positive at just under 54 000 cedis and the IRR of 26% is higher than the estimated opportunity cost of capital (20%). Although costs of processing by the improved and traditional methods are comparable, the benefits of the new technology are:

- environmental (no need for fuel)
- time-saving (releasing time for other activities)
- process simplification

Laboratory analysis of samples

Moisture content

In order to obtain a maximum oil yield, the moisture content of the paste should be increased from a typical level of 7% to a level of 12±0.5%.

Paste samples were taken from some field trials and analysed at NRI, the results, shown below, confirmed that the correct quantity of water had been added.

Trial	1	2	3
Moisture content of paste (% m/m)	12.6	12.1	12.6

Oil content

The oil content of the nuts used in Chanzegu and Kanfehiyli was 52.1%. The oil extraction efficiency of the process was 61.4%.

Similarly, the nuts used in Tabiase had an oil content of 52.5%. The oil extraction efficiency was 58.7%. In these trials it was noted that the kernels were almost black in colour. Women processors explained that this colour showed that the nuts had not been properly parboiled and dried and that they would expect a lesser yield than that obtained from good quality kernels.

Oil rancidity

Samples of shea butter, produced from both traditional and bridge press processing were examined for signs of rancidity. Free fatty acid content is a measure of the degree of hydrolysis of oil resulting in the formation of fatty acids which may be associated with off flavours. The totox value (the sum of twice the peroxide value plus the para-Anisidine value) provides an indication of oil deterioration and a totox value less than 10 generally represents an acceptable product.

After initial analysis, the samples were stored for 75 days at a temperature of 30°C at 75% relative humidity and analysed regularly to detect any deterioration in quality.

The results (shown overleaf) indicate that, under forced conditions, shea butter produced by the bridge press process may deteriorate slightly more slowly than that produced by the traditional process. However, the butter from both the traditional and the bridge press method were both still acceptable after the 75 day storage period.

Storage trial of shea butter

	Free fatty acids (%)		Totox value	
Sample	Day 1	Day 76	Day 1	Day 76
Bridge press processing				
1	2.7	2.9	1.8	4.0
2	2.9	3.1	1.8	4.3
3	3.0	3.1	1.2	2.8
4	2.2	2.2	2.6	3.9
5	2.2	2.4	2.3	4.7
Traditional processing				
6	1.6	1.7	1.9	4.4
7	1.2	1.3	1.7	4.7

Polyaromatic hydrocarbons (PAH)

Two samples of shea butter produced from the bridge press, one using paste made from roasted kernels the other from paste from unroasted kernels, and one sample of traditionally processed shea butter were analysed for PAH contamination. PAH are organic compounds containing two or more fused carbon rings and have known carcinogenic and mutagenic properties and are produced by processes that involve incomplete combustion, pyrolysis and pyrosynthesis of organic matter. It has been suggested that levels of total PAH in vegetable oils should be restricted to ≤ 25 µg/kg (Gertz and Kogelheide 1994) although no international standards yet exist which restrict levels of PAH contained in oils. PAH levels in oils from a range of processes are being collated by NRI.

The results (µg/kg), shown below, suggest that PAHs are introduced into the oil during the roasting stage. Of the three samples tested only that from unroasted kernels met the proposed levels of acceptance. It also appears that oils produced using the bridge press method may contain lower levels of PAH than the traditional method. However it must be emphasised that these results were obtained from only three samples and before any conclusions can be drawn a more detailed study should be conducted.

PAH residues in shea butter samples (ug/kg)

Sample	Flouranthene	Pyrene	Benz(a)anthracene	Benzo(b)flouranthene	Benzo(k)flouranthene	Benzo(a)pyrene	Dibenz(ah)anthracene	Benzo(ghi)perylene	Total
1	15.8	7.2	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	23.0
2	37.3	29.2	7.5	3.8	2.1	3.7	N.D.	5.1	88.8
3	38.1	12.7	14.8	13.4	7.1	13.0	0.7	10.3	110.2

N.D. = not detectable
Sample 1 = bridge press using unroasted shea kernels
Sample 2 = bridge press using roasted shea kernels
Sample 3 = traditional processing

Study of existing markets for shea butter

The market system was analysed in and around Wa, Tamale, Kumasi and Accra. Shea butter is consumed widely in the North, principally as a cheap cooking oil and as a skin pomade in the dry Harmattan season. In Kumasi it is also used for cooking and as a skin pomade. The use of shea butter in Accra for cooking is limited to northerners living in the south and is principally demanded as a skin pomade. Only one company, Kassardjian, have recently become involved in the export of shea butter as opposed to the kernels. The Body Shop are also buying small quantities of butter each year for use in skin products. It appears that there is a potential for expansion in the export market for shea butter in Japan and Europe and some

local entrepreneurs are showing interest in shea butter for inclusion in the manufacture of beauty products.

Project workshop to discuss findings
A workshop was held in Tamale and was attended by local NGOs currently working with women's groups, a representative from Lever brothers, local shea kernel exporters and other interested parties.

An illustrated presentation describing the installation and operation of the bridge press and highlighting the differences between the traditional and bridge press processes was made. All participants were provided with an illustrated handbook detailing the construction and operation of the press (Hammond et al 1997). Project participants highlighted the following constraints which they felt should be addressed by any technology transfer initiatives following the R&D carried out within these project activities.

- Credit requirements (both capital and operational)
- Regular use of the press to provide cash flows
- Identification of markets for the product

The mechanisms which could be called upon to address these constraints in Ghana were discussed and the need for effective training in the operation of the press and in the running of small-scale business enterprises was recognised.

The workshop participants were taken to Kanfehiyli for a demonstration of the process at which the speed and simplicity of the process were appreciated. Proceedings of the workshop were distributed to all participants (Swetman 1996)

Outputs

Graham Anstee: Workshop drawings of the bridge press. NRI 1997

Lynda Hammond, Graham Anstee, Peter Donkor and Lawrence Wumbeidiow: Handbook of shea processing using a manually operated bridge press. NRI March 1997

Tony Swetman and Lynda Hammond: Proceedings of a workshop on shea nut processing held at the offices of the Tamale Archdiocesan Agricultural Programme, Kumasi Road, Tamale on 18 March 1997

Ann Gray: Socio-economic investigation of improved processing of shea nuts in northern Ghana. NRI report. March 1997

Ann Gray: Back-to office report (BTOR) October 1996

Tony Swetman: BTOR July 1996

Lynda Hammond: BTOR October 1996

Lynda Hammond: BTOR January 1997

Lynda Hammond: BTOR February 1997

Tony Swetman: BTOR March 1997

Contribution of outputs

This project was formulated to address Purpose 2 of the Semi-arid Production System (Efficiency of Small-Scale Agroprocessing Improved).

This project has provided evidence that the bridge press technology is a technically-viable option which offers savings in fuel and water. Research has highlighted that the process is socially acceptable and is financially viable. The technology can be manufactured in-country and can be maintained locally. Moreover the process has been well-received by women processors who consider the extraction efficiency of butter to be greater than that of the traditional process. The process also has advantages in terms of an additional product (slabs of shea paste residue) which finds use as a fuel in these arid regions where this commodity is scarce.

The project has put into place the essential elements which are necessary for technology transfer: workshop drawings of the press; dissemination material (handbook on press-use, workshop with full interaction of NGOs and others active in technology transfer); areas which are considered by in-country collaborators to be constraints to technology transfer (credit requirements - both capital and operational; regular use of the press to provide cash flows and identification of markets for the product).

The project, although carried out in Ghana, has strategic value as shea nuts are grown in sixteen African countries: Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Ghana, Mali, Guinea, Ivory Coast, Niger, Nigeria, Senegal, Sudan, The Gambia, Togo and Uganda.

References

Swetman A, Stringfellow R and Anstee G. Progress report on improvements to rural oilseed processing in Africa. February-September 1995. NRI Report.

Gertz C and Kogelheide H. Investigation and legal evaluation of polycyclic aromatic hydrocarbons in vegetable fats and oils. Fett-Wissenschaft Technologie 1994 96(5) 175-180