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ASSISTANCE IN THE DESIGN OF A PROTOTYPE PALM OIL EXTRACTION PRESS FOR RURAL AREAS

SI/CMR/82/801
CAMEROON

Technical report: Assistance in the design of a Prototype Palm Oil Extraction Press for Rural Areas *

Prepared for the Government of Cameroon
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Leslie D.G. Coward,
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United Nations Industrial Development Organization
Vienna

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A B S T R A C T

UNIDO were requested by the government of the Republic of Cameroon to give assistance in the design of a prototype palm oil extraction press for rural areas. The number of the project was SI/CMR/82/801/11-01/31.9.B. and it was for a period of one month at Yaoundé with one week of research prior to departure. During the week the expert would review the range of existing presses particularly those in use in developing countries.

The objective was to design a prototype press which could be purchased and used by farmers with 2 hectares of land, and about 10 tonnes of palm fruit bunches per year to process. In view of the limit of 100,000 cfa (215 $ US) which was placed on the purchase price of the press it was decided that an 8 tonne hydraulic automobile jack would be used as the power source. It was necessary to design the cage to give the optimum cake pressure, and cage capacity for the size of the press. A cake pressure of 40 kg/cm2, and capacity of 7kg of fruit pulp was used. The press was given successful commissioning and field trials with wild Dura, mixtures of Dura x Dura, and Tenera fruit.

The necessity to optimise fruit pulp temperature at 70-90°C during pressing, and to ensure that there are not less that 40% or more that 60% of nuts in the cake was emphasized. Pretreatment of fruit prior to pressing, and correct cake pressure in the press are prerequisites to ensure efficient pressing and obtain efficiencies of 70-80%. The need to pulp the fruit thoroughly (digestion) was also stressed.

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There is a growing reaction against hard physical work at the high temperatures caused by the proximity of the various fires needed for the preprocessing of palm fruit. It is recommended that further development work be carried out on simple inexpensive methods of digesting such as a well designed hand operated stirrer for use in reheating and digesting the fruit. This device if effective would mean that it would no longer be necessary to pound the fruit in mortars as well as stirring the pulp with sticks in the reheat drum.

The press can be produced at just under 100,000 cfa.

INTRODUCTION

The "Centre National d'Etudes et d'Expérimentation du Machinisme Agricole" has been investigating the production of oil from oil palm. The United Nations Industrial Development Organization was asked, by the Cameroon Government to provide an expert to assist in the development of an oil palm press for use by the farmers in the rural areas.

The project began on 24 September 1984, and was completd on 25 October 1984. Although the job description for SI/CMR/8 /801/11-01/ 31.9.B gives the purpose of the project as providing assistance to the Government in the design of a prototype palm oil extraction press for rural areas, it is not possible to disassociate the press design, from the preprocessing of fruit, which is essential before pressing takes place. Indeed if the preprocessing, which is both tedious and labour consuming, is not carried out well, the efficiency of any press will be drastically reduced. The project was actually put in hand in 1982, but because the post was not filled until 1984, CENEEMA had already carried out some work, and had manufactured a hand operated hydraulic press using an automobile jack to power the ram. They had also used the Colin hand operated expeller to provide them with design information for their own oil palm expeller. Some trials carried out in the field during August of this year indicated that the Colin type expeller could express oil from Tenera fruit, but that there was a possibility that its efficiency could be improved. It was quite expensive to manufature, and would only be used by fairly large cooperatives.

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The hydraulic press trials were not very successful, and that particular design was abandoned. During early discussions on the project it was agreed by the author that he would undertake redesign of the hydraulic press, and that he would endeavour to improve the processing of the fruit which has to take place prior to the expression of oil if either the hydraulic press or the Colin type expeller are used. It was also agreed that he would arrange for trials of both of these presses to take place in the field usin, the improved process methods, and would advise regarding oil in the cake from both machines. The quantity of oil remaining in the cake fibres would give a clear indication of the efficiency of the presses and would be used as the basis for decision making regarding any further work to be done on either the pressing and the fruit treatment which preceded them.

In view of the short time for the work to be done it was agreed that some overtime would be worked when the hydraulic press was completed it would be given commissioning tests using Dura Palm fruit in the CENEEMA workshops, and would then be taken to a farm in OTELE for field trials lasting about three days. The Colin type expeller would also tested during these trials using standard preprocessing techniques. Any improvements in process or design would be decided upon after the trials, and the author would leave design information for a Mark II hydraulic press which would be inexpensive, and rugged for use by the small farmer who had mainly wild Dura palm trees on his land.

The original objectives of the activity were to assist in

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the development of an oil palm press for use by farmers in rural areas. These objectives were attained, and were enhanced by providing information and equipment which would materially improve the efficiency of any press or expeller expressing palm oil from oil palm fruit.

RECOMMENDATIONS

1. It is recommended that UNIDO should offer to pay for the manufacture of 10 hydraulic presses and fund a small publicity-campaign directed at the small farmers in the rural districts of Cameroon. UNIDO should also provide the funds to set up the tests in the field. The tests would be carried out at the farmers where the presses were to be installed, and the tests would be witnessed by other farmers of the neighbourhood.

2. It is further recommended that payment by UNIDO would be conditioned to the receipt of detailed reports from the farmers to whom the presses had been issued; at the end of 12 months from the date of issue of the presses.

3. Further follow up visits to be made to each farm 2 years after issue of the presses.

4. A leaflet to be drawn up as part of the publicity campaign which indicates the important aspects of pretreatment, and points out the gains in efficiency of oil recovery to be made by good pounding and reheating adding or taking out nuts as required and by streamlining the process as much as possible. These leaflets should be handed out immediately prior to, or at, the tests carried out at the farms.

5. It is recommended that CENEEMA carry out the press redesign suggested. This will decrease its cost slightly, to just below 100,000 Cfa. The modified press to be commissioned and tried out in the field before the extension work at (1) to (4) is carried out.

6. CENEEMA should endeavour to obtain unmixed fruits of the various varieties, and carry out careful tests to ascertain the highest efficiencies to be obtained from these fruits. The oil content of mesocarp and fibre to be obtained from the University Chemical Analysis Laboratory, these data together with nut/mesoarp ratios and pressing results will give the accurate efficiency assessment necessary for each variety.

7. It is further recommended that a stirred, heated digester be designed and manufactured by CENEEMA as discussed. Tests to be made to find the best stirring blade configuration which produces a reheater drum full of hot, well pulped fruit which is easy to press. It will be necessary to involve the farmers at Otele at some stage to get their reactions to a new device.

8. If the stirred digester is successful CENEEMA should carry out a series of tests involving the Colin expeller as well as the hydraulic press to optimize the efficiency of both pieces of equipment.

9. In addition it is recommended that some attention be paid to the use of the fibre and nuts which arise from the processing of the fruit. The nuts should be dried dawn to 7 - 10% and decorticated as soon as possible after the oil has been extracted from the mesecap. The use of the fibre as an animal feed ration should also be considered.

ACTIVITIES AND OUTPUT

Main duties of the job description and objectives of the activity.

The duties were to carry out a week of research prior to departure for Yaounde. Information would be obtained on the developments in oil palm pressing which had taken place, particularly in developing countries. This information would be used in Cameroon to determine a press suitable for rural use which could be manufactured locally. The objectives of the activity were changed slightly by the time which had elapsed since the Cameroon government had decided to improve the oil palm presses available to farmers. In that period, CENEEMA had made a version of the Colin hand operated expeller, which was originally manufactured by SPEICHIM (Société pour l'Equipement des Industries Chimiques) of Bondy BP 12 France. SPEICHIM will now only manufacture these presses if orders of 500 or more are received. They are ideally suited to the fairly wealthy farmer with 7 - 10 hectares of land planted with Tenera cultivated oil palms, which when properly tended yield 8 - 10 tonnes of fruit bunches per hectare per year.

The fruit from these trees is particularly suitable for use with an expeller, rather than a press. The nuts in the fruit are quite small, (see sketch at annex) and they are 20 % by weight of the fruit. The mesocarp or fibrous outer layer contains a considerable amount of oil and the ffb (fresh fruit bunches) of these palms will contain from 20 - 30 % of oil at maturity (8 - 10 years after planty).

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An expeller consists of an helical worm, working in a cage with perforations or slots. Fruit, preferably macerated is fed into one end of the worm which carries it through the cage, and an adjustable cone at the exit causes the fruit fibres to be compressed and oil is expressed through the holes in the cage. Tenera fruit, because of the small nuts and high percentage of fibre will pass out through the cone readily, but the Dura fruit cannot be processed as satisfactorily.

The wild Dura fruit grown in the vicinity of Yaounde has a nut to fibre ratio of 59 : 41, compared with the local Tenera ratio of about 20 : 80. The expeller manufactured by CENEEMA was given some trials in August of this year, with which CENEEMA is quite satisfied.

During discussion it emerged that they are not carrying out the usual preprocessing of the kernels, which will be described later. It was agreed that while the author was in the country further trials would be undertaken and the whole process followed. An analysis of the oil remaining in the cake would be made from samples taken during the trials.

CENEEMA had also manufactured an hydraulic press but they asked for another design to be made because certain problems had arisen during its use in the field.

A sketch of the press is shown at annexe. An 8 tonne hydraulic jack was welded by its head to the underside of the channel section, and a ram was attached to the jack base. Pumping the jack caused the ram to move downward into a slatted metal cage which held the palm fruit charge, and the pressure exerted by the ram caused palm fruit oil

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to be expressed from between the slats and into a tray. The oil and water mixture was received into a container and then passed into an oil clarifier.

Technical activity

A considerable amount has been written regarding the pressing of oil palm fruit using hydraulic presses. The literature stresses three things in particular. The first point is that there is an optimum cake pressure, i.e. the pressure actually applied by the ram when the oil bearing fibre in the cage has been fully compressed. This pressure is usually accepted to be 80 kg/cm2, certainly above 90 kg/cm2, oil is left on the fibres, and as the pressure drops below 80 kg/cm2, so less oil is expressed. The original CENEEMA press had a cage diameter of 340 mm, and because of the type of cage construction the ram could not be an accurate fit, and was 275 mm, leaving a 32.5 mm gap around the ram if centred in the cage. These dimensions meant that at best a cake pressure of 9.94 kg/cm2 would have been achieved with a close fitting ram. In the event with a difference in diameter of 65 mm between ram and cage a considerably lower pressure could be expected. The normal Stork hydraulic press operates at 50 kg/cm2 to obtain efficiencies of about 85 % oil extraction. It can therefore be seen that there were fundamental design problems which would prevent the press from working effectively. Furthermore there is an optimum percentage of nuts compared with fibre, in the fruit if hydraulic pressing techniques are to be used.

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About 40% of nuts in the digested fruit gives the highest efficiency of oil extraction. The presence of nuts within the cake is of considerable advantage during the pressing operation, because they help to distribute the pressure. It is however obvious that too many nuts in proportion to fibre causes the nuts to bear against one another and the fibre present is not pressed effectively. The third important point is the need to rupture the oil cells in the mesocarp before pressing. This is done during the digestion process. The operations involved prior to pressing are :

1) Cut down bunches,

2) quarter bunches with machettes,

3) sterilize bunches by boiling at least two hours as soon as possible after cutting down (to keep FFa as low as possible),

4) the next day boil bunches for a further 4-8 hours depending upon ripeness,

5) the long boiling process loosens the fruit on the bunches and the fruit is readily removed by knocking off with sticks. Difficult (unripe) bunches can be put back in drum for further boiling. Without letting fruit temperature drop put it into the reheat drum and continue boiling.

6) as required remove fruit for pounding using a colander and draining it. Pound for a least 5 minutes using pestle and mortar. Fruit has been sufficiently pounded when skin can no longer be seen.

7) put pounded fruit in another reheat drum over low fire with little water and stir. The pounded fruit should not be allowed to drop below 70° - 90° C. High oil removal efficiencies depend upon good pounding and separation of oil cells, and keeping the pulp temperature above 70° C.

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8) Carry out pressing, when pressure has been put on to cake, wait for about 2 minutes and gently apply further pressure. The above points must be born in mind when considering the overall design of the press and the process.

DESIGN OF THE PRESS

Cost is a prime factor in all cases of engineering associated with rural technology. In this case the equipment has to withstand considerable loads and the steels must be substantial and therefore expensive. CENEEMA is of the view that a press to be used by the small farmer should not cost much more than 100,000 CFA. This immediately limits the type of power unit to be used. A proper hydraulic pump and ram fitted with relief valves and pressure piping would cost very much more than this sum. Particularly because they must be bought from a developed country. Even the cost of a hydraulic jack must be given detailed consideration. Although this item can be bought locally, the larger the jack the more it costs, also, and more importantly the increase in the cost of providing and manufacturing the heavier steel members required for the enhanced loading of the press will add greatly to the cost of the machine.

With these facts, and the small farmer, in mind it was decided that we should use an 8 tonne jack as used in the earlier CENEEMA press, and design for the maximum efficiency which could be attained with the output required. There was insufficient time to examine the needs of the small farmer in depth, but the priest at Otele mission said that many small farmers have 2 hectares bearing 4-5 tonnes of bunches per hectare

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per annum. Assume that there is a need to process 10,000 kg of fruit bunches per annum, and that the harvest is over 5 months or so with a maximum of 20% per month.

Equals 2000 kg of bunches per month

Say 500 kg of bunches per week

or 100 kg of bunches per day

But fruit is about 65% of bunch

There is 65 kg per day to process.

There is a considerable amount written on the subject of the cake pressure required for hand operated and hydraulic press systems. The cake pressure is the pressure applied to the pulp when it has reached its final compressed position, and the press ram is then exerting its maximum pressure. From 50 to 70 kg/cm2 is the zone in which most large to medium sized presses fall. As an example, the smallest Stork press is of 50 tonnes capacity, handles 200 kg of pulp per hour, and has 50 kg/cm2 cake pressure, while its larger counterparts have cake pressures of 70 kg/cm2. As a press for use by the Cameroon farmers requires a very much lower capacity than the Stork press mentioned, and because of the need to keep the cost down, the press cage (see sketch at annexe) at 160 mm diameter was designed to give a cake pressure of about 40 kg/cm2, and at 320mm high the cage would take a load of about 7 kg of digested fruit. Four millimeter diameter holes were drilled into the cage at 12.5 mm centres. It was thought that these holes could be increased in

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diameter if necessary. It is not really practical to use a cage less than 160mm in diameter because of the quantity and size of nuts in the pulp. The activity was therefore directed towards the production of a prototype press which would carry out six to seven pressing cycles expressing oil from same 42 kilogrammes of fruit pulp and processing the small farmers crop in 1 1/2 hours. The pressing efficiency, the ratio of oil extracted from the pulp, expressed as a percentage of the total oil, was estimated to be between 70 - 80%.

The Dura fruit

Fruit to bunch	=	65%
Mesocarp to fruit	=	43%
Oil to Mesocarp about		50%

The allowing 10% loss during processing and press running for 6 hours. In 6 hours it will process 240kg digested fruit (producing about 36 litres of oil)

$= \frac{240}{90}$ x 100kg of picked fruit

= 266 kg " " "

or $\frac{266}{65}$ x 100kg of bunches

= 409kg of bunches/day or about 40T

One of the limitations imposed by using a jack was the amount which the ram moved from its closed to fully extended position. With an overall movement of 155mm and a cake which would be compressed

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from 230mm to about 120mm thickness. It was obvious that if the hydraulic jack was to be used a means of overcoming this shortcoming was required.

This was resolved by ensuring that the daylight between the ram and the cage with the jack down was just over 15mm, and by inserting 15mm thick circular steel distance or make up pieces into the cage after a first pressing had been made. The first pressing took the ram down 140mm into the cage, and on retraction 6 in number 15mm distance pieces were dropped into the cage giving a further 90mm of compression. A larger number of pieces could be added if required.

It was necessary to mount the jack on the floor on the press so that it moved the cage and oil tray upwards, and on to the ram which was secured to the underside of the steel member forming the top beam of the press.

This was fundamental, because it is not possible to operate an hydraulic jack upside down. It made the press considerably easier to use, because the pumping handle was at the lower level. Additionally there was no need for the retraction springs required when the pump is at the top of the press. In this instance the weight of the cage, and charge causes the jack to retract directly the release valve is opened, and makes operation simple.

The cages were made 4mm thick and drilled with 4mm holes on a 12.5mm lattice, a flange was fitted at the end on which the cage set. It was intended to anchor the cage if it tended to rise under pressure. This bolting down was found not to be necessary.

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Both ends of the cage were left open, and with the flange placed on supports the cake could readily be knocked out on completion of pressing. A 60mm and a 22mm cage was made, with base flanges both 210mm diameter. The tray into which the oil from the pressing was drained was 150mm high and left unfastened. It sat on the flange welded to the top of the jack during pumping and could be put on the ground when it was necessary to put a recharged cage back in the press. The oil was directed by a hose from the tray to a container at ground level.

The overall dimensions of the press were 925mm high and 450mm x 450mm base. The tray was designed to allow the cage to be slid out after pressing so that it was clear of the ram. See sketch and photagraph at annexe. The 15mm thick mild steel base was mounted on 50mm square section tube to give maximum stiffness. The side supports were of 60mm square section tube, braced from top to outside of base on each side with 40mm square tube given further stiffening with triangular fillet plates of 15mm steel at top and bottom. The top steels were made of the original press side supports of channel cut to size and welded together back to back to form an I beam.

To keep down costs, it was decided that the unit should not be provided with a stand. Robust wooden stands, and indeed sections of tree trunk can readily be used in the field and the provision of a metal stand added more expense, was heavy and unwieldy and made transport much more difficult.

Manufacture of the press and ancilliary equipment. This was carried

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out very expeditiously by the CENEEMA workshop. It had been intended that the cages should be made in a private sector workshop, but they were unable to roll such small diameter cylinders. This work was thereforedone in the CENEEMA workshop using rolls which were not really long enough for the job. They managed extremely well, and although the final cage was 165mm it was quite within tolerance as far as out of round was concerned. There was a maximum of 3mm gap showing when the ram was inserted. The processing required before pressing takes place made it necessary for various small pieces of equipment to be manufactured. A reheating drum for the digested fruit was essential. This was made 300mm diameter, 400mm high, and of 1mm thick mild steel. The 220mm diameter cage was modified by blanking off the unflanged end, and used to contain the pulp over boiling water in the reheat drum. A thinner mesh container was put in hand for future tests. A substantial metal colander was made to remove the hot fruits from the drum after boiling.

Commissioning Trials Commissioning trials in the CENEEMA workshop commenced just two weeks after arrival in Yaoundé, which says a great deal for the enthusiasm and drive shown by the two engineers Messrs SONDY FOMUNYAN and Jules TETKA assigned by the counterpart Mr. Emmanuel N. MOFOR. It goes without saying that it also indicates the dedication shown by Mr. Mofor and the amount of assistance he gave ; for discussion design, and manufacture to have taken place in such a relatively short time.

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The first two days of the commissioning trials were spent in trying to find the best means of boiling the fruit and keeping it warm, and in getting used to the routine of purchasing fruit on the market at the right times for sterilizing preprocessing and pressing to take place. Having tried a kitchen type charcoal wood fired cooking stove situated remote from the workshop without great success, and trying the hearth of the forge in the workshop in conjunction with the stove we found that we needed to have all the process in the same place, and decided that the workshop was the best situation for this work. The fruit was first boiled for the six hours period on the air blown hearth in the workshop while 2 fires were lit on the ground in the workshop yard. One of these fires was then used to keep the fruit boiling while pounding was carried out, and the other was used to heat the reheater drum and keep the pulp hot.

The first trial was carried out using a 40% nut, and 60% fibre mix, after having checked that the ratio of nuts and 40% fibre.

The quantities to be used were decided upon as follows:

The trials were carried out in the workshop area, and it took about two days to establish the correct routine of fruit purchase, sterilizing, and further boiling to a total of six hours. The first fruits to be bought in the market were Dura x Tenera mixes in unknown proportions. They gave a considerable quantity of oil rich fibre, and 2.2. litres of oil, water and sludge were obtained per 7 kg pressing, which when clarified became 1.4 litre of oil. When Dura fruits were obtained they were extremely difficult to press in the first instance. The high nut to fibre ratio of 61% to 39% gave a very poor cake and only .8 litres of oil, water and sludge were expressed per 1 kg charge. The flange at the base of the cage caused it to lift and cake pressure was lost. It was decided to make up a new 16.6cm diameter cage with no flange, and drilled with 6mm holes at lattice centres of 12.5mm. The cage was fitted with mild steel brackets on each side at the top for handling and to use as supports when knocking out the cake.

The new cage was tried out with a 35kg run of Dura fruit. Examination of the cake of the earlier Dura run had indicated that the considerable quantity of large nuts were causing problems. Nuts were accumulating around the outside of the cake, and at the bottom in such numbers that there was little fibre between them, and pressure was not being properly transmitted. It was therefore agreed that the quantity of nuts should be reduced during the pulping operation, when of nuts frequently appear at the top of the mortar. The Dura fruit was

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60% nut 40% mesocarp fibre and the optimum ratio for this type of pressing being 40 nut 60% fibre it was necessary to remove nuts. Care had to be taken not to lose much time and cause temperature loss, with consequent loss of pressing efficiency. In an effort to strike a compromise 8.4kg of fruits were pounded and 1.4kg of nuts removed.

		60% nuts	40% fibre
8.4kg of fruit =		5.04kg	3.36
	loss	- 1.4 kg	
		3.64	3.36
	final percentage	52% (nuts)	48% (fibre)

Although this was not an ideal ratio it was the best which could be obtained by picking nuts from the two rather small (about 3.5kg) mortars which were being used, and still maintaining a high enough temperature for the oil to run quite freely.

A series of eight runs were carried out (see annexe), and these resulted in the following outputs

Run NO.	Nut pulp (kg)	liquid expressed (l)
1	6	1.4
2	6.5	1.75
3	6.2	1.55
4	5.8	1.4
5	6.0	1.5
6	5.0	1.1
	35.5	8.7

Two cages full of the cake (which had be reheated) from

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the above runs were also pressed giving 1.0 and 1.5 litres of liquid. Unfortunately, it was too dark to carry out any more runs, and at least another cage full of fibre remained unpressed. Neither was there sufficient time to clarify the oil obtained, but the runs were reasonably satisfactory with a total of some 12 2 litres of oil, water and sludge from 35.5kg of Dura fruit pulp.

Following the final commissioning trials at CENEEMA, the press was taken to the mission at Otele for field trials. The fruit provided was said to be Dura, but there seemed to be same smaller fruits present, and the mesocarp was certainly considerably thicker than the very large Dura fruits obtained from the Yaounde market.

A total of 10 test presses were made, 3 with 1.2kg of nuts removed, two with nuts left in, two reheat tests with all nuts left in, two reheat tests with 1.2kg of nuts taken out, end one test with all nuts left in, using the CENEEMA macerator in lieu of pounding the fruit.

Reheating was carried out in the usual manner by putting a small quantity of water in a drum over a fairly low fire, putting in the pulp and continually stirring until all of the pulp had reached 80-90°C details of the tests are as follows.

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FIELD TRIALS, FIRST DAY

Field Test NO	Wt pulp in cage kg	Liquid out (Oil H20+slurry) litres	Samples taken taken	Remarks
Run 1 7 mins	5.5	1.4	-	1.2kg nuts removed
Run 2 6 mins	6.25	1.95	-	1.2kg nuts removed
Run 3 6 mins	6.0	1.9	-	1.2kg nuts removed
Run 4 6 mins	7.0	2.3	-	All nuts in
Run 5 6 mins	7.0	2.2	Sample 1	All nuts in
Run 6 4 mins	7.0	3.6	Sample 2	Reheat 1.2kg nuts removed
Run 7 6 mins	5.3	2.7	Sample 3	Reheat 1.2kg nuts removed
Run 8 5 mins	7.0	2.2	Sample 4	CENEEMA macerator used All nuts in
Run 9 4 mins	7.0	3.2	Sample 5	Reheat All nuts in
Run 10 5 mins	6.0	2.9	-	Reheat nuts in
Total	64.05 kg	24.35 l of liquid producing		

64.05 kg = 13.55 l of oil

1 kg = .21 l of oil

FIELD TRIALS, SECOND DAY

The next series of field tests were planned to check whether the hand operated macerator designed by CENEEMA was as suitable for the hydraulic press as hand pounding using pestles and mortars ; particularly when reheating of the charge was carried out.

The following tests were carried out during the second day of field trials at Otele.

Test NO	Wt pressed	Liquid out	Sample taken	Remarks
Run 11	7	2.4	Test 1	All nuts in, Dura fruit, CENEEMA macerated used; Reheated
Run 12	6.8	2.5	Test 2	All nuts in, Dura fruit, CENEEMA macerated used. Reheated
Run 13	7	2.85	Test 3	All nuts in, Dura fruit, CENEEMA macerated used. Reheated
Run 14	4.75	2.2	-	All nuts in, Dura fruit, CENEEMA macerated used. Reheated
	25.55	9.95		
	25.55kg = 4.55 l oil 1kg fruit = 1.86 l oil			
Run 15	-	-	Test 4	Colin expeller used to expell oil from Dura nuts, not macerated A lot of fibre not expressed. Quantities not measured.
Run 16	7	2.7	Test 5	Hydraulic press used on Tenera nuts, all in macerated by CENEEMA machine (not well)
Run 17	-	-	Test 6	Colin press on Tenera fruit not macerated No quantities measured

Discussion regarding trials results

The short time to design, manufacture and commission the press has obviously placed severe limitations on the overall number and detail of trials carried out. During commissioning runs at CENEEMA it was found necessary to manufacture another cage of the same height and diameter (320 and 165mm) but with no lower flange and with 6mm holes. This was found to be necessary because the press cake caused the cage to lift due to protrusions left on the bottom of the flange. The holes were enlarged to allow the oil to escape more rapidly. It had been decided before the first trial that the press could be operated much more quickly if the cage and tray were left unfastened and capable of being lifted off the machine. The tray could then be properly drained, and taken together with the cage (when the press cake had been removed) to a convenient position for putting the fresh charge. Another design change which was made to replace all but two of the steel make up pieces with circular pieces of hard wood 12mm thick. These were much less expensive, lighter and easier to handle.

The trials carried out with the new cage, and pressing Dura x Dura mixed fruits at 60% nuts and 40% fibre were quite satisfactory. With all nuts left in, a 7kg test gave 2.4l of oil, water and sludge which clarified to 1.32 litres of oil (.171kg oil per kg fruit) of fruit. With 50% of oil in the mesocarp this would give a pressing efficiency of 85%. This test was carried out pounding the fruits well for 5 minutes in the two mortars provided and with no reheating.

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A second test, picking out sufficient nuts and adding fibre to change the nut/fibre ratio to 40% and 60% respectively did not give particularly good results, only 1.4 litres of oil obtained from 7 kg of a much richer mixture, which only yielded oil at 60% pressing efficiency. This was found to be due to the pounded nuts being quite cold and the fibre which was added, was not mixed in but only put in the cage as a top layer. We thus had the most inefficient pressing situation. A charge at the top with no nuts in to give a good pressing to the layer below, and the bottom layer cold enough for the oil to have started to become viscous and difficult to remove. The trial was worth while because it indicated the absolute necessity to keep the whole charge above 70°C, and to ensure that there were at least 40% of well distributed nuts in the charge (see annexe). Two pulp holders of wire mesh were made to find out if charges of 7kg of pulp kept above fast boiling water and well steamed would attain temperatures of 70°C. This method was not successful, and the best way to keep pulp hot was found to be to heat it with a small quantity of water, stirring well. The importance of stirring is stressed because it not only distributes the heated pulp throughout the container, but also continues the breaking up of the oil cells making the pulp easier to press. The need to design a reheater drum with a simple built in rotary stirrer is noted at this point.

For the final commissioning trials at CENEEMA we managed to obtain about 50kg of large wild Dura fruit with a nut/fibre ratio of 63% to 37%. When this fruit was pounded well and pressed it gave only .81 of oil water and sludge and the cake felt quite moist, further

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pressings keeping the pulp temperature as high as possible with reheating still only gave 1 litre of oil, water and sludge and this is only about 40% efficiency.

We then carried out a final series of trials still using the large wild Dura fruit. Six tests were made out taking 1.3kg of nuts out and leaving a fruit composition of 59% nuts, 41% fibre. From 35.5kg of fruit we obtained a total of 8.7 litres of fluid which produced 4.8 litres of oil. The oil available in the fruit was .22 litres per kilogramme and we obtained .14 litres per kilogramme an efficiency of 64%. It should be noted that this was without reheat, and that the cake was then put into the reheat drum and brought up to about 80° C and a total of 3.0 litres of oil, water and sludge obtained from about 20kg of cake, say 1.6 litres of oil. The time lost in picking out nuts causes the charge to cool too much, and it is obvious that reheating is essential if nuts are picked out . It is worth noting that by reheating fibre the overall efficiency of processing 35.5kg of pulp was increased from 64% to 83%.

Field trials at OTELE (discussion)

The fruits had been sterilized for about 5 hours when we arrived. They were a Dura x Dura, percentage mix not known. The two types of Dura being quite different, and one being smaller, with more oil bearing mesocarp. The test were carried out as planned, Runs 1, 2, and 3 with 1.0 - 1.3kg of nuts removed, Runs 4 and 5 with nuts in, Runs 6 and 7, were reheat runs with 1.2kg of nuts out. Run 8 used the CENEEMA macerater with no pounding, all nuts in, and reheating and Runs 9 and

.../

10 were reheat runs with all nuts in. It was not possible to accurately estimate pressing efficiencies because we could not establish the proportions of the fruit mix. The results indicated that the runs with 1.3kg of nuts removed were not as efficient as the runs with nuts in. That the reheat runs with nuts out were better than the earlier pressings without reheat and that the reheat runs with all nuts in were nearly as efficient as those with nuts taken out, and were a lot easier to carry out. It was not possible to be sure of the quantities of nuts removed, and of the exact charge weight.

.../

FIELD TESTS AT OTELE. DURA X DURA FRUIT

TEST NO	Wt pressed kg	Liquid out l	Sample taken	Operational Mode	Efficiency
Run 1 7 minutes	5.5	1.4 l	-	1.3kg of nuts out no reheat. Pounded.	
Run 2 6 minutes	6.25	1.95	-	1.2kg of nuts out, no reheat. Pounded.	
Run 3 6 minutes	6	1.9	-	1.2kg of nuts out. No reheat. Pounded.	
Run 4 6 minutes	7	2.3	-	All nuts in. No reheat. Pounded.	
Run 5 6 minutes	7	2.2	Sample 1	All nuts in. No reheat. Pounded.	
Run 6 6 minutes	7	*3.6	Sample 2	1.2kg nuts out. Reheated. Pounded	
Run 7 6 minutes	5.3	2.7	Sample 3	1.2kg nuts out. Reheated. Pounded.	
Run 8 6 minutes	7	2.2	Sample 4	All nuts in. Not pounded. CENEEMA marcerator used.	
Run 9 5 minutes	7	3.2	Sample 5	All nuts in. Reheated. Pounded.	
Run 10 5 minutes	6	2.9	-	All nuts in. Reheated. Pounded	
TOTAL	64.05	24.35 l or 3.551 of oil	)) or .21 litres of oil per kg of fruit)		

Estimates have been set down, but the tests can only be regarded as indicative as it was quite impossible to conduct them scientifically.

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The next field trial was undertaken using the remainder of the Dura x Dura fruit, and some of the Tenera which had been prepared.

TEST NO	Wt pressed kg	Liquid out l	Sample taken	Remarks
Test 1	6.7	2.4	Sample 1	Dura x Dura, all nuts, pounded and reheated
Test 2	6.8	2.5	Sample 2	Dura x Dura, all nuts, pounded and reheated
Test 3	7	2.85	Sample 3	Dura x Dura, all nuts, pounded and reheated
Test 4	5	2.2	-	Dura x Dura, all nuts, pounded and reheated
	25.5	9.95 4.55 l oil		

Note, the longer the above samples stayed in the reheater, the higher the oil production. The pulp was about 90°C by the last test

Three runs were then carried out using the coling press on Dura x Dura, the hydraulic press on Tenera, and then the Colin press on Tenera.

Test NO	Wt pressed kg	liquid out l	Sample taken	Remarks
Test 5	Not weighed	Measured not numeral	Sample 4	The Dura x Dura was macerated in the CENEEMA machine and then put through the Colin press. The objective was to assess the cake. It was put through twice press oil production
Test 6	7	2.7	Sample 5	Tenera fruit, put th rough the CENEEMA mace rated and hydraulic pressed. Would have had higher oil output if nuts added (about 70% efficient)

Test NO	Wt pressed kg	Liquid out l	Sample taken	Remarks
Test 7	-	-	Sample 6	Tenera fruit passed straight into Colin press. Good oil production

The first test of this series indicates that the Colin press was able to handle the Dura x Dura fruit but produced an oily cake with fibres still on nuts and on skin. The fruit was not macerated sufficiently and would have benefited considerably by reheat and stirring.

Test n° 6 with the hydraulic press handling Tenera fruit pressed through the macerator, was about 70% efficient with an estimated 20% nut and 80% mesocarp, but it would have had a very considerable increase in sufficiency if the nuts had been pounded and additional nuts added to increase the nut percentage to 40%.

The sociological aspect

There was little doubt that the fairly sophisticated farmers of OTELE who are associated with the Palmerai Villageoise did not care for the type of work associated with either pounding the fruit in a mortar, or stirring it in a reheater drum. They reacted very favourably to the press itself. I understand from the priest of Otele Mission (P. Urs. Fiedrich Egli) that there are a growing number of farmers who are no

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longer willing to hazard their lives in climbing the very tall, old Dura palms which can be about 20 metres high, and they are growing the Tenera trees from seedlings which the mission produces.

This is undoubtedly true of the very restricted area around OTELE, but it will be necessary to investigate the more remote areas of Cameroon. Mr. E. Mofor is of the view that there are farmers in other areas who will be willing to use a pestle and mortar as long as they obtain the product they require.

Financial aspects

The workshop technician at CENEEMA gave an estimate of the cost of materials used to make the prototype press. Including the cost of the hydraulic jack the total material cost was about 110,000 cfa. The method of accounting for labour at this establishment is to add 25% of the materials cost, giving a total cost of the prototype of about 137,500 cfa. If the machine is used to process 10 tonnes of bunches per year (of Dura fruit), then with 65% fruit to the bunch there will be 6,500 kg of fruit available, and $\frac{43}{100}$ x 6500 kg of mesocarp = 2,795 kg

about 50% of the mesocarp is oil. There is a possible 1,398 kg of oil in mesocarp. Allow 10% for losses and 70% for press efficiency.

Then quantity of oil which could be obtained is

$$\frac{70}{100} (1398 - 140) = \frac{70}{100} \times 1258 \text{ kg}$$

$$= \text{say } 880.6 \text{ kg oil}$$

$$\text{or } \frac{880.6}{.92} \text{ litres} = 957.2 \text{ litres}$$

With oil from 300 - 400 cfa per litre .../

Then value of crop is between 288,000 t - 384,000 cfa p a

The press represents an investment of about 1/3 to 1/4 the value of the crop, and the only moving part which will require replacement is the hydraulic jack at 23,000 cfa. With reasonable use the jack should last three or four years with no problems ; as long as it is topped up with hydraulic fluid as required.

CONCLUSIONS

1° The design of the press was successful. The 8 tonne press with 165mm diameter and 320 mm high cage is large enough for the small farmer. It has efficiently handled the Dura. Dura x Dura, and Tenera fruit grown around Yaounde. It is understood that the priest and the farmers at Otele were surprised at its efficiency.

2° Care must be taken to ensure that the preprocessing of the fruit is carried out correctly.

a. That it is sterilized by boiling far out least 6 hours.

b. It would be better if the farmers sterilized the bunches and then knocked the fruit off. The local custom is to leave the bunch on the ground for a day or so and then knock, or cut off the fruit. This causes an appreciable rise of F.F.A, and it is also hard work to remove the fruit.

c. The fruit must be properly macerated to loosen and detach the oil cells in the fibres. If farmers are unwilling to use a pestle and mortar then a more efficient, and smaller macerator should be designed. It will obviously have to be very inexpensive if it is to be used by the owners of 2 hectares of palm. The present macerator used by CENEEMA has no means of adjustment to allow it to be used for macerating large or small fruit. An adjustable anvil is required.

It is unlikely that this type of macerator could ever be used with mixed fruit.

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d. It would be better perhaps to concentrate on the design of a reheater drum with a hand operated stirring device which macerates the hot fruit by gentle abrasion. By this means a large quantity of fruit could be macerated, the temperature kept up, and the efficiency of pressing considerably improved. The hard work of pounding, the fruit in the first instance, and then stirring with a stick in the reheater would be replaced by one steady activity, and the quality and temperature of the pulp optimised.

e. By removing a quantity of nuts when dealing with the large wild Dura fruit, and adding nuts from the cake when pressing Tenera fruit the efficiency of the press will remain high. The quantity to be taken away or added is a matter of judgement (see graph at annexe)

f. If under exceptional circumstances double pressing is required the press cake must be stirred in the reheater with a small amount of water, and the temperature brought to as near 90°C as possible.

g. If delays are kept to a minimum it is possible to make 6 to 7 pressings per hour, which means that a drum of 150kg of fruit can be pressed in 3 to 4 hours.

3. It is difficult to understand why the local farmers do not use a proper clarifying drum, and minimise the effort in this hot and time consuming operation.

4. If CENEEMA is to carry out further trials of this nature a certain amount of additional equipment will be required. A number of long

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mercury thermometer reading up to 100°C, some graduated vessels with a capacity of 2 litres a supply of tie on labels to allow samples to be clearly marked are immediate requirements.

ANNEX I

EXPLANATORY NOTES

The value of currency during period of mission was

CFA to 1 US dollar.

ABBREVIATIONS

CENEEMA	CENTRE NATIONAL D'ETUDES ET D'EXPERIMENTATION DU MACHINISME AGRICOLE
ENSA	ECOLE NATIONALE SUPERIEURE AGRONOMIQUE
DAYLIGHT	GAP BETWEEN PRESS & CAGE WHEN RAM HAS BEEN RETRACTED OR CAGE LOWERED
FFB	THE COMPLETE BUNCH OF PALM FRUIT INCLUDING THE STALK. THE PERCENTAGE OF OIL IS OFTEN GIVEN AS A PROPORTION OF THE FFB
FFA	FREE FATTY ACIDS

A N N E X E 2

SENIOR STAFF MET AT CENTRE NATIONAL D'ETUDES ET D'EXPERIMENTATION DU MACHINISME AGRICOLE (CENEEMA).

Mr Roland ELA EVINA	Director CENEEMA BP : 1040 NKOLBISSON, Yaoundé
Mr Marcel Roger BALO	Assistant Director
Mr Emmanuel N. MOFOR	Counterpart (Mechanical Engineer). Chef du Département de Construction mecanique
Mr Jules TETKA	Counterpart staff (Mechanical engineer). Département Construction.
Mr Sonny FOMUNYAM	Counterpart staff (Mechanical engineer).
Mr Paul Pierre DITONE	Technicien Supérieur Chef Section Réalisation
Dr Charles J. MINKA	Chef du Département des Energies Renouvelables. Chargé de Cours à l'Université de Yaoundé
Mr NDZIE ZENON	Chef de Section BIOGAS, CENEEMA

STAFF DEALT WITH AT ECOLE NATIONALE SUPERIEURE AGRONOMIQUE (ENSA).

Dr TCHUMBAYA	Lecturer, with responsibility for technical analysis of seeds, etc.

/...

THE CATHOLIC MISSION AT OTELE

P. URS FRIEDRICH EGLI BENEDICTIN	Priest in charge of Mission and responsible for Palmeraie Villageoise Project. Mission Catholique OTELE, BP : 22
Mr CLIVAZ	Assisting in running Project & Mission work
Mr YEBGA Korbert	- " -

O N U D I

Mr ABDENOUR BENBOUALI	Conseiller Industriel Principal (ONUDI) Bureau du PNUD, BP : 836 YAOUNDE

APPROXIMATE OIL PALM FRUIT COMPOSITION

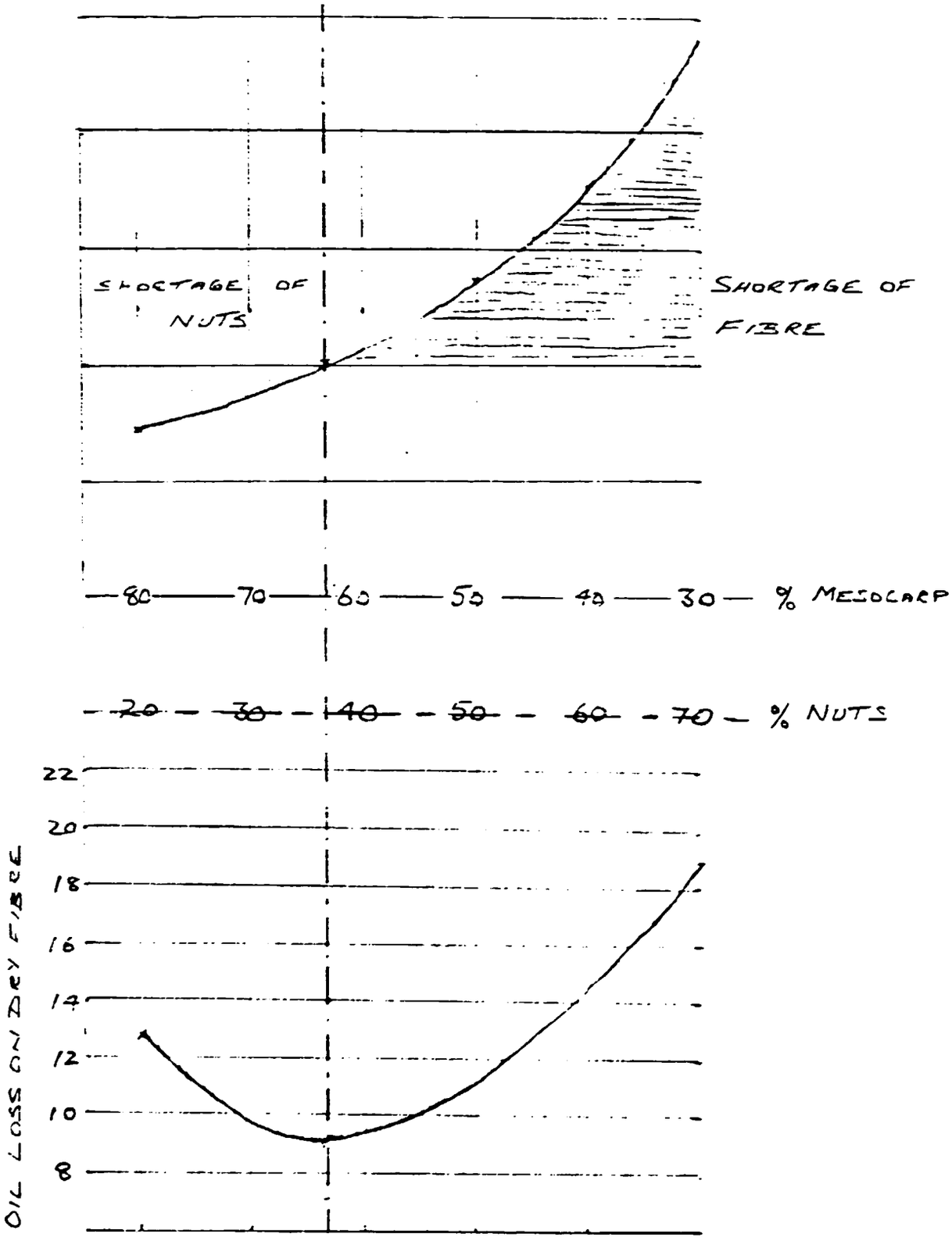
D U R A

Fruit to bunch	65 %
Mesocarp to fruit	43 %
Kessel to fruit	14 %
Shell & Water less to fruit	42 %
Oil to mesocarp	50 %

Good commercial Tenera fruit has 75 - 80 % mesocarp in fruit.

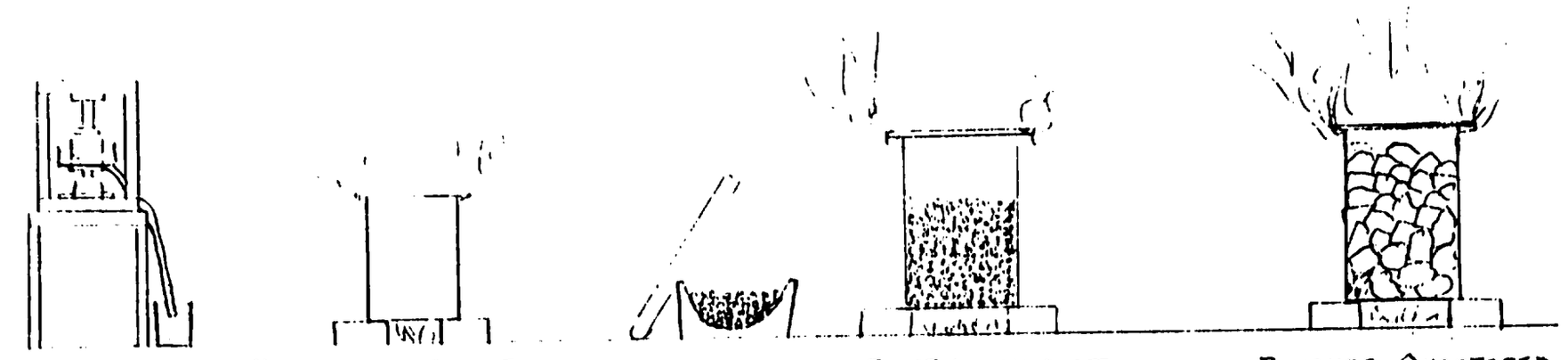
Mesocarp yields 50 % oil.

ANNEX 4



THE INFLUENCE OF FRUIT COMPOSITION

ON OIL LOSSES ON DRY FIBRE



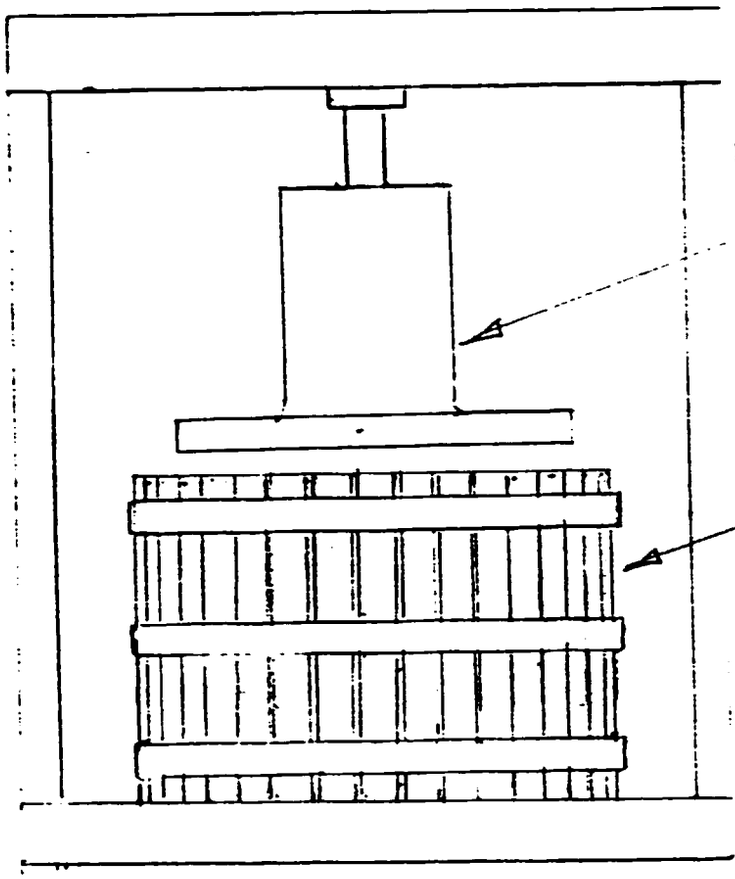
Annex 5

BASIC SYSTEM FOR PROCESSING OIL PALM FRUIT

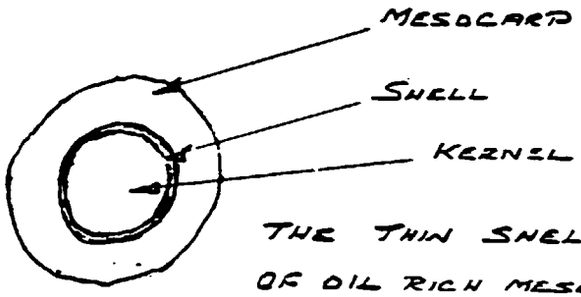
ON SMALL SCALE

SKETCH OF ORIGINAL CENEEM.A. PRESS

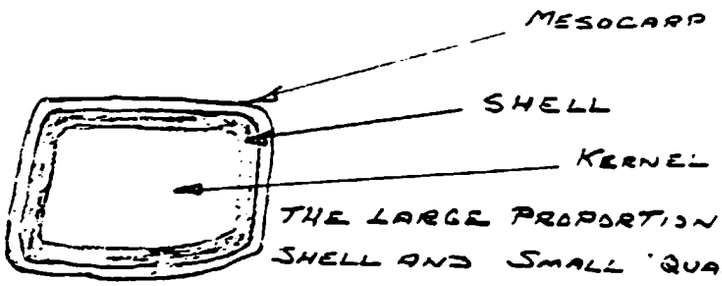
NOT TO SCALE



ANNEX 7

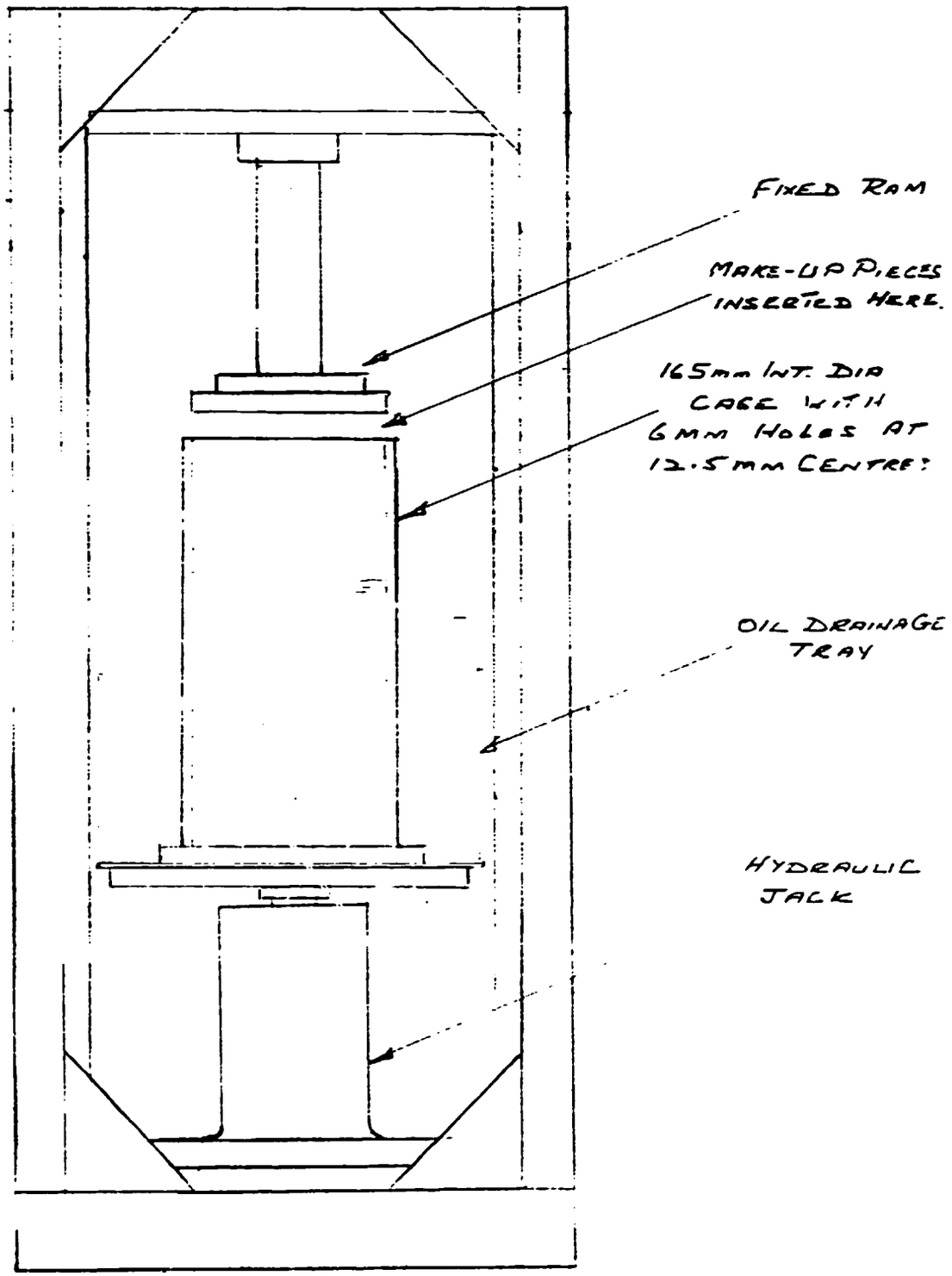


THE THIN SHELL AND LARGE PROPORTION OF OIL RICH MESOCARP FIBRES MAKES THIS FRUIT MOST SUITABLE FOR EXPRESSION BY AN EXPELLER (COLIN TYPE)



THE LARGE PROPORTION OF NUT, THICK SHELL AND SMALL QUANTITY OF MESOCARP REQUIRES AN HYDRAULIC PRESS OR SIMILAR TO REMOVE OIL. EXPELLER CANNOT BE USED.

SKETCH OF TENERA AND DURA FRUIT FROM OTTLE MISSION



PROTOTYPE OIL PALM PRESS WITH 165MM CAGE

REFERENCES

ANON Journal of NIFOR The Hydraulic Hand Press pp 301 - 315

ANON STORK Palm Oil Review Vol 1 N° 3 June 1960.
GEBR Stork Sterilizers & Auxiliary Equipment AMSTERDAM

ANON STORK Palm Oil Review "Bunch Stripping and Stripping machines" Vol 1 N° 3 October 1960.
GEBR STORK AMSTERDAM

ANON STORK Palm Oil Review "The Digesters" Vol 1 N° 5 December 1960 GEBR STORK AMSTERDAM

ANON STORK Palm Oil Review "Digesters (II)" Vol 2 N° 1 January 1961 GEBR STORK AMDTERDAM

ANON STORK Palm Oil Review "The Correlation between Press cake components & losses of oil in fibre" Vol 2 N° 2 March 1961 GEBR STORK AMSTERDAM

ANON STORK Palm Oil Review "Hydraulic Presses" Vol 2 N° 3 July 1961 GEBR STORK AMSTERDAM

CORNELIUS J.A. Processing of Oil Palm & its Products. Tropical Development & Research Institute LONDON Publication G 49 99 pp

HARTLEY C.W.S. (1977) The Products of the oil palm & their extraction "The Oil Palm" 2nd Edition pp 692-780 LONDON LONGMANS 806 pp

/...

CORNELIUS J.A. A recent development in the small scale extraction of Palm Oil.
Tropical Sciences 19 pp 34-38

Tropical Development & Research Institute
LONDON

NWANZE SC The Economics of the Pioneer Oil mill
J. West African Institute
Palm Oil Research 1961 3 233 253

TUMER P.D. & GILLBANKS R.A. (1974)

"Processing" in Oil Palm Cultivation & management pp 508-536

Kuala Lumpur Incorporated Society of Planters 672 pp