

**INTERMEDIATE MOISTURE CONTENT METHOD
OF COCONUT OIL EXTRACTION COCONUT OIL
IN TANZANIA:**



A Final Report

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“IMPROVING THE SMALL-SCALE EXTRACTION OF COCONUT OIL”

Final Report on Sub-Objective 2.2 -

Intermediate Moisture Content Method in Tanzania

Background

The promotion of improved small scale coconut oil processing in Tanzania started in the financial year 1991/92. During this time a team of experts from the Natural Resources Institute (NRI), of Chatham Maritime, Kent, England worked hand in hand with the National Coconut Development Programme (NCDP), of Dar es Salaam, Tanzania, in testing three types of coconut graters and a bridge press. The initial trials of the graters were conducted at the campus of the NCDP and later taken for demonstration and general field testing to the villages of Mlingotini, Madanga and Mji mpya of Bagamoyo, Pangani and Muheza districts respectively. Much as oil processing activities are performed by women members of the rural as well as urban households in Tanzania, the trials were generally carried out with women groups.

The bridge press on the other hand was evaluated through an experimental unit which was set up at the Tanga-based Mlingano Agricultural Research Institute.

The results of these early field trials made a bench mark for a collaborative project between the NRI and the NCDP that aimed at developing and field testing improved techniques for the extraction of coconut oil at the small rural and domestic scale.

Starting in 1993/94 the three years project is funded by the Common Fund for Commodities (CFC), Amsterdam, The Netherlands. Other collaborators in the Project are Ghana, Côte d'Ivoire, Indonesia, India and Sri Lanka.

The Project is subdivided into a number of components, defined by the CFC as “Sub-Objectives”, which cover different technical approaches to the problem of small scale coconut oil processing. The NCDP has been collaborating in three of the sub-objectives, namely:

- Sub-Objective 1.1: Improving Aqueous Processing Techniques
- Sub-Objective 2.1: Use of the Ram Press.
- Sub-Objective 2.2: Examination of the Intermediate Moisture Content Method.

The work programme within each Sub-Objective was defined by the CFC as a series of numbered activities. This Report details the work in Tanzania on the sub-objective 2.2 - Examination of the Intermediate Moisture Content Method. Other collaborators in this project sub-objective are Ghana, Côte d'Ivoire and Sri Lanka.

The activities of this sub-objective included:

2.2.1.1 - An Experimental programme aimed at resting the efficiency of the Intermediate Moisture Content Method, and developing a procedure suitable for local circumstances.

2.2.2.1 - Selection of sites for field trials and for evaluation of the technique

2.2.2.2 - Field Trials at selected rural sites

2.2.2.3 - Assessment of the financial viability of the technique and the socio-economic implications of its introduction at the various trial sites.

2.2.2.4 - Monitoring of the performance of the technology in various trial sites

2.2.2.5 - Dissemination of the findings of the project including the technical performance, efficiency and yields of the method and socio-economic implications under local conditions.

Introduction

Research work at NRI in the early 1990's had examined the factors that influenced the extraction of oil from oilseeds. A relationship was found to exist between the pressures needed to obtain good oil extraction yields and the moisture content of the seed, with an optimum moisture content (usually between 12 and 15%) at which the pressures required were at their lowest.

This finding prompted the proposal that relatively low pressure manual presses would be suitable for oil extraction provided the oilseed's moisture content could be brought to the optimum level. Most oilseeds are marketed in a dry state (usually at around 3 to 5% - in equilibrium with atmosphere) and it is a relatively straight forward matter to add a calculated quantity of water to the seed to bring it up to the required moisture level. Such a technique has been successful with sunflower seed, groundnuts, and shea nuts in other parts of Africa.

With coconuts, however, this is more difficult since fresh coconut kernel has a moisture content approaching 50%, and bringing this reliably and precisely down to the optimum level is impracticable in a rural situation, given the difficulty of accurate moisture content measurements without expensive equipment.

The experimental programme, carried out at the Mlingano Agricultural Research Institute in collaboration with NRI, therefore focused largely on developing a simple procedure for producing a grated coconut raw materials at the moisture level required for a low pressure press. In addition it had to be established whether the oil produced by the method was acceptable to the consumer as an alternative to oil produced by the traditional aqueous process.

The Experimental Programme

The simplest technique, in a rural environment, for yielding grated coconut kernel at the intermediate moisture content required appeared to be to mix fresh coconut gratings with fully dried grated coconut. Mixtures of various proportions were therefore prepared and pressed.

Experimental sun drying of coconut gratings, thinly, spread on a concrete surface covered with plastic sheet, revealed that the moisture content could be reduced to around 3% in about four hours. Wet grated coconut was assumed to have a moisture content in the region of 50%, and it was mixed with the sub-dried material in the proportions 17: 100, 19:100, and 20:100. These ratios were expected to give batches

with final moisture contents in the range of 10% to 12%, which had been found by NRI to give the best oil extraction efficiencies.

Five hundred gram lots of the mixtures were placed in cotton cloth bags and loaded into a manually operated bridge press, originally developed by NRI for the extraction of oil from digested oil palm fruit. Brought to Tanzania by the NRI, the bridge press is a low pressure machine which uses an intermediate moisture content method to extract the oil contained in oil seed crops. The oil seeds or in this case coconut gratings are pressed slowly and with maximum pressure by a plunger or round steel plate. The material to be pressed is forced down by a screw and into a cylinder with a large number of small holes (see drawing 1).

Batch sizes from 6 kg to 14 kg were pressed using this press. The force applied to extract the oil was increased gradually to reach a maximum pressure after about 30 minutes.

The results of several runs appear in appendix 1, and show that the best extraction rate was obtained at a batch size of around 9 kg using a wet and dry coconut ratio of 19:100. All the press runs however, indicated that a good yield of oil could be produced by this method in Tanzania, and that the oil could be produced in the space of a single day.

The oil produced by the method is water white in colour, and has the sweet odour and flavour of fresh coconut. It is thus distinct from the light brown oil with a toasted coconut smell derived from the traditional aqueous process.

Drawing 1: A Bridge Press

Site Selection

Comparison of the oil originating from the bridge press with that from traditional processes was assessed through a consumer survey that was conducted in the following villages of Tanga region:

Table I: Villages Participating in Consumer Survey

Village	District
Kicheba	Muheza
Mkuzi	Muheza
Kilulu	Muheza
Mlingano	Muheza
Mwera	Pangani
Madanga	Pangani
Kirare	Tanga

The survey involved 214 non-professional food tasters from the seven villages. Foods that were cooked or fried with the two oils for testing included manioc (cassava), cabbages, rice, pan-cakes (chapati), meat and fish.

Results of the survey indicated as per table II the advantages of the bridge press and bridge press oil over the traditional aqueous oil processing method:-

Table II: Comparison of Traditional Method with Bridge press

Traditional aqueous oil Extraction Method	Oil Extraction by the Bridge Press
Water is used during the process	Water is not needed during the oil extraction process
Oil is processed over 2 days	Oil is processed on the same day
Fire wood is needed as a source of energy for boiling	One is friendly to the environment by sparing on fuel wood utilisation
The oil is light brown oil with a toasted coconut smell	Oil is water white in colour, and has the sweet odour and flavour of fresh coconut

Despite all the advantages given to bridge press oil, the traditional oil was however, slightly preferred for frying. The two oils were generally, equally acceptable for the preparation of food.

On the basis of this experimental work, the following procedure was adopted for the field trials:

1. Select 45 mature dehusked coconuts of the same size.
2. Set aside 5 coconuts from this batch.
3. Grate the remaining 40 coconuts and dry them in the sun for about 4 hours on mats or plastic sheets. The area selected for the drying should be out in the fields and free from dust and interference by animals and children. Cassava drying areas would be suitable.
4. After the 4 hours drying, gather the dried coconut gratings, divide it into 5 equal portions and put the portions into containers of the same size so that the same level of dried coconut is in each of the containers.
5. Now grate the 5 coconuts that were set aside and without delay add one grated coconut to each of the 5 containers. Mix well the wet and dry coconut portions.
6. Divide the contents of each container into two and put each half into a cotton bag. Close the bags by using the draw cords and load them into the bridge press.
7. Press the oil out from the coconut gratings in the bags by applying pressure for about 30 minutes. This pressure should be applied slowly and only built up to maximum towards the end of the 30 minutes.
8. The oil obtained should be filtered through a cotton bag to remove any fragments of coconut gratings that may be present.

The entire oil extraction process should be completed in one day. If this is not possible, the process can be halted after the grated coconut has been dried in the sun for 4 hours and before the final 5 coconuts are grated. The dried grated coconut must be carefully sealed in plastic bags and stored under cover overnight. The process should then be continued the following day by grating the balance of 5 coconuts. The gratings of these

freshly grated coconuts are added to the dried grated coconut. From here the oil extraction process is then carried out in the normal way.

Field Trial at Selected Rural Sites

The characteristics of the new procedure were discussed with the Kicheba Women's group, and the benefits considered. They commented favourably on the amount of labour that the process saved and that no firewood or water was needed to extract the oil. Use of the press saved at least half the time taken to extract oil by the traditional process. The press was transferred to their village and they undertook to continue using the process, under the supervision of NCDP, so that it could be tested over a longer period.

To extend the field trials the NCDP procured two extra presses and placed them at Msonge village in Zanzibar and one at the NCDP headquarters in Dar es salaam. The NCDP stationed press served for training and demonstration purposes

To complement the activities of the NCDP, the Tanzania Freedom from Hunger Campaign (TFFHC) purchased 5 bridge presses from Chuwa Workshop in Ubungo Kisiwani. These presses were given free of charge to 3 women groups in Zanzibar and one in Mainland Tanzania. The location of the beneficiaries is as shown on table III below.

Table III: Groups Served with presses from TFFHC

Group Name	Village	Number of Members
Kikungwi	Kikungwi	10
Mto wa Pwani	Mto wa Pwani	12
Vumilia Women Group	Pale	11
Tekla Bwire	Mtoni Kijichi, Temeke district	7

One private innovator of Ubungo Kibangu, Kinondoni district purchased a press which he has up to now not put into effective use.

With Mrs Bwire owning 2 presses from the TFFHC the total number of bridge presses in use within the coconut growing belt amounts to 9.

Socio-economic Viability

A preliminary examination of the financial aspects of the use of the method indicated that the cost of the bridge press could be recovered after producing between 400 and 900 litres of oil depending on the oil yield, nut prices and oil and machicha value assumptions made. Cheaper presses could probably be manufactured in Tanzania, but the press clearly has to be used intensively to make the intermediate moisture content method a worthwhile alternative.

In 1994 for example, presses that were manufactured by the Dar es salaam-based Space Engineering, sold at Tsh. 110000/= (ca. US \$ 260). The high inflation rate in Tanzania taken into consideration, a bridge press should be costing more than Tsh. 200000/= (> US \$ 330) at 1997 prices.

With minimum monthly salaries of government employees being in the range of Tsh. 30000/= (US \$ 50), the price of the bridge press is no doubt very expensive for the targeted private women entrepreneurs as well as for the women groups.

Manufacturing the press in the rural areas of the country is not possible because very few of the villages have electricity for welding the parts.

The Institute of Production Innovation (IPI) of the University of Dar es salaam is thinking of making modifications on the spindle and cage so as to improve the oil extraction efficiency. Manufacturers who have indicated their ability to produce prototypes of the press include Karume Technical College of Zanzibar, Space Engineering, Chuwa Workshop and the IPI.

As far as the use of the press is concerned, it has always been a problem to bring the group members together for common action despite constant monthly visits that included retraining on economic operation of the press.

Keeping reliable data on the groups daily activities has also been a constraint.

Under-utilisation of the press by some operators has been expressed as being caused by fluctuations on nut supplies. It is very unfortunate that the low yielding capacity of the Tanzanian palms is attributed to a number of constraints that include the presence of unfavourable weather conditions in particular inadequate and unevenly distributed rainfall such as that of 1996/97.

From a technical point of view the major problems on the press have been that of quick bending of the pressure plates and wearing of the cloth bags.

Members of Pale village oftenly complained of being over occupied with farm work that left very time for operating the press. Some members of the same group attributed their failure to put the press to effective use on the old age of some the members who happen to be very influential.

Monitoring the Performance of the Technology

The technology on oil processing using the bridge press has been monitored on a monthly basis. The number of trials conducted by the various groups are indicated on table IV below.

Table IV: Performance of the Technology

Village	Batch & Number of nuts					Oil Extracted (lt.)				
	1	2	3	4	5	1	2	3	4	5
Pale	33	49	29	40	0	2.25	3.00	1.69	1.5	0
Kicheba	90	135	146	215	110	4.5	5.25	6.375	8.625	5.25
Kikungwi	443	0	0	0	0	34.5	0	0	0	0
Mpapa	3746	0	0	0	0	251.6	0	0	0	0
Total	4312	184	175	255	110	292.85	8.25	8.065	10.125	5.25

When expressed as percentage of the weight of gratings that were pressed, the average amount of oil that was extracted in all test villages is 4.924%.

The average price of nuts in the villages is between Tsh. 10/= and Tsh 20/= whereas the resultant oil sells at Tsh. 450/= to Tsh. 550/= per $\frac{3}{4}$ litre bottle. It is apparent that Kicheba used small and immature nuts, hence the low oil yields.

The group at Mto wa Pwani has over time disintegrated as a result of social disagreements between the members. The press given them is consequently only stored pending the decision of the TFFHC.

The press that was located at Msonge village has been shifted twice for lack of commitment by the group members. Initially it was shifted to Mpapa and later on to Zingwezingwe village.

Fry Dry Method

During rainy seasons the women groups at Kicheba and Pale complained of being unable to process any oil. As a result of this the Kicheba group was trained on the extraction oil using the Fry Dry Method. In this method, coconuts are grated and later fried using low heat from firewood. The gratings are turned frequently until they reach a moisture content of about 14%. At this moisture oil can easily be pressed from the gratings using the bridge press.

The Kicheba women group grated a total of 60 coconuts out of which they fry dried a total of 3234 grams of gratings due to rainy weather conditions. The fry dried gratings were pressed in the village bridge press to obtain 1211 grams of oil at an oil extraction efficiency of 65.4%. The moisture content of the fried gratings was later analysed in the post harvest technology laboratory at the ARIM to be 16.5% while that of the resultant wet residue was 22.8%. Other data related to the analysis of the Kicheba sample are as shown on appendix II.

The limiting factor to the fry dry method in Tanzania is its demand for fuel wood which is becoming scarce and more expensive everyday. Not only this but the processor has also to be on the watch while frying to avoid over heated / over dried gratings which will give a smelly oil.

Recommendations

Studies conducted by Bagachwa (1993) and other economists have identified finance as being one of the major stumbling blocks to the growth and expansion of small and medium scale enterprises in Tanzania and in many other countries South of the Sahara. In view of this and in view of the fact that bridge presses are expensive, the future prospects of the intermediate moisture content method as an appropriate technology for the rural masses in Tanzania is not very bright. The instability of the Tanzanian shilling vis a vis international foreign currencies makes the purchasing power of the people lower and lower every other day leaving no balances for the purchase of an expensive technology like the intermediate moisture content method.

On the other hand the potential villages for the utilisation of the technology are not credit worth in the formal banks in the country. Despite this however, interested group members could voluntarily establish village-based self-reliant co-operative savings and credit societies (SACCO). From these societies which have been lawfully established by the Tanzania Co-operative Society Act number 15 of 1991, and which are currently very popular with cash crops production in the country, the groups could finance the purchase and management of the technology. Shares and membership fees into these societies could initially come from the sale of fresh nuts and oil accruing from the traditional method. The commitment by the members to establish this funding source is very vital for the sustainability of the technology.

An alternative to the establishment of SACCOs is for Non-Governmental Organisations (NGOs) such as the National Income Generation Programme (NIGP), Credit Scheme for Productive Activities of Women in Tanzania (Crew Tanzania), Poverty Africa and Promotion of Rural Initiatives and Development Enterprises (PRIDE Tanzania) to finance groups that are well organised or simply guarantee them in securing a credit from some financial sources.

The villages of Kicheba and Pale happened to have had formal groups at the time of selecting collaborating trial villages. Experience from their performance over the years has however, indicated that they were chosen without their own consent. They should have been given time to discuss the feasibility of the trial with their members and a consensus reached as to how and when they were going to operate. Seldom did they touch the equipment in absence of a monitoring team from the NCDP.

Villages such as Mwera in Pangani and Mpapa in Zanzibar could have performed better because they also happen to be located in areas where there are surpluses of coconuts and seem to be more interested. These and a lot of other potential villages will be approached during the project's dissemination phase.

Although the technology is expensive its adoption is called for because of its multiple advantages over the traditional aqueous coconut oil processing, particularly so the higher quality of the resultant oil. Much as the current generation of Tanzanians is more interested in quality rather than quantity, this aspect should serve as a centre for advertising the equipment and the technology in general during the dissemination phase. The mass media (television, radio and newspapers), group approaches and individual contacts with the potential and active small scale coconut oil processors will be used to drive home the message.

Although it costs more to process oil through the fry dry method, its application is appropriate during the short and long rain seasons when sun drying of gratings becomes almost impossible or takes many days. The technology may in view of this sell very well in Pemba, Zanzibar, Mafia and Pangani where annual rainfalls are comparatively higher.

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ARIM is not synonymous to NCDP, but it has since 1995/96 taken up the main research and development activities of the NCDP that was officially closed on the 30th. June 1996.

Appendix 1: Results from the Experimental Programme on Intermediate Moisture Content Method

Experiment No.	1	2	3	4	5	6	7
Dry Grated Coconut (kg)	7.36	12.03	11.41	10.86	9.87	6.00	6.38
Dry Grated Coconut mixed with Coconut (kg)	1.39	2.29	2.28	1.84	1.88	1.08	1.55
Ratio [Wet : [Dry	19 : 100	19 : 100	20 : 100	17 : 100	19 : 100	18 : 100	24 : 100
Total Coconut Pressed (kg)	8.75	14.32	13.69	12.70	11.75	7.08	7.93
Estimated content of Oil (kg)	5.49	8.97	8.60	7.99	7.35	4.45	4.87
Oil Produced (kg)	3.65	4.80	5.01	5.23	4.30	2.55	3.10
Oil Extraction Efficiency (%)	66.50	53.50	58.30	65.50	58.5	57.3	63.7

Note:

The moisture content of Sun-Dried grated coconut was assumed to be 3%, whilst that of Fresh (Wet) Grated Coconut was 50%. The estimated quantities of oil in the material that was pressed were calculated assuming a 70% oil content of coconut kernel, on a moisture free basis. Comparison of this figure with the actual yield of oil obtained, provided a value for the Oil Extraction Efficiency (OEE), expressed as a percentage.

Appendix II: Intermediate Moisture Content, Kicheba Village Data

Input		Products Out			
		Oil		Residue	
Number of coconuts sun dried	14				
Wt. of moisturised gratings processed	3234 g	Wt. of isolated oil	1211 g	Wt. of residue	1866 g
MC of grated kernel	16.5%	Extraction Efficiency	65.4%	MC of wet residue	22.8%
Dry Wt. of kernel processed	2700.4 g	OEE by difference	67.7%	Dry Wt. of residue	1440.6 g
Oil content of grated kernel (MFB)	68.6%			Oil Content of Residue (MFB)	43.8 %
				Wt. of oil in Residue	630.9

Mass Balance for Dry Matter

Input	Oil	Output Residue	Weight Out	% Loss	
Coconut	2700 g	1211 g	1440.6 g	2651.6 g	1.9
% Dist. in Product	-	44.8	53.3	98.1	-

Mass Balance for Oil

Input	Oil	Output Residue	Weight Out	% Loss	
Coconut	1852.5 g	1211 g	630.9 g	1841.5 g	0.5
% Dist. in Products		65.4	34.1	99.5	-