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A MODEL CONCEPT FOR THE UTILIZATION OF BALANITES AEGYPTIACA FRUITS FOR THE PRODUCTION OF VEGETABLE OIL AND ANIMAL FEED*

US/GLO/84/233

Prepared by P. F. Bauer, UNIDO consultant**

* This document has not been edited.

** Incorporating the work of the Industrial Research and Consultancy Centre, P.O. Box 268, Khartoum, Sudan.

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TABLE OF CONTENTS

	Page
Table of Contents	a
List of Tables	b
List of Figures	c
P R E F A C E	I
A C K N O W L E D G E M E N T S	II
I N T R O D U C T I O N	III
1.) COMPOSITION AND CHARACTERISTICS OF BALANITES AEGYPTIACA	1
1.1.) Composition	1
	4
1.2.) Final products in general	4
	8
2.) BALANITES AEGYPTIACA IN THE SUDAN	9
2.1.) Growing areas	9
2.2.) Available quantities of Balanites aegyptiaca	9
2.3.) Market prices for raw material	9
3.) EXPECTED PROCESSING AREA IN THE SUDAN	11
3.1.) Infrastructural parameters	11
3.2.) Location of processing plant in view to growing areas of Balanites ae.	11
3.3.) Requirements for most economic utilization	11
	12
4.) UTILIZATION MODEL FOR BALANITES AEGYPTIACA AT ABU GUBEIHA	12
4.1.) Specification of model	12
4.2.) Application of model in assigned area	13
5.) UTILIZATION MODEL IN DETAIL	13
5.1.) Collection of fruits	14
5.2.) Transportation and storage	14
	15
5.3.) Payment mode for fruit collectors	15
	16

	Page
6.) PROCESSING TECHNOLOGY FOR BA. DUE TO CONVENTIONAL OILMILLING	16
6.1.) Oilmilling in general	16
	17
	19
	20
	21
6.2.) Additionally required special equipment	21
	23
	26
6.3.) Process description for processing of *Balanites aegyptiaca*	26
	27
7.) ADAPTATION OF PROCESSING MODEL SPECIALLY FOR THE SUDAN	27
7.1.) Specifications in general	27
7.2.) Specifications in view to Abu Gubeiha	28
8.) OILMILL AT ABU GUBEIHA	28
8.1.) Description of already existing equipment	28
	29
8.2.) Adaptations required for processing of *Ba*	29
	30
8.3.) Throughputs and yields	30
8.4.) Investment costs	33
8.5.) Layout for a new oilmill for processing of *Ba*	33
	36
	37
	38
	39
	40
8.6.) Figures of demand, throughputs and yields	41
8.7.) Investment costs for new 200 t/d *Ba* plant	42
9.) FINAL PRODUCTS	44
9.1.) Specification and chemical composition	44
	45
	46
	47

	Page
9.2.) Utilization	48
9.3.) Market prices	49
10.) CONCLUSIONS	50
10.1.) Technical evaluation of project	50
10.2.) Economic and financial aspects	51
10.3.) Aspects of rural development	51
	52
11.) APPENDICES	52
11.1.) Economic evaluation based on COMFAR-system	52
12.) BIBLIOGRAPHY	53

LIST OF TABLES

Table	Title	Page
8.6.) No. 1	Figures of demand	41a
8.6.) No. 2	Throughputs and yields	41a
8.7.) No. 3	Investment costs in US$	43
9.1.) No. 4	Amino-acid profiles	47

LIST OF FIGURES

Figure	Title	Page
1.1.) No. 1	Balanites tree	2
1.1.) No. 2	Balanites fruits/cross-section	3
1.1.) No. 3	Balanites fruits	5
1.1.) No. 4	Balanites nuts	6
1.1.) No. 5	Balanites shells and kernels	7
2.1.) No. 6	South Kordofan Province	10
6.1.) Appendix No.1	Mechanical oil extraction	54
6.2.) No. 7	Mesocarp separation tank	22
6.2.) No. 8	Nut cracker	24
6.2.) No. 9	Hull separator	25
8.2.) No.10	Layout for Abu Gubeiha oilmill	31
8.3.) No.11	Product balance	32
8.5.) No.12	New oilmill/Flow diagram	34
8.5.) No.13	New oilmill/Layout	35
8.6.) No.14	New oilmill/Product balance	42

I. PREFACE

Balanites aegyptiaca is an oilbearing fruit hardly utilized up to now but available in thousands of tons in different districts in the Sudan and in some other cuontries of the African Sahel-zone. Detailed specifications and description can be found in the UNIDO elaboration IO 494 / 13th of April 1983, named: Balanites aegyptiaca. An Unutilized Raw Material Potential Ready for Agro Industrial Exploitation.

1979 UNIDO together with the Sudan Industrial Research and Consultancy Centre (IRCC) initiated for the Sudan the elaboration of a study for commercial utilization of Balanites aegyptiaca.

1988 it was agreed by all participating parties that for the beginning of the project only edible oil and protein meal for feeding purposes should be produced from Balanites aegyptiaca.

Therefore the elaboration of this proposal about the "Technical requirements for processing of Balanites aegyptiaca." (Machinery, equipment, plant lay-out and processing technology) was initiated.

As a matter of fact the elaboration of this model was done in view to the possibility of realization in all Balanites growing areas, taking into consideration modifications and adaptations depending on the conditions in the respective country.

Acknowledgments

The work carried out by a study team of the Industrial Research and Consultancy Centre, Khartoum, is herewith gratefully acknowledged. The team consisted of the following persons:

Mr. Zakaria Abdel NABI	-	team co-ordinator
Mr. Oleish AWADALLA	-	team leader
Mr. Mubarak S. El AMIN	-	team member
Mr. Mohamed GOMMA	-	team member
Mr. Mohamed Ali OSMAN	-	team member

The team on contract with UNIDO and with the assistance of UNIDO international experts has elaborated a model concept for the utilization of Balanites aegyptiaca fruits ready for implementation in the Sudan. The review presented herewith is a summary for the use of all engaged and interested in the utilization of the so far unutilized Balanites aegyptiaca fruits with special attention paid to the African Sahel Zone.

UNIDO project officer was Mr. H. Koenig.

III. INTRODUCTION

Initiated by the worldwide trend for utmost utilization of the natural resources for human consumption, UNIDO has commissioned the elaboration of a study about the utilization of _Balanites aegyptiaca_.(Arab name"Lalobe")

A fruit, available in large quantities in the Sahel-zones of Africa, specially in the Sudan but unutilized as far as now.

With the permission and assistance of the relevant authorities of the governement of the Sudan an intensive development work was started on the economical utilization of _Balanites ae._

During this research and it's very promising results, _Balanites aegyptiaca_ turned out to be a valuable raw material rich in vegetable oil, protein and carbohydrates and could very well be seen as the basis for a new agro-based industry.

This elaboration deals with the processing of oilseeds in general and the required adaptations for processing of _Balanites aegyptiaca_. It will explain the reasons and advantages of the estimated processing area in the Sudan and why the city of Abu Gubeiha was recommended for the start-up of the project.

This study should represent a digest containing details and specifications of a processing scheme and its technology specially developed for the utilization of _Balanites aegyptiaca._

1.) COMPOSITION AND CHARACTERISTICS OF BALANITES AEGYPTIACA.

Basing on the requirements to use also non traditional agricultural raw materials for the production of human food and feed for animals, UNIDO has commissioned an intensive product development on Balanites aegyptiaca nearly unutilized as far as now in the Sudan. (Fig. No. 1)

The fruit is growing on a tree with a strong, deep rooting tap root. Due to the thick bark the tree is very resistant to grass fires. It is semi-deciduous, loosing a part of its leaves during the dry season but always retains some leaves over the whole year. It flowers from November till April. The ripe fruits can be collected from January till August.The Balanites tree begins to fruit in about five to seven years and reaches full maturity within twentyfive years. Thereafter it has a lifetime of over hundred years.

An average mature tree annually yields between hundred and hundredfifty kilograms of ripe fruits. The size of the fruits is differing between 2,5 to 4,0 cm in length and about 1,5 cm in diameter depending on the species of tree.

1.1) Composition.

For the better understanding of the process technology we repeat in a short rewiev the composition and chemical constituents of Balanites aegyptiaca fruits.

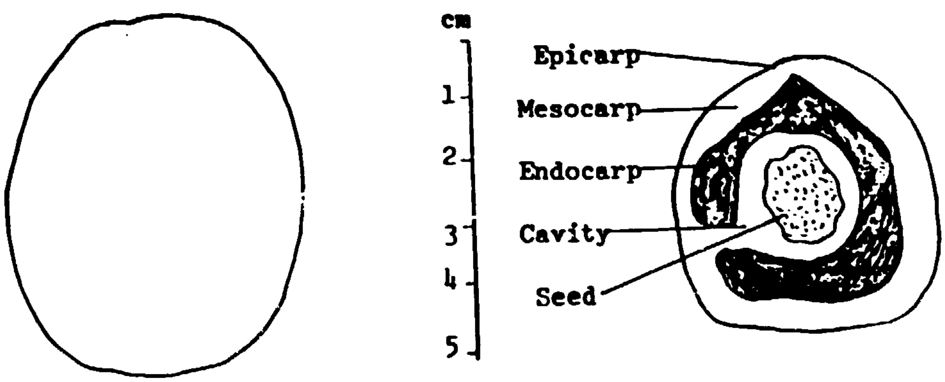
The ripe fruit consists of a leathery outer skin(epicarp) covering a yellow-brown sticky edible(but bitter) flesh (mesocarp) composed primarily from sugar as glucose and fructose. Additionally it contains steroidal saponins as yamogenin and diosgenin as well as crude protein, crude fibre and vitamin C. The mesocarp surrounds a hard, fibrous wooden shell, mainly consisting of cellulose(endocarp) in which the kernel is embedded. This kernel actually is the oil- and protein containing oilseed of Balanites ae. (Fig. No. 2)

Figure No. 1

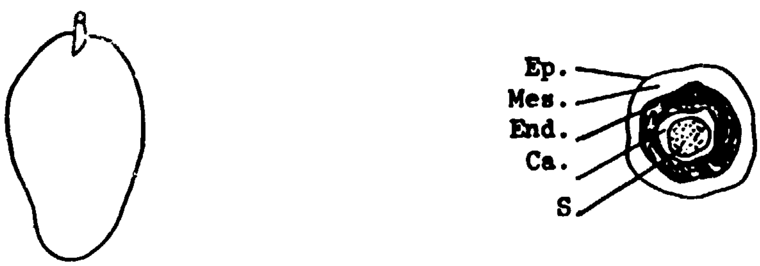
Balanites aegyptiaca tree
in the
Southern Kordofan Province

Figure No. 2

African Species of Balanites Fruits with longitudinal cross-section.



Balanites wilsoniana



B.aegyptiaca

B. orbicularis

B. pedicellaris

The weight of a ripe Balanites fruit ranges between 10 and 15 grams per fruit. The composition of the parts of the fruit in average in weight/weight % is as follows:

Epicarp (outer skin)	17%	
Mesocarp (soft flesh)	33%	
Endocarp (wooden shell)	40%	
Kernel (oil-seed)	10%	(oil content appr.46%)

The composition may vary due to the different geographical growing areas in the Sudan. (Figures No. 3, 4, 5)

The following table shows the chemical composition of the <u>Balanites ae.</u> fruit:

	weight/weight%	
	Flesh	Kernel
Moisture	18 - 25	3,5 - 4,5
Fat	0,1 - 0,5	46 - 51
Crude Protein	3 - 7	26 - 30
Crude Fibre	1 - 4	2,5 - 3,5
Ash	5 - 7	2,5 - 3,5
Carbohydrates(total)	64 - 72	15 - 18
Diosgenin/Yamogenin	3,5 - 4,0	2,0 - 2,5
Vitamin C	0,01 - 0,02	-

Details and specifications can be taken from the UNIDO edition IO 494/1983.

1.2.) Final products in general.

Since in the study of UNIDO/IO 494 / 1983, the final products are specified in detail, in this draft only a short review will be given as follows:

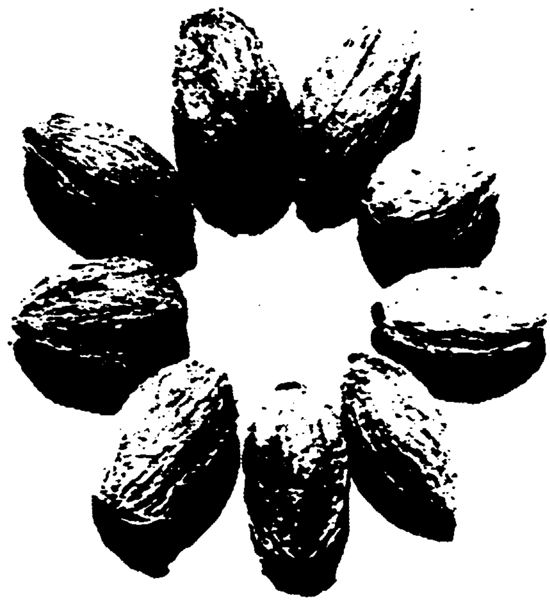
Balanites ae. mesocarp

The mesocarp which forms 28 - 33% w/w of the whole fruit is considered to form an important potential for the sugar- fermentation- and steroid manufacturing industry.

Figure No. 3

Balanites Fruits
of different sizes.

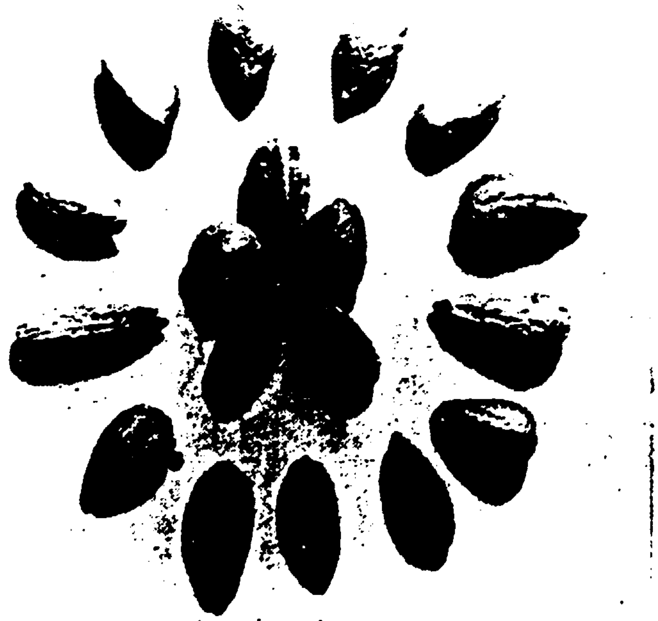
Figure No. 4



Balanites Nuts
different sizes

Figure No. 5

Crushed Balanites Shells



Balanites Kernels

For the start-up of this new agro industrial business it was decided to use the mesocarp as an addition for animal feed only. Incorporated into mixed feed or sprayed on roughages or grain mixtures it is of good nutritional value and makes the food more palatable for the animals.

Used for fermentation it will yield ethyl alcohol and carbondioxide. after the distillation of alcohol, used for industrial purposes, the mash can be used for the hydrolysis of the steroidal saponins as diosgenin and yamogenin.

The remaining slops with an approximative content of 60% w/w solids will be used also as an animal feedstuff.

Balanites ae. shell

The shell forms about 49 - 54% w/w of the whole fruit.

Considering the shell as a source of fuel it is assumed that the calorific value is appr. 4.000 Kcal.(-16.500 Joule) which is nearly half of the calorific value of heavy fuel oil.

Balanites shell can also be used for the production of charcoal or even activated charcoal, all two products with good market value and demand.

Balanites ae. kernel

The Balanites kernel forms about 8 - 12% w/w of the whole fruit. The oil content is appr. 50% of its weight.

By expellerpressing of this kernel we will get yields of 35% of edible oil and 65% of cake for feeding purposes.

Therefore our utilization model and our technology is elaborated in view to the processing of these two main products from the fruits of Balanites aegyptiaca.

2.) BALANITES AEGYPTIACA IN THE SUDAN.

The Balanites tree is usually found mixed with trees of Acacia Seyal. This is known as the Acacia Seyal-Balanites savanna in the wide tropical Sahel belt of Africa from Tanzania to the Ivory Coast.

2.1.) Growing areas

In the Sudan the Balanites ae. tree can be found mainly in the provinces of Darfur, Kordofan, Blue Nile and Kassala. (Fig. No. 6)

THe Balanites(Lalobe) tree grows where the rainfall exceeds 250 mm/Year. It can be found on the sands of Kordofan and Darfur, on rock-debris on the foot of rocky hills as well as hard surfaced sandy clays and sandy soil.

2.2.) Available quantities of Balanites aegyptiaca

Primary survey done already 1979 shows that appr. 72.000 acres (28.800 hectares) in the Blue Nile Province are covered with Lalobe trees. In Southern Kordofan Province where our test-plant will be located appr. 105.000 acres (42.500 hectares) with an average density of 15 trees/acre (38 trees/ha). An estimated amount of 1,6 Mill. trees in this area will provide a quantity of nearly 200.000 tons of Balanites fruits per year.

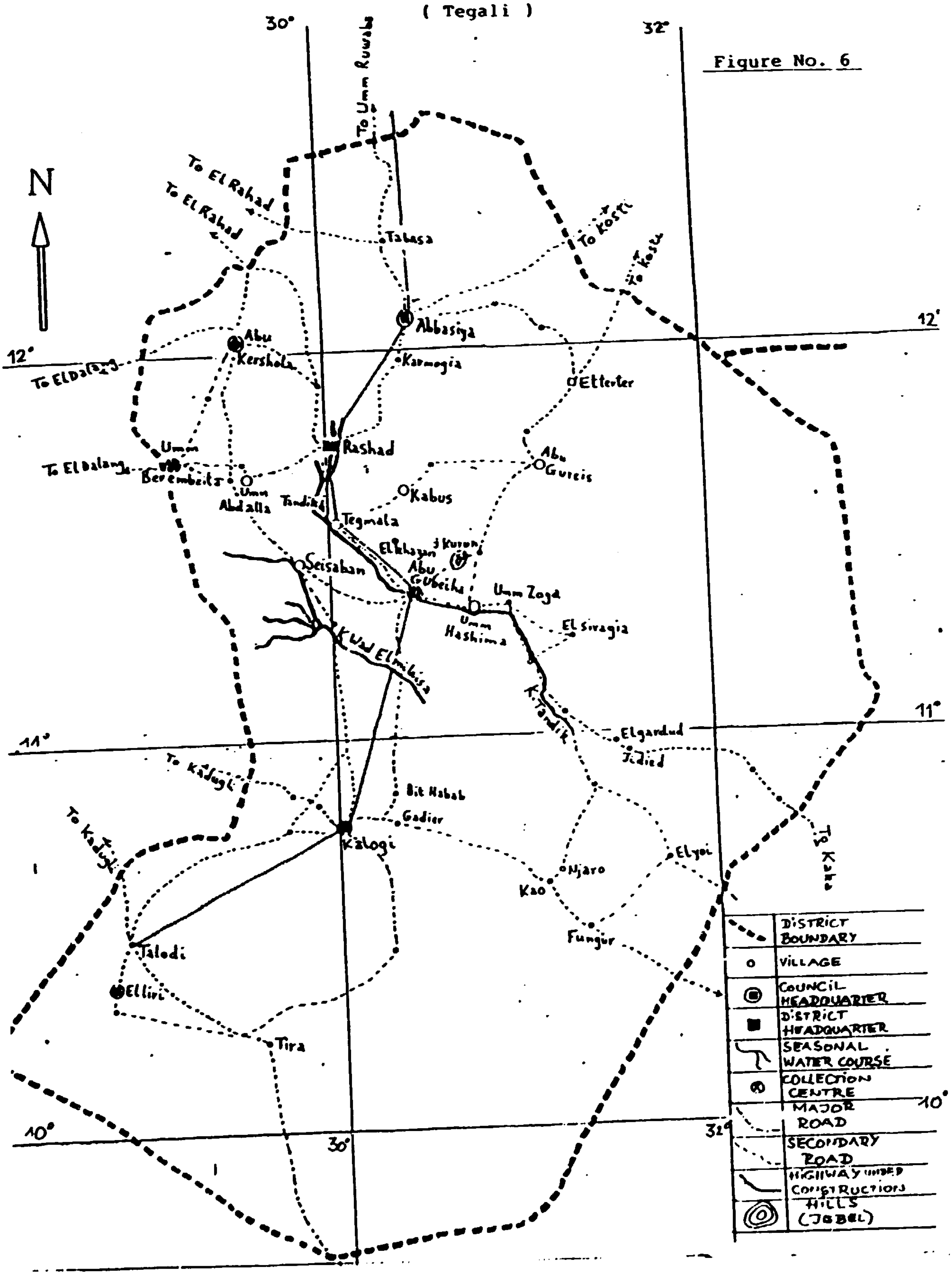
2.3.) Market price for raw material (1 US$ = LS 4,50)

Taking into consideration that transportation costs for one ton of Balanites fruits over a distance of 100 kilometres will be LS. 70.-- and the costs for collecting of the fruits amounts to LS 170.-- per ton of fruits we can calculate our cost price for 1 ton of Balanites fruits arriving at the processing plant will be LS. 240.-- (US$ 54.--) per ton of fruit.

Eastern Diastrict of the South Kordofan Province

(Tegali)

Figure No. 6



3.) EXPECTED PROCESSING AREA IN THE SUDAN.

For the installation of a new agro industrial project you have to provide the utmost conditions concerning to raw material supply, technology low operating costs and market for final products. Therefore it is most important to find a site where all above mentioned requirements can be realized.

3.1.) Infrastructural parameters

After having selected a site due to the demands it will be very important to check the infrastructure of the place. There are mainly four parameters which must be taken into consideration:

1.) Satisfactory supply of water for process and cleaning?
2.) Available resources of energy (electricity and steam)?
3.) Good connection of site to roads or railway.(transport)?
4.) Is the site big enough for installation of the new plant as well as storage capacities even in view to expansion?

If this questionnaire can be answered positively in all points you will have a satisfactory basis for the start-up of the project.

3.2.) Location of processing plant in view to the growing area of Ba.

As a matter of fact the best situation of the plant will be in the center of the lalobe growing district. But having in mind that the finished products must be supplied to the people via markets you have to find a compromise between these two aspects to run the plant as economically as possible.

3.3.) Requirements for most economic utilization.

In the state of planning a new agro industrial project you have to deal intensively with all requirements to meet the parameters for most economic utilization.

In our case this starts from the selection of the site with an already existing oilmill in the centre or close to the growing area of Balanites aegyptiaca.

You have to choose an economic distance for the transportation of the raw material from the field storages where it is collected to the factory. You must already have an oilmill equipped with the machinery for conventional oilmilling to keep your investmentcosts as low as possible. You must have the required storage capacity. Water- and energy supply must be sufficient for the estimated processing capacity. and last but not least the market for the final products should be close to the oilmill. collecting points as well as market must be connected to the factory with satisfactory roads.

In view to meet this target many visits to different sites and areas had to be made by the IRCC team and UNIDO consultants to find the best site for processing of Balanites fruits but finally it was decided that the city of Abu Gubeiha in the South Kordofan Province will fulfill all the required parameters for the economic utilization of Balanites ae. Collecting camps will be installed in the surrounding areas and the already existing oilmill will be adapted for the manufacturing of Balanites aegyptiaca.

4.) UTILIZATION MODEL FOR BA AT ABU GUBEIHA.

Within the former chapter it was explicated why Abu Gubeiha was selected for the installation of the pilot processing model for Balanites ae. Here the utilization model will be explained in detail.

4.1.) Specification of model.

We always had to take into consideration that the development for initiation of a new agro industrial project has to be done not only in view to national interests. Technical Know How as well as the entire utilization model will certainly be of great importance to other Balanites growing countries in the Sahel zone of Africa.

Therefore a model was developed which could easily be transferred with some slight modifications to other countries as well. The model was based on the already existing experience on the field of oilmilling technology but had to be modified and adapted to the specific properties of an unused as far as now but now discovered for utilization, oilbearing fruit, the Balanites aegyptiaca(Lalobe) and to the local conditions in the Sudan.

4.2.) Application of model in assigned area.

The area around Abu Gubeiha has all required advantages for the realization of a Balanites ae.utilization model.

The area is rich in Balanites(Lalobe) trees. The population is eager for new resources of income and will enjoy an increase of their social standard, earning more money by collection of Balanites fruits and working in the new industry.

Since the oil was made by hand in very small quantities in this area local people already know Lalobe-products and specially the oil which they prefer to other vegetable oils.

Abu Gubeiha is considered as the main market of the Eastern Kordofan Region. It supplies the whole area with consumer goods and is a distribution centre for agricultural and forestry products.

The area is linked by roads to the other parts, villages and towns of South Kordofan thus enabeling transportation of raw materials as well as consumer goods at minimum of costs.

There is an oilmill in Abu Gubeiha and its owner is willing to cooperate by adaptation of his oilmill for the processing of Balanites ae.

The area is secure and densily inhabited which guarantees sufficient supply of manpower for fruit collection, transportation and manufacturing.

All these facts together prepare an ideal basis for the realization of the project for Balanites aegyptiaca processing in this area.

5.) UTILIZATION MODEL IN DETAIL.

One of the most important steps of the model is an efficient supply of the oilmill with Balanites fruits as raw material and as a matter of fact we will start explanation of the utilization model with the bringing up of the Balanites fruits.

5.1.) Collection of fruits.

Before a project for the processing of a new oilseed can be started the sufficient supply of raw material has to be organized to render a continuous manufacturing process.

Since there is an average number of 20 trees per ha and from one tree 120 kgs of fruits can be harvested per year, it will need quite a number of collectors to supply the daily quantity of 100 tons of fruits to the oilmill.

The procedure of collection should be done in two steps:

1.) Small groups of collectors located in or close to the forrests collect the Balanites fruits and bring them by small carts to decentralized collecting stations (field centres)
2.) From there the weighed fruits will be supplied by trucks directly to the oilmill for processing.

The field centres should be managed by a group leader who is assigned to look after the collecting activities, does the weighing of incoming and outgoing fruits, unloading of the collection carts, loading of trucks and the payment of the collectors due to his records. He should be responsible for the intermediate storage, the bringing up of the required amount of raw material but also for orderly social living conditions in the camp.

5.2.) Transportation and storage.

The collecting teams should be equipped with small carts with a loading capacity of appr. 250 kgs. These carts could be manufactured locally. The total weight should not exceed a limit where it could be pulled by an animal or the collectors themselves. These standardized carts will help to facilitate the control of the incoming Balanites fruits because no weighing will be required to know the incoming quantity of fruits and therefore the calculation with the collecting teams will be easy.

The storage could be a flat storage covered by an open shed and with a ground made of stamped earth, fenced by a wickerwork up to on meter high. The size can be selected due to the quantity of daily incoming fruits but should not be less than for 100 tons of storage capacity.

From this field storage the fruits will be transported by trucks to the oilmill.These trucks should nott exceed a loading capacity of 6 to 8 tons because of the road conditions not allowing more weight.

By that way every day between 15 and 20 trucks will arrive at the oilfactory respectively its storage which should have a storage capacity for a two weeks production or about 1.500 tons.

5.3.) Payment mode for fruit collectors.

The utmost benefit of this project should be for the fruit collectors as an additional source cf income.

The proposed collection and payment system is derived from the "Gum Arabic Company" which needed 20 years to develop the present system. Both, Gum Arabic and Lalobe fruits are forestry products that overlap in the growing area.

If a payment mode similar to the system of the Gum Arabic Comp. will be installed it is known and will be accepted in the area.

The main steps in organization of collecting and payment system are:

a.) Formation of an organization that looks after collection, purchasing, storage and transport of Balanites and being responsible for the management of these activities.

b.) To reserve certain areas where dense Balanites forests are located. This will give an opportunity to protect these forests and a guarantee that the fruit collectors can do their jobs without interference from individuals, tribes or local forest authorities. This is also on line with government policy.

c.) Assignment of collection centres near the main collection areas providing them with the following:
Erection of storage facilities
Installation of field station as a service station for the collectors, providing water, medical treatment, tools, carts and spareparts, packing material etc.

d.) Appointment of an agent in each collection centre. This agent should work either on commission- or on fixed price basis.(price from collector to agent, another price from agent to project management.) At later stage according to quality and supply-distance, distributed prices could be installed.

e.) The selling price has to be fixed before the collecting season to ensure:

1.) A reasonable price justifying the commercial utilization of Balanites ae.

2.) Since the fruit collector will directly benefit from his activity the price must be high enough to make collecting attractive for the people.

3.) The collector will be aware of the selling price.

4.) Elimination of black market activities, intermediaries, brokers and unfair trading manners.

5.) Control of price policy for raw material as well as finished products.

f.) Arrangement of transportation from field centre to the oilmill.

6.) PROCESSING TECHNOLOGY FOR BA DUE TO CONVENTIONAL OILMILLING.

The technology for processing of Balanites ae. is basing on conventional oilmilling. Therefore we will give a view about the equipment and machinery used in oilmills, manufacturing other oilseeds as groundnut, sesameseed, cottonseed or sunflower. Since there are many of such oilmills already existing in the Sudan, processing above mentioned oilseeds by conventional methods, knowledge of this technology will facilitate the understanding of the additional equipment required for the adaptation for processing of Balanites aegyptiaca.

6.1.) Oilmilling in general. (Appendix, Figure No.I)

As a matter of fact there are three methods used worldwide for the processing of vegetable crude oil from oilseeds:

1.) By pressing with hydraulic- or expellerpresses.

2.) By solvent extraction with hexane.

3.) Combined process. First step - expellerpressing followed by solvent extraction.

Since methods mentioned in items 2 and 3 are requiring an expensive machinery and equipment they are mainly used in large scale production of vegetable oil.Therefore we will confine our explanations on the method in item No.1.

Production of vegetable oil by expeller pressing.

To start from the seed intake over a weighbridge you need some conveying equipment to bring the oilseeds to the processing plant. Such a plant in general consists of the following processing steps:

1.) Seed storage
2.) Seed cleaning
3.) Decortication (cotton seed must be delintered before dec.)
4.) Pretreatment (size reduction)
5.) Conditioning
6.) Pressing by continuous screw presses (expellers)
7.) Crude oil filtering
8.) Crude oil storage
9.) Cake breaking
10.) Cake storage

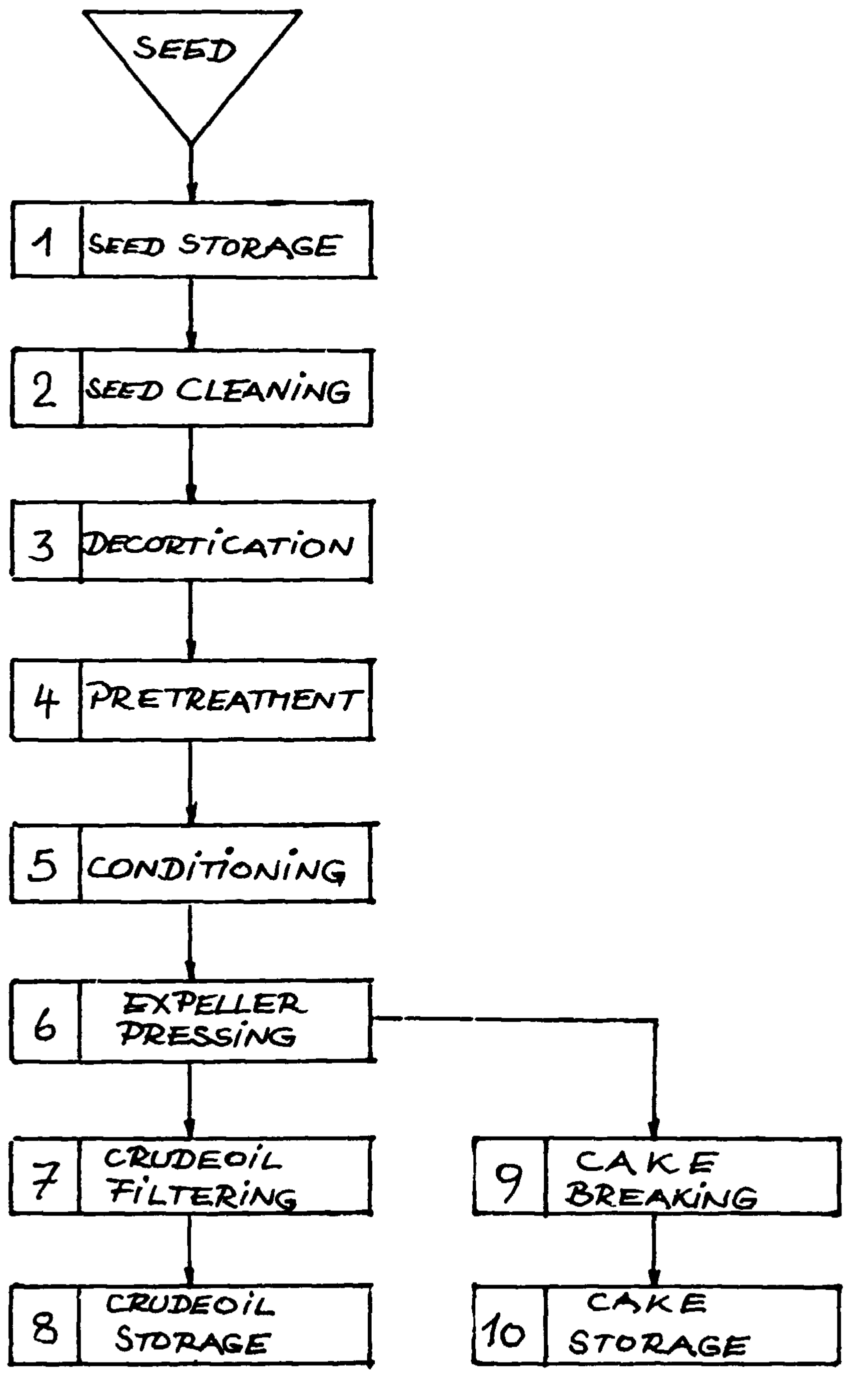
(see flow diagram page no. 18)

The oilseeds normally arrive at the oilmill by road, railway or ship, depending on the location of the factoy. the unloading equipment must be capable of handling the incoming seeds at the rate of arrival. The material has to be weighed, sampled and tested on quality in the laboratory. A well-trained staff and an appropriate recording and accounting system is required to effect proper payment to the suppliers. A weighbridge has to be provided to control all incoming and outgoing material.

1.) Seed storage

Proper storage is perhaps the most important factor in successful oilseed processing. Spoilage of seeds can result from the effects of mould, insect damage and overheating during storage.

Flow Diagram



Storage can be done by silos. They are usually offering the best opportunities for controlled storage of seeds. Since they are expensive in acquirement, silos are likly used for storage of big quantities of seeds.
For oilmills working on small scale basis it will be much more economic to store in "Flat storages" covered by sheds and with floors made of concrete or even stamped ground. Specially if the storage time will not last too long, this kind of storage turns out to be sufficient. There is no experience about the storage properties in silos of Balanites aegyptiaca.

The following points will show the proper seed-preparation.

2.) Seed cleaning

This process is necessary to remove sand, stalks, plant debris and any foreign matter. Cleaning is done by table- or rotary-sieves usually equipped with an air aspiration by fans and cyclones for dust removal. Thorough cleaning is essential to avoid damage and wear to the subsequent milling and expelling equipment.

Delintering of cotton seed

Cotton seed is obtained from the ginneries with appr. 10-14% of linters(residual fibre) that have to be removed by delinting prior to further processing. Special delintering machines are used for this purpose.

3.) Decortication

To obtain a cake or meal with low fibre and high protein content it is necessary to remove the hulls from the oilseeds. Specially designed decorticators working on the principle of impact are used for this purpose. The hulls and the kernels (meats) are subsequently separated by vibrating screens and the light hull fraction removed by an airstream. Appr. 8-12% of hulls are left in the meats to facilitate the subsequent pressing process.

4.) Pre-treatment

For efficient oil recovery the decorticated seeds have to be prepared by size reduction, by breaking them in hammer mills or fluted roller mills.

5.) Conditioning

The process is done in vertical or horizontal conditioner-cookers. A vertical cooker is mostly fixed on top of an expeller press and consists of 4 - 6 stages wherein the seeds are moved by paddle stirrers.

For adjustment of the moisture content and the temperature the seeds are kept there for appr. 30 - 60 minutes at a temperature of 90 - 95°C.

This process facilitates expellerpressing and additionally raises the oil-yield.

6.) Pressing by continuous screw presses(expellers)

Srew presse are used in the oilmilling technology for two different purposes:

a.) Pre-pressing. Seeds containing a high oil content are usually pre pressed in modern large scale oilmilling. The obtained oil cake with a residual oil content of appr. 15 -18% after prepressing will be further processed, usually in a continuous solvent extraction plant producing a cake with a residual oil content below 1,0%.

b.) High pressure pressing. To achieve the maximum oil yield the pressing will be done by one, single press. (remaining oil in cake appr. 5,0%)

This result also can be reached by two, subsequently arranged presses(first pressing to 15-18% residual oil, second pressing 5,0% residual oil.).

Disadvantages of process:

Relative low oil recovery.
High electric power consumption.
High mechanical wear therefore high maintenance costs.

Advantages:

Low investment costs.(solvent extractions are expensive)
More flexible in small scale processing.
Easy and quick in installation.
Simple process control and maintenance.
No danger of fire by solvent.
Less skilled operators required.

For better understanding we finally give a short review about the mode of operation of an expeller press.

It consists generally of a shaft fitted with a screw-like worm around it. This shaft turns inside a horizontal cage consisting of bars which form kind of a slotted tube around the shaft.

The oilseed moves from feed end to the discharge end. By this way the oil is expelled through the cage slots. The cake is expelled through a choke gear, regulating the pressing pressure and the residence time of cake and by this way the oil yield, respectively the residual oil content of the cake.

6.2.) Additionally required special equipment.

The processing of Balanites aegyptiaca required the development of a new technology consisting mainly additional equipment to the conventional oilmilling technology, as follows:

1.) Mesocarp separation tanks.
2.) Decanter separators. (separation Mesocarp/water)
3.) Nut dryer.
4.) Magnet (separation of iron)
5.) Nut cracker.
6.) Hull separator.

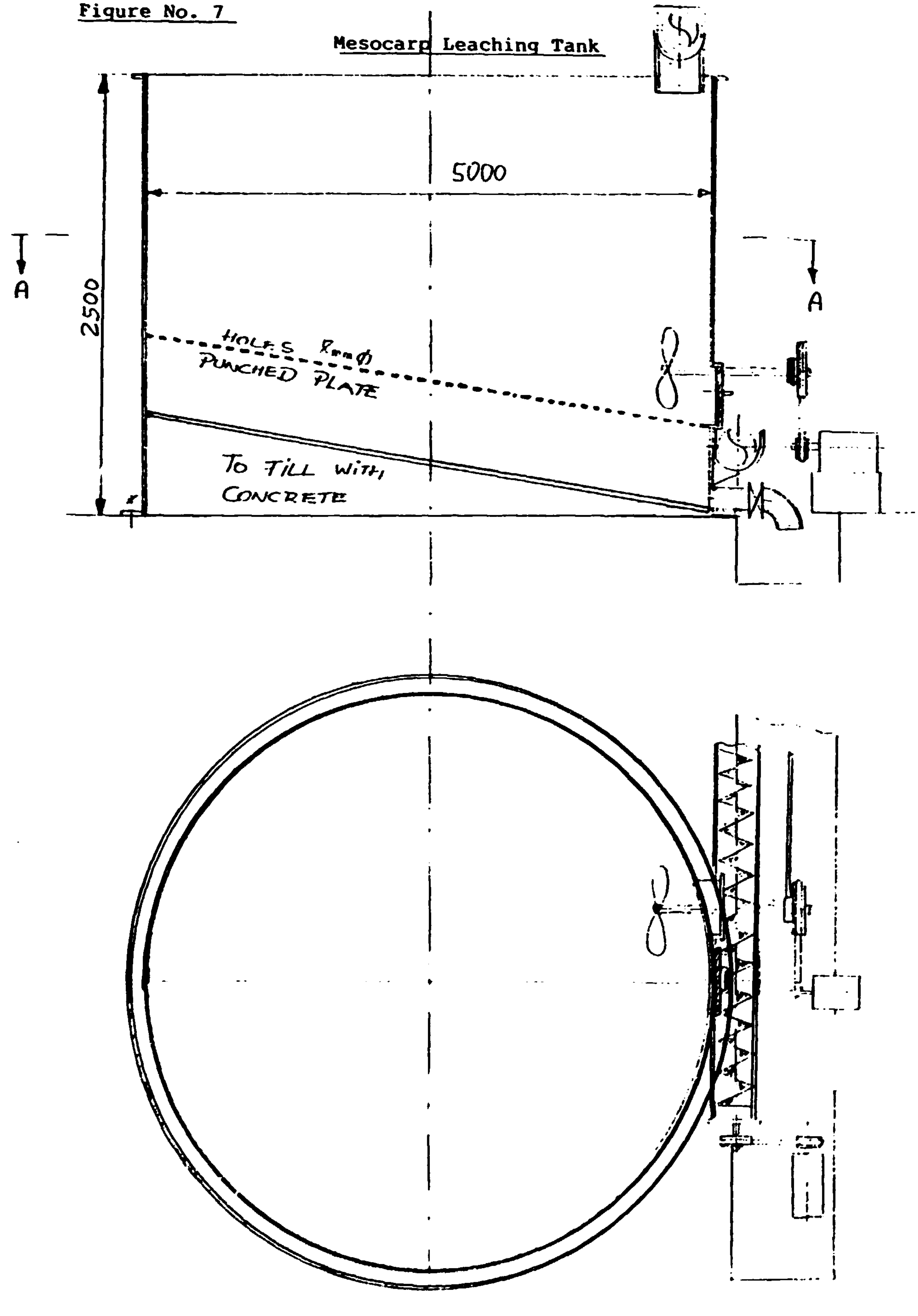
Explanation of newly developed equipment:

1.) Mesocarp separation tanks.

The mesocarp can be removed by leaching the whole fruits in hot water (appr. 60°C) for 12 hours under constant agitation. The tanks could be made of concrete, sheeted iron or even wood. Every tank with a content of appr. 40 m^3 (5 m in dia, 2 m high) which turned out to be the most economic size, has to be equipped with a stirrer and an angled sieve-plate and should be fixed on a concrete foundation. (Fig. No. 7) For emptying of the tanks a pulp drainage channel made of concrete should be installed under the outlet valve of the leaching vessel. An extra outlet above the sieve plate for the cleaned nuts will be emptied into a screw conveyor.

Figure No. 7

Mesocarp Leaching Tank



SECTION A A

2.) Decanter separators.

If after finishing of the leaching process the Mesocarp leaching tanks are emptied, most of the water can be recycled by sending the pulp through decanter separators, separating the water from the dissolved Mesocarp.(water loss appr.2%) The Mesocarp-fraction as well as the recovered water can be stored in different tanks for further use.
Decanter separators are available from experienced manufacturers worldwide.

3.) Nut dryer.

After removal of the Mesocarp the nuts must be dried before further processing. This should be done in two steps. First step will be a vibrating screen removing the surplus water between the nuts. In the second step, a cascade dryer, steam-heated air is blown in countercurrent to the downstreaming nuts drying them to a satisfactorily degree for grinding.

4.) Magnet.

Above a beltconveyor feeding the nuts to the nut-cracker a magnet should be installed to prevent mill damage by iron parts.

5.) Nut cracker.

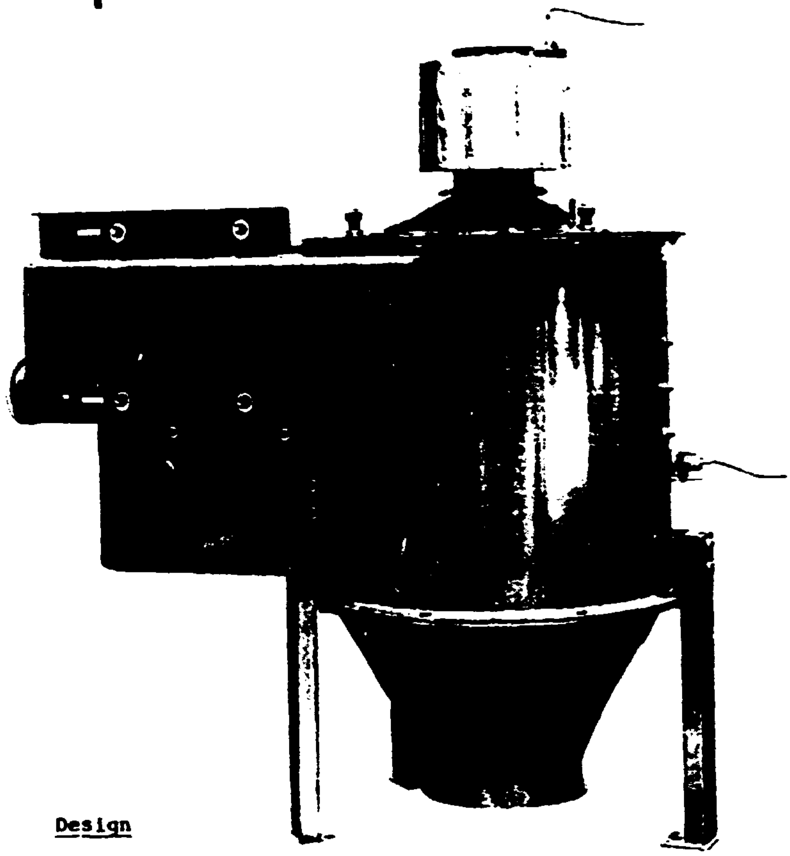
A hammermill, an impact-dehuller or fluted breaker rolls can be used to crack the nuts which contain the oilbearing kernels. The more the kernel fraction is broken, the better will be the oil-yield. The kernel-hull mixture is fed to the next process step. (Fig. No. 8)

6.) Hull separator.

For separation of hulls from kernels a combination of a sifter with an air-classifier or a hydrocyclone-sifter can be used. Appr. 41% of the total of 53% of hulls can be removed. An average of 12% of hulls will be remaining in the kernel fraction. Hulls as well as kernels will be conveyed to intermediate storage from where they are disposed for further use.
(Fig. No. 9)

Impact - Dehuller

Figure No. 8



Design by Buhler Brothers Ltd.

Design

Dust-tight all-metal constructions.

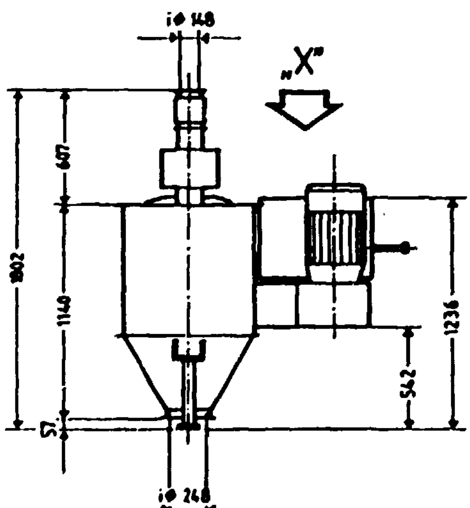
Zylindrical housing with supports, in- and outlet spouts as well as in^egral motor base.

Horizontal rotor mounted on vertical mainshaft. The rotor is equipped with easily exchangeable rotor flight made of high wear resistent steel.

Between housing and rotor is the impact cone mounted, which is adjustable in hight in order to adjust the clearance between rotor flight tip and cone.

The mainshaft runs in roller bearings and is driven by a 15 kW motor via a variable belt drive.

The motor support is manually adjustable by means of a spindle.



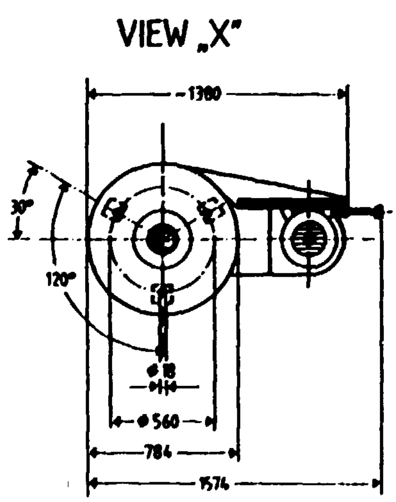
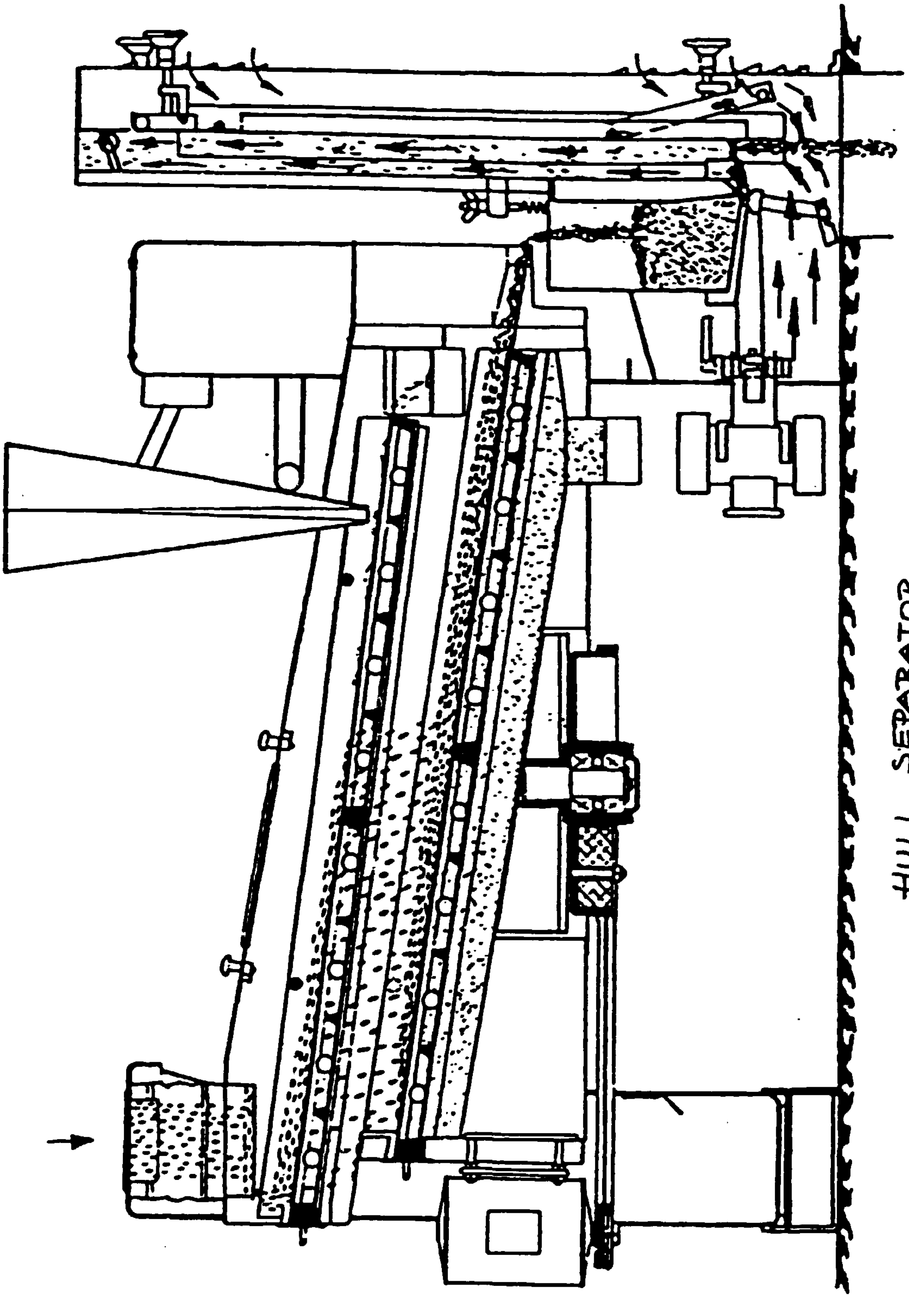


Figure No. 9



HULL SEPARATOR

DESIGN BY BUHLER BROTHERS LTD.

With the above mentioned equipment every conventional oilmill could be adapted for the processing of Balanites aegyptiaca.

6.3.) Process description for processing of Balanites ae.

After arrival at the oilmill the Lalobe-transports are weighed on a weighbridge and then discharged into the fruit storage. From there it will be moved by carts to a hopper which feeds via screw conveyor the Mesocarp separation tanks. The tanks are equipped with a bottom valve for the pulp-outlet, an agitator driven by a diesel or animals, a sieve-plate with holes 8 mm in dia and an outlet door for the nuts.

After removal of the Mesocarp (12 hours) under continuous agitation the pulp-water-mixture is emptied by the bottom valve into a collecting channel from where it is pumped to a holding tank. From there the mixture is fed to decanter separators for for separation of pulp/water. Nearly all the water can be recycled (loss appr. 2%) and stored in a tank for further use. The pulp is pumped to a tank from where it will be discharged for feeding purposes. The nuts are fed via screw conveyor to a drying unit, consisting of a vibrating screen and a cascade-dryer, heated with steam. A magnet for iron separation is fixed over the conveying belt, feeding the nuts to the nut-cracker. (hammer-or impact mill or fluted breaker rolls.) The mixture of kernels and hulls is discharged at the crackerbottom and fed to the hull separator.(double sifter with air classifier or hydrocyclone sifter.) I would not recommend the wet separation with brine solution because it needs big vessels, hugh quantities of water an extra drying unit for the kernels and on top of it its heavily polluting the environment.

The separated hulls are fed to a flat storage from where they can be conveyed to the steam boiler for burning.

The kernel fraction (mixed with appr. 12% of hulls) is conveyed to an intermediary tank from where it is fed to the conditioner cooker. This will be a vertical 5-stage heating kettle wherein the broken kernel fraction are conditioned by the means of heat and open steam are to the required temperature and moisture content for optimal deoiling. The conditioned kernel fraction is fed now to the high-pressure-expeller presses.

From this step of the process we get our final products, crude-oil and the presscake. The crude oil containing containing some solids (foots) is screened by a foots-vibrator-screen. (all particles bigger than 0,4 mm are removed). The crude-oil subsequently is pumped through a cloth-filter or a self-cleaning Niagara-filter, to be polished. The finished crudeoil is stored in a store-tank from where it is pumped to the bottling plant or sold in bulk.

The presscake is stored in a flat storage from where it can be sold as it is, as a feedstuff. It also can be ground by a cake grinder and bagged for retail sale. All the press-cake leaving the factory has to be weighed for proper calculation.

7.) ADAPTATION OF PROCESSING MODEL SPECIALLY FOR THE SUDAN.

Every processing model must be specially adapted to the respective country and its local conditions.

7.1.) Specifications in general.

The utilization model for Balanites aegyptiaca required the development of a system including all parameters starting from the Balanites(Lalobe)tree, its growing areas, local conditions, population, water-and energy resources, up to the existing oilfactories in operation, transportation, roads- and road conditions and last but not least the possibilities of marketing of new products.

A scheme had to be worked out taking into consideration the establishment of a new agro industrial business and all its problems as raw material supply by collection of fruits, field storage, transportation to site, a new processing technology and a market research for the demand and utilization of new products by the local population.

After the elaboration of some relevant studies a processing model was worked out enabeling the Sudan to start the realization of the Balanites utilization project.

7.2.) Specifications in view to Abu Gubeiha.

Looking for a suitable site and an area for installation of a pilot plant after many proposals and comparisons the city of Abu Gubeiha was selected for realization of the developed model. More and more it turned out that this city will fulfil the required advantages for proper implementation of the new model.

Situated in the centre of the Lalobe-growing area, dense population, already existing oilmill of sufficient size and in good operation, sufficient road connections in the region and a market for already known products.

Not only the infrastructural requirements are available but also the local population is very interested in the new industry.

Therefore it was decided by all involved parties to start the project from this area by special adaptation of the processing model to the city of Abu Gubeiha.

8.) OILMILL AT ABU GUBEIHA.

As mentioned before there is an oilmill already in operation at Abu Gubeiha, processing Sesame seed, Groundnuts and Cotton seed. The owner of the oilmill wants to cooperate and participate in the project. So it was decided to adapt this oilmill for the processing of Balanites aegyptiaca (Lalobe).

8.1.) Description of already existing equipment.

The oilmill is situated near the edge of the town. The factory is well equipped, has a lot of unused area for extension, its own well, a new Diesel-generator-set and an oldfashioned but powerful steamboiler. The factory owns 4 expellerpresses. Two of them with a capacity of 5 t/day each and two modern Chinese expellers for 7 t/day each, one already in operation, the other one installed soon. Total pressing capacity 14 t/day of Lalobe-kernels, using the double pressing method.

Concerning to the energy- and water supply, the plant is independent from the official local supply.

In the moment the plant is processing sesame-seed and groundnuts. (Even a self constructed but very efficient dehulling machine for peanuts is available.)

The plant is situated in the center of the Balanites ae. growing area of the South Kordofan Province. There also seems to be enough flat ground in size of 50 x 100 m for erection of a flat store with a storage capacity of appr. 1.500 t.

In the following a short, listed, specification of the machinery and equipment already existing at Abu Gubeiha will be given:

a.) 2 expellerpresses for 5 t/day each in operation.
b.) 2 expellerpresses for 7 t/day each, one in operation.
c.) Cloth-filter unit for crude oil.
d.) Storage tank for crude oil.
e.) Presscake storage 10 x 15 m for appr. 150 t.
f.) Water well equipped with pump.
g.) Steam boiler for production of 500 kg of steam with 4 - 6 bar
h.) 2 Dieselgenerators appr. 100 Kwh each (one standby)

8.2.) Adaptations required for processing of Balanites ae.

For proper processing of Balanites fruits and due to the process scheme explained on pages 16 and 17, following additional equipment will be required for the adaptation of the Abu Gubeiha oilmill:

1.) Weighbridge 6 x 2,5 m weighing capacity 10 t.
2.) 4 Mesocarp separation tanks capacity appr. 40 m^3 each (see drwg. annex)
3.) Feedhopper for fruits to a.m. tanks (1 m x 2 m)
4.) Decanter separator for separation of water/pulp-mixture.
5.) 2 storage tanks for recycling water (50m^3 each).
6.) Nut dryer (vibrating screen and steam heated rotating dryer).
7.) Feedhopper for kernels. (1m x 1m)
8.) Magnet separator.
9.) Nut cracker (impact dehuller or hammermill).
10.) Hull separator (sifter with air-classifier).
11.) Cake breaker.
12.) Conveying equipment.

To get the quantity of 14 t of kernels per day, required for the production, 64 t/day of Balanites fruits must be processed.

The Mesocarp separation should consist of 4 tanks with 40 m^3 each, operated with 2 fillings within 24 hours. (1 fill consists of appr. 10m^3 Balanites fruits and 30m^3 water.)

To reduce the water consumption the water should be recycled via a decanter by separation from the pulp.

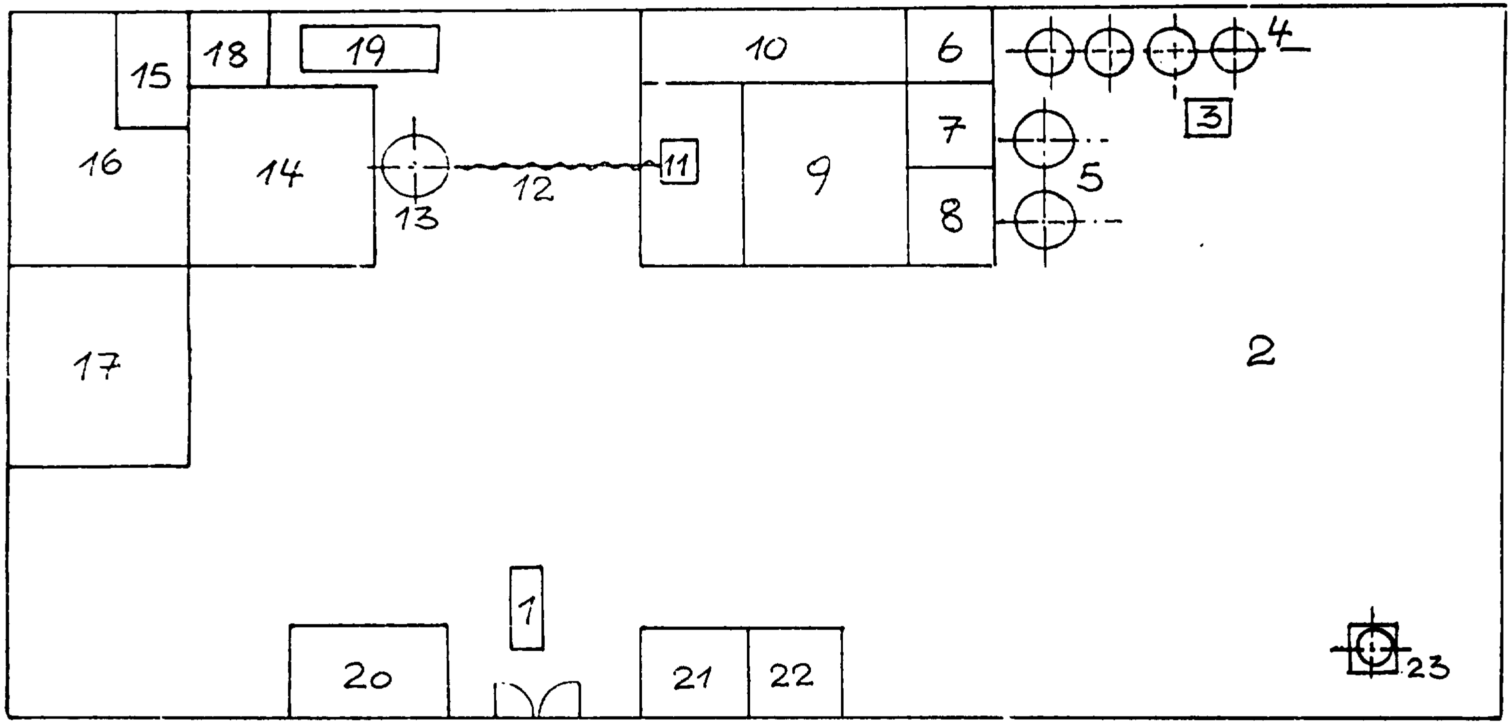
A complete layout drawing for the plant at Abu Gubeiha will be given in Figure No. 10.

8.3.) Throughputs and yields.

The following Figure No. 11 shows in a product balance the throughputs as well as the yields which will be received by the Abu Gubeiha oilmill during one day or 24 hours of operation.

Figure No. 10

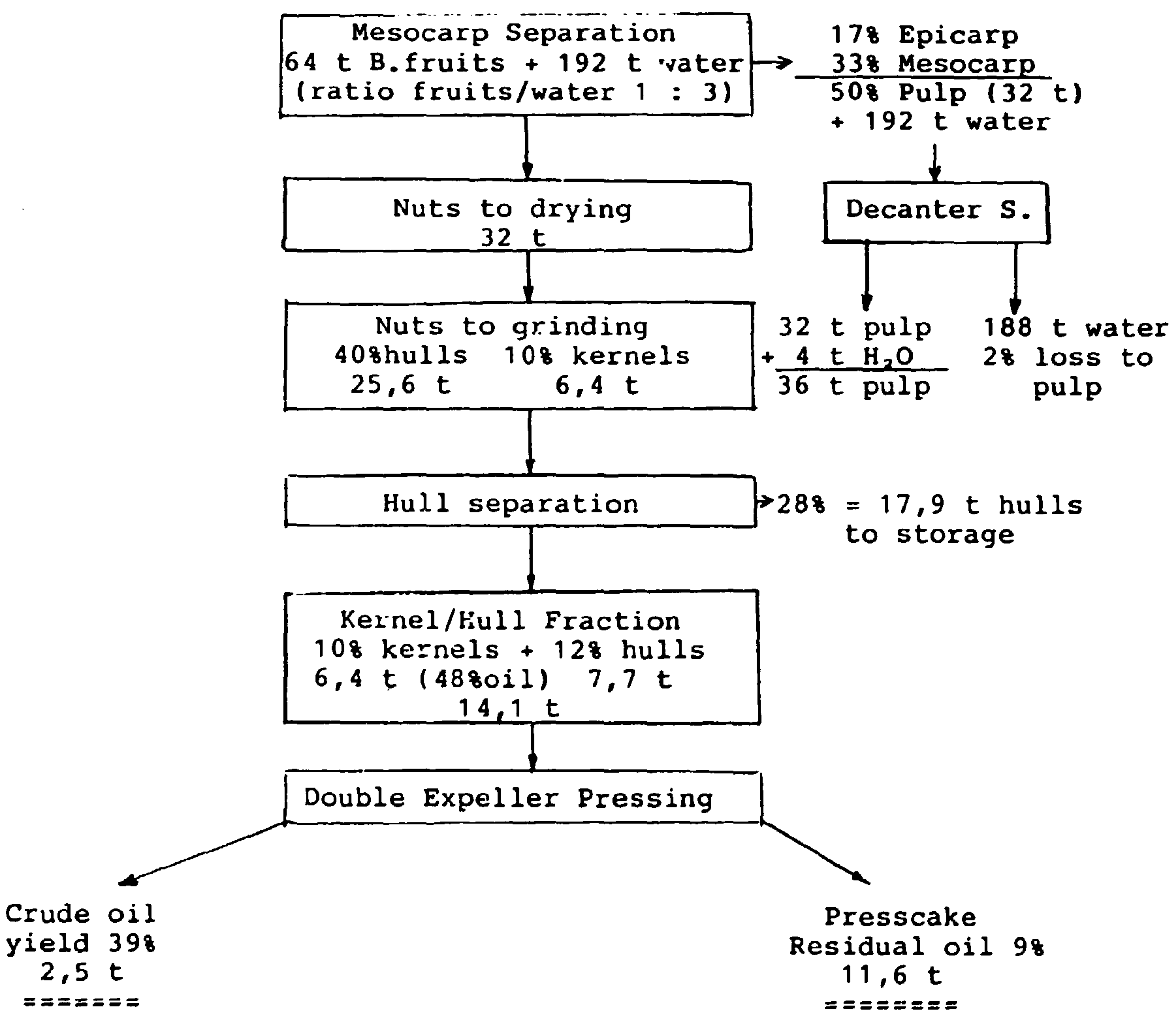
Layout for Abu Gubeiha Oilmill
Adapted for the Processing of Balanites Fruits.



1.) NEIGHBRIDGE
2.) FRUIT STORAGE
3.) FEEDER HOPPER
4.) MESOC. SEP. TANKS
5.) TANKS / RECYCLED WATER
6.) DEC. SEPARATOR
7.) NUT DRYER
8.) NUT CRACKER
9.) DECORTICATION
10.) HULL STORAGE
11.) FEEDER HOPPER
12.) CONVEYOR
13.) INTERMEDIARY T.
14.) EXPELLER PRESSES & OIL FILTER
15.) CRUDE OIL STORAGE
16.) BOTTLING
17.) CAKE STORAGE GRINDING/BAGGING
18.) ELECTRIC GENERATORS
19.) STEAM BOILER
20.) SOCIAL ROOMS
21.) OFFICE/ADMINISTRATION
22.) WORKSHOP/STORAGE FOR SPAREPARTS
23.) WATER WELL & WATERPUMP

Figure No. 11

Product Balance



8.4.) Investment costs.

Estimated investment costs for additional equipment required for the adaptation of the Abu Gubeiha oilmill for processing of Balanites aegyptiaca. (in US$) 1 US$ = 4,50 LS

Weighbridge 1.000 kg	5.000.--
Feedhopper for fruits	1.000.--
4 Mesocarp sep. tanks à40m³	50.000.--
Decanter separator	70.000.--
Nut dryer	20.000.--
Feedhopper for nuts	700.--
Magnet separator	1.000.--
Nut cracker	15.000.--
Hull separator	90.000.--
Cake breaker	5.000.--
Electric installations	4.000.--
Conveying equipment	20.000.--
Total equipment costs	281.700.--
Errection costs	
(appr. 30% of equipment costs)	84.500.--
Unforseen (10% of equipm. costs)	28.200.--
Total investment costs for	
m/c, equipment & erection	394.400.--
Total costs for plant adaptation	400.000.--
	LS 1,800.000.--

8.5.) Layout for a new oilmill for processing of Balanites ae.

If the processing at the Abu Gubeiha oilmill turns out to be a success, a new plant for large scale production working with the utmost economy has to be installed. In the following Figure No. 12 a Flow Diagram for such kind of plant will be shown. Figure No. 13 describes a layout for the new plant with a throughput capacity of 200 t/day of Balanites fruits.

Figure No. 12

Flow Diagram

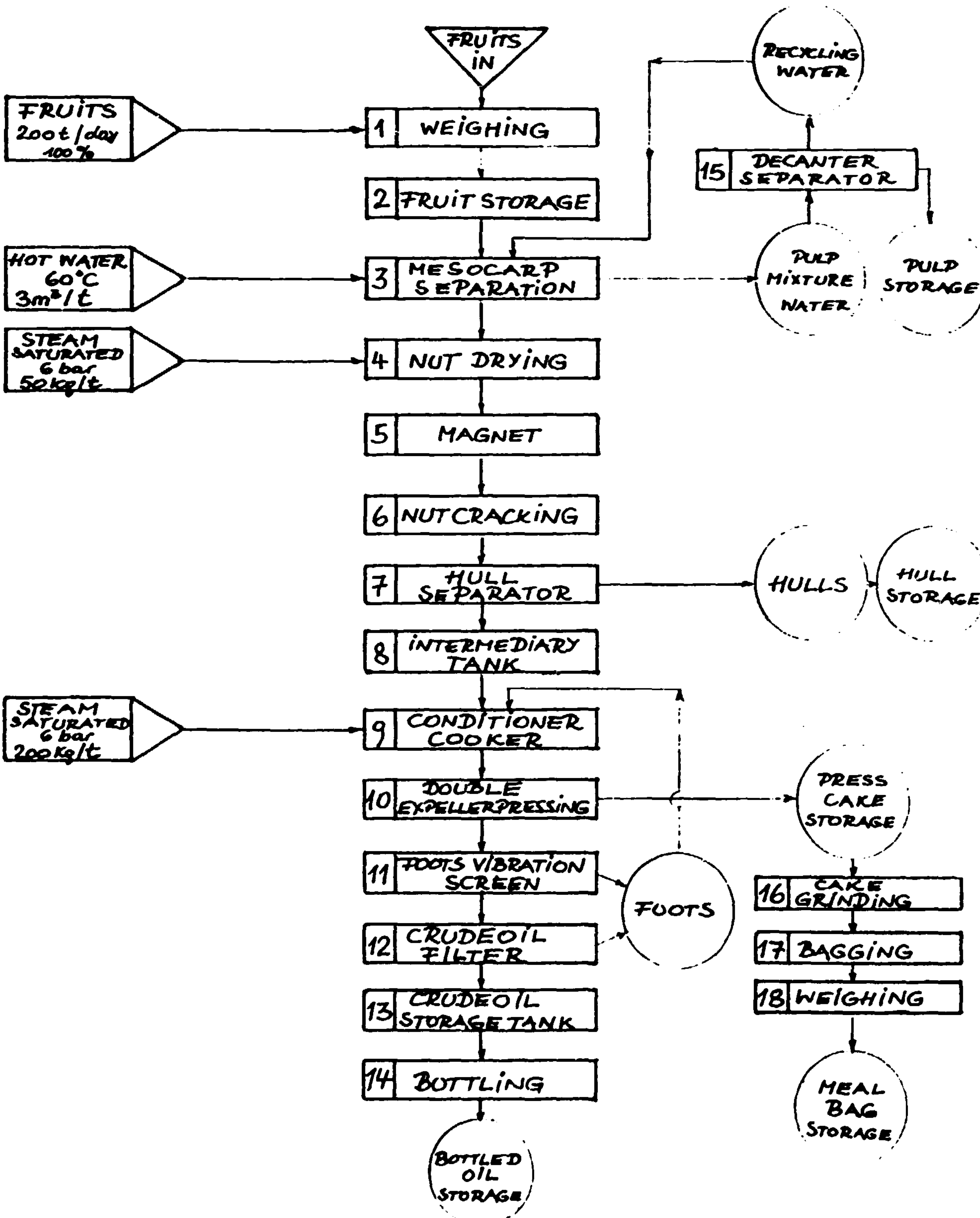
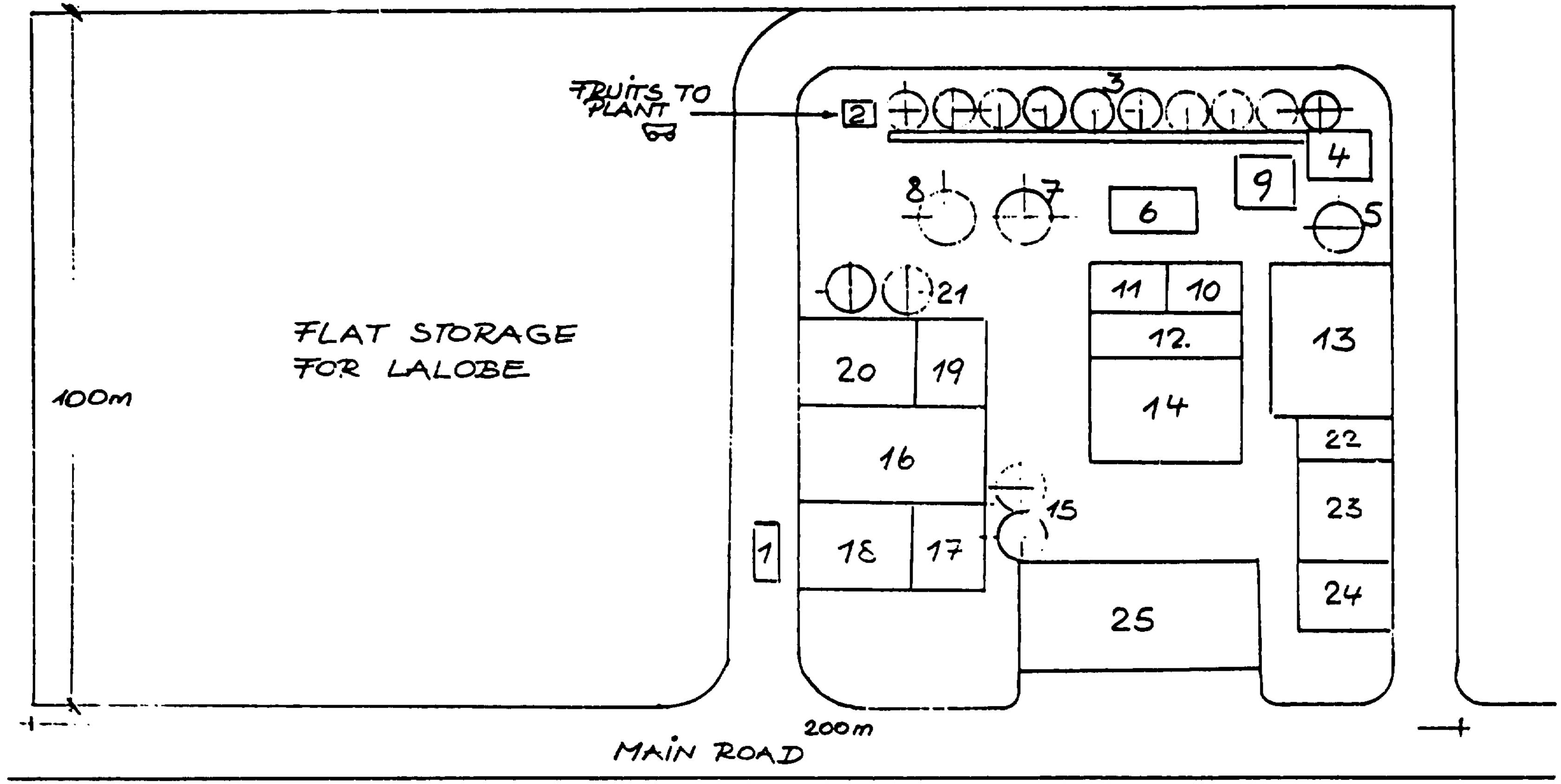


Figure No. 13

Layout for New Oilmill



1.) WEIGHBRIDGE
2.) FEEDER HOPPER
3.) MESOCARP SEPARATING
4.) PULP COLLECTOR PIT
5.) PULP TANK
6.) DECANTER SEPARATOR
7.) RECYCLING WATER TANK
8.) FRESHWATER TANK
9.) COLLECTING PIT FOR NUTS
10.) NUT DRYER
11.) NUT CRACKER
12.) HULL SEPARATOR
13.) HULL STORAGE
14.) HIGH PRESSURE PRESSING CRUDEOIL FILTRATION
15.) CRUDEOIL TANKS
16.) PRESSCAKE STORAGE
17.) BOTTLING PLANT
18.) STORAGE FOR BOTTLED OIL
19.) CAKE GRINDING / BAGGING
20.) BAG STORAGE
21.) PULP STORAGE TANKS
22.) BOILER HOUSE
23.) ELECTRIC GENERATOR
24.) FUEL STORAGE
25.) ADMINISTRATION, LABORATORY, WORKSHOP, SOCIAL ROOMS

Specification of items mentioned in Flow-diagram.

item 1.) Weighbridge

Taking into consideration that the fruits can be supplied also by heavy trucks the weighbridge should be designed for a max.-load of 10 tons.(size 8 m x 2,50 m)

item 2.) Flatstorage for fruits

Since the Lalobe fruits can only be harvested from December to End of February (3 month) the fruits must be stored in a quantity to have enough rawmaterial for the processing all over the year.(210 workingdays)The layer of fruits in a flatstorage may not exceed 30 cm. Therefore appr. 4 m² are required for storage of 1 ton of fruits. A lot of Lalobe can be stored outside of the factory but to ensure the operation of the oilmill a quantity of fruits for 10 - 14 days of operation should always be available. Therefore I suggest to prepare appr. 10.000 m² of flat ground by proper cleaning. This will be enough storage capacity for appr. 2.500 t of fruits. From here the Lalobe can be supplied by carts to a hopper from where it is fed to the next processing step via screwconveyor.(5kWh)

item 3.) Mesocarp separation

The mesocarp can be removed by leaching the whole fruits in hot water (60°C) for 12 hours under constant agitation. For 200 t of fruits 10 tanks will be required (40 m³ each) (5 m dia, 2 m high) containing 10 m³ of Lalobe and 30 m³ of water. If the tanks are emptied the water could be recycled (loss appr. 2%) using 2 decanter-separators (20 KWh each) to separate the pulp from the water. From a pulp channel under the leaching vessels the pulp-water mixture will be pumped to a storage tank for 80 m³. (pump 5KWh) from here it will be pumped by another pump (pump 5 KWh) to the decanters. The recycled water can be stored for reuse in a tank with 60 m³.

To cover the loss of 2% of water a freshwater tank containing 50 m³ should be installed.
The clean but wet nuts will be removed from the separation tank by the built in agitator through the outlet door into a screw conveyor (5KWh) for further processing.

item 4.) Nutdryer
=========

After removal of the mesocarp the remaining quantity of 124 t of nuts must be dried. This will be done in two steps. In the first step, a vibration screen, the surplus water between the nuts will be removed. In the second step, a cascade dryer, steamheated air is blown in countercurrent to the downstreaming nuts (fan 15 KWh) 50 kg of saturated steam with 6 bar will be required to dry the nuts to a satisfactory degree for grinding.

item 5.) Magnet
======

Above a beltconveyor feeding the nuts to the cracker a magnet should be installed to prevent mill-damage by iron parts.

item 6.) Nutcracker
===========

In this process step a hammermill or an impact mill or breaker rolls will be used to crack the hulls of the nuts and to remove the oilbearing kernels. (mill 15 KWh). If the kernels are used for the production of oil it willbe an advance if they are broken because it is increasing the oil-yield.

item 7.) Hullseparator
=============

For separation of hulls from kernels a combination of a sifter and an airclassifier or a hydrocyclonesifter can be used. (10 KWh) Appr. 40% of the total amount of 53% of hulls will be separated (12% hulls remaining in the kernel fraction) The hulls are conveyed to a flat-store for appr. 200 t of hulls 10 m x 20 m/ storage hight 2 m.)

item 8.) Intermediary tank
================

The kernel-fraction is fed to a tank with a capacity of appr. 35 m^3 (3 m in dia and 5 m high) This tank serves as a buffering tank for the mechanical extraction.

item 9.) Conditioning (Heating kettles)
=============================

Since the kettles are supplied together with the press 2 units will be available (1 for every press). The conditioning is done in 5 stages. During a treatment with heat and open steam a certain temperature (appr. 100°C) and moisture content (appr. 9%) is introduced into the kernels to achieve a maximum oil-yield during the extraction.

item 10.) High pressure-Expeller pressing
===============================

2 presses with a capacity of 25 t / day each will be required to extract the oil from the conditioned kernel-fraction by high pressure in single operation. 2 x 100 KWh incl. drive of the conditioner have to be installed. The remaining oil-content in meat after pressing will be appr. 13%.

item 11.) Foots vibration screen
=====================

The crude oil from the press still contains fine particles of kernel-meat. These particles called foots are removed from the oil by this screen and fed back to the conditioner. (5 KWh)

item 12.) Crudeoil filter
==============

The crudeoil already cleaned mechanically has to pass this filter unit to take out all visual impurities. (Cloth-filter or a selfcleaning Niagara-filter) and get a clear product ready for sale.

item 13.) Crudeoil storage tank
=====================

(2 tanks 25 m^3 each) The tanks should have a storage capacity for the crudeoil-production of 7 days. From this tank the oil can be sold in bulk or pumped to the bottling plant.

item 14.) Bottling plant
==============

For the retail market the oil should be bottled. Plastic-bottles of 2 litres and jerrycans containing 5 litres would be the most common size.
For the beginning it will be more economical to buy the containers. Later on they can be produced locally by a blow moulding machine.

item 15.) Storage for bottled oil.
========================

The bottles and jerrycans should be kept cool and dark to prevent autooxidation. A special storehouse should be used for this purpose.

Presscakestorage
================

The other product coming from the high-pressure-press is the presscake. Its proteincontent is appr. 43% and therefore an excellent feed for animals. the store for presscake should be able to keep the Production of 7 days which will be appr. 260 tons. (size: 15m x 20m, storage height 1m)

Cake grinding
==============

For local use and retail market the cake should be ground by a hammermill (15KWh) and bagged for easy handling and transportation.

Weighbridge
===========

All final products leaving the factory should be weighed for exact price calculation. all transports entering as well as leaving should have to go over the weighbridge.

Building for Administration
===========================

This building should contain all offices for the staff, Laboratory, social rooms, canteen and workshops for repair and maintenance as well as store for spareparts.

Steamboiler and electric generator

Every oilmill needs for operation steam and electricity. Therefore a steamboiler for the generation of 1 t/hour of steam with a pressure of 6 bar has to be installed to cover the steam supply for production. The burner has to be designed to burn solid fuels as hulls of Balanites as well as fuel oil for the start up, till hulls are available. Instead of fuel oil firewood should be taken into considerstion for this purpose.

The electric generator set consisting of two units with an installed capacity of 450 KWh and driven by Diesel-engines is planned in a way that one unit is in operation, the other one on standby for emergency.

Maintenance and spareparts

Proper maintenance and the availability of spare parts are the guarantee for satisfactory and economic operation for a manufacturing plant.

Since appr. 60% of the equipment and the installations of the plant can be supplied locally in the Sudan only special equipment as the expeller-presses, weighbridge, steamboiler and electric generators should be supplied from abroad but priority should be given to suppliers with agencies in the Sudan to facilitate the prompt supply of spare parts.

If in times to come more factories are in the Balanites(Lalobe) business a mobile workshop could be purchased for the maintenance of the Balanites processing oilmills with special equipment, spare parts and experienced fitting hands.

8.6.) Figures of demand, throughputs and yields.

Taking into consideration the basic figures, worked out in the preceding studies and the required utmost economy of an industrial plant, a throughput of 200 tons of Balanites fruits per day was decided to meet the above mentioned conditions in a sufficient way. Therefore the plant was designed for a pressing capacity of 2 x 25 t/day of Balanites-kernels.The plant will be operated 210 days per year.

The following tables No.1 & 2 will show the figures of demand as well as yields and a product balance in Fig.No.14

Table No. 1

Figures of demand.

	throughput t/y	demands/t of fruits	demands/year
Steam	42.000	250 kg	10,500.000 kg
Electricity	42.000	45 KWh	1,890.000 KWh
Water	42.000	1,5 m³	63.000 m³

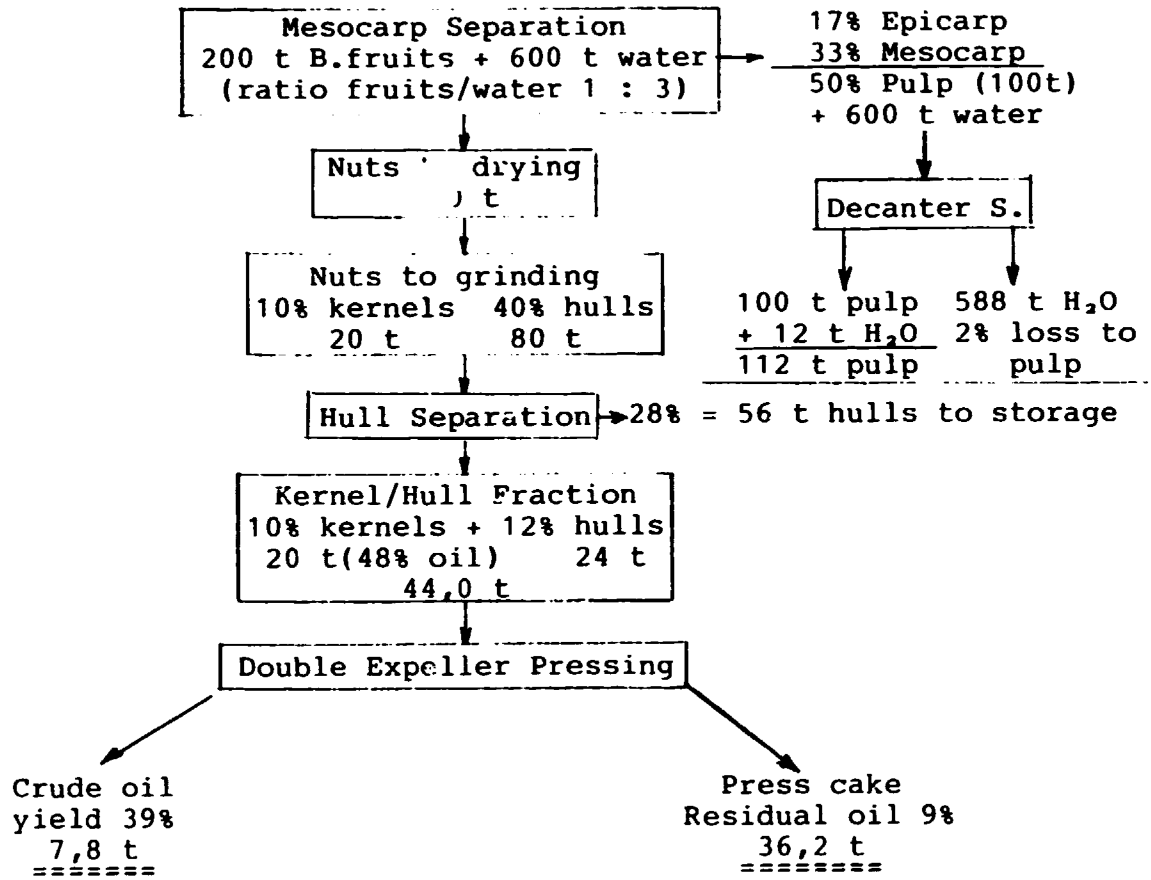
Table No. 2

Throughputs and yields in % and t/year.

		oil		presscake		hulls		pulp	
	throughput t/y	%	t	%	t	%	t	%	t
Lalobe fruits	42.000	3,9	1.638	18,1	7.602	28	11.760	54 +2	21.000 2.520 water

Figure No. 14

Product Balance of New Oilmill



8.7.) Investment costs for new 200 t Balanites plant.

The investment costs in the following table are based on international prices.

Detailed operating and financiation costs of such a plant can be found within the UNIDO - COMFAR calculations in the annex.

Table No. 3

Investment Costs in US$

Weighbridge 20t	33.000.-
Mesocarp Separation 10 tanks à 40m³	125.000.-
2 Decanter Separators	166.000.-
Nut Dryer	22.000.-
Magnet Separator	2.000.-
Nut Cracking, Dehulling Hull Separation	130.000.-
2 Highpressure Expellerpresses 2 x 25t/day	433.000.-
Crudeoil Vibration Screen and Filtration	75.000.-
Bottling Machine	35.000.-
Cake Breaker Hammermill	10.000.-
Bagging Machine	15.000.-
Steamboiler 1t/h/6bar	145.000.-
Electic Generator 450 KWh (2 sets)	140.000.-
Tanks and Storage crude oil, cake, hulls	60.000.-
Electric Installations Switchboards	20.000.-
Conveying Equipment	50.000.-
Pipes and Insulation	25.000.-
Laboratory Equipment	10.000.-
Total Equipment Costs	1,496.000.-
Errection and Start-Up of OPeration (30% of plant)	448.800.-
Spareparts for 2 years	100.000.-
Unforseen (10% of plant)	149.600.-
Total Investment Costs for Machinery, Equipment & Errection	2,194.400.-

Total Costs of Plant ~ 2,200.000.-

9.) FINAL PRODUCTS.

In the first chapter we have mentioned quite a lot of products which can be produced from Balanites aegyptiaca. But for the start up of the project all participating partners have decided to limit the production to the four main products, not only to facilitate the process but also of economic reasons.

Therefore in the following chapter we will show detailed specifications of the Mesocarp, the shells, of the oil and of the presscake (resp. meal, if ground).

9.1.) Specification and chemical composition.

The specifications as well as the chemical composition of the m.a. products will be described successively as they are received during processing of Balanites aegyptiaca.

Mesocarp (soft flesh of the fruit)

It is enclosed by a thin outer skin, the epicarp in a quantity of 5 to 9%. This epicarp which breaks easily will not be removed during the process and remains in the pulp together with the Mesocarp.

This Mesocarp forms appr. 28 -33% of the whole fruit and is very rich in fermentable sugars, amounting up to 56 -65%w/w. The protein content is appr. 5 - 6%. Additionally it contains Vitamine C and some minerals as well as steroidal saponins up to 8%w/w, which gives it a bitter taste.

Chemical constituents of Balanites mesocarp.

Constituent	% w/w
Moisture	22,32
Ash (sulphated)	4,85
Protein (crude)	5,56
Fat (crude)	0,10
Carbohydrates (total)	65,51
Fibre (crude)	1,72
Vitamine C	0,02
(Free reducing sugars(gluc.+ fruct.)	56,08

Although the high content of fermentable sugars will offer many different possibilities for the utilization of the Mesocarp in the present it will only be used as an addition of considerable nutritional value to animal feed. In the moment this will be the best way of utilization not requiring the installation of sophisticated and expensive plants for the processing of other products.

The unutilized material would be a great source of environmental pollution.

Endocarp (wooden shell)

Its proportion in the Balanites fruit comes from 40 to 50%w/w of the whole fruit and is a fibrous material mainly consisting of cellulosis and lignine. It has a calorific value of appr. 4.000 Kcal (16.400 Joule) which is appr. 50% of the calorific value of fuel oil. During the process appr. 30% of the shell will be removed, this will be an appr. quantity of 300 kg of shells per ton of Balanites ae.

Kernel (oilseed)

This part of the nut amounts to 8 - 10%w/w of the whole fruit. To give an idea about its constituents we show in the next table the composition of the Balanites kernel in comparison to other oilseeds.

Comparison of some oilseeds with Balanites ae.

Oilseed	Protein	Fat	Fibre	Ash
Balanites Kernel	26,4 - 29,9	46,0 - 50,6	2,4 - 3,3	2,8 - 3,3
Sesame seed	40,0	47,0	4,0	5,0
Soybean	42,0	18,0	5,0	6,5
Groundnut	48,0	44,0	2,8 - 3,0	2,5 - 3,0
Cottonseed	38,0	20,0	10,0	4,4
Sunflower	37,0	42,0	14,4	3,5

From this kernel the two most important products, vegetable oil and presscake(protein-meal) will be produced by double expeller pressing. Within our utilization scheme and due to our proposed equipment we can produce appr. 35 - 40% of vegetable oil. Residual oilcontent in cake will be appr. 10 - 15%.

In the following we will give a view about the composition and the properties of the Balanites oil.

Balanites oil composition.

The oil of the Balanites kernel is golden yellow in colour, with acceptable scent and taste. It is characterized by high stability towards auto-oxidation. The oil components are mainly triglycerides with small quantities of diglycerides, phytosterols, sterol-esters and tocopherols. The fatty-acid-composition of Balanites kernel-oil will be shown in comparison with other vegetable oils, used in the Sudan, in the next table.

Comparative composition of fatty-acids of some vegetable oils including Balanites oil in % w/w

Oilseed	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid
Balanites Kernel	10 - 12	9 - 10	30 - 40	40 - 48
Soybean	7 - 10	2 - 6	15 - 33	43 - 56
Sesameoil	7 - 9	4 - 5	37 - 49	35 - 47
Groundnut	6 - 9	3 - 6	53 - 71	13 - 27
Cottonoil	20 - 23	1 - 3	23 - 35	42 - 54
Sunflower	3 - 6	1 - 3	14 - 43	44 - 75

Kernel cake (Meal) from Balanites ae.

The cake from Balanites contains quite an amount of protein and therefore is of good nutritional value for feedmeal as an addition. The cake as leaving the expeller press with an appr. residual oil content of 9 to 15% due to pressing pressure can be fed as it is, without grinding to meal, to the animals.

The following table shows an average composition of the presscake

Table No. 4

Amino-Acid Profile of some Oilseeds, including Balanites Kernels(mg/g Nitrogen)

Amino-Acid	Balanites Kernels	Soyabean	Peanut	Sesame	Cotton seed	Sunflower seed
Alanine	100	266	243	282	254	263
Arginine	394	452	697	756	700	499
Aspartic Acid	1200	731	712	513	586	579
Cystine + Gysteine	106	83	78	113	97	93
Glutamic Acid	1520	1169	1141	1213	1249	1365
Glycine	1106	261	349	305	264	338
Histidine	119	158	148	153	170	145
Iso-Leucine	256	284	211	226	206	267
Leucine	331	486	400	419	370	401
Lysine	319	399	221	171	276	225
Methionine	94	79	72	176	81	119
Phenyl Alanine	194	309	311	277	326	278
Proline	113	343	272	231	236	279
Serine	525	320	299	291	277	270
Threonine	100	241	163	223	206	230
Tryptophan	63	80	65	84	78	85
Tyrosine	113	196	244	195	180	118
Valine	263	300	261	288	290	317

It must be stated that there is a disadvantage in Balanites-kernels and this is the presence of steroidal saponins (appr. 4% w/w) which makes it unattractive for human consumption because of its very bitter taste. Since the process of debittering takes 48 hours and requires hugh quantities of fresh water it was decided to leave the presscake as it is, without debittering and use it for feeding purposes only. In feeding tests it turned out that the undebittered kernelcake contains no toxicity and are eaten by the animals without hesitation.

9.2.) Utilization.

Within a market analysis it could be stated that for the products made from Balanites ae. ther will be quite a demand not only in the South Kordofan Province but in the whole Sudan.

Growing population and hand in hand with it an increasing number of animals raise an increasing demand on vegetable oil for human consumption as well as soap production and for feed-meal in general.

The kernel cake with its protein content as well as the Mesocarp with high contents of sugar, mixed in a certain ratio will give a feedstuff with good nutritional value that will help to reduce the lack on animal feed.

The oil already handpressed in very small quantities and used since long times by the local population is highly valued specially in the Kordofan Province. It has an excellent fatty-acid composition and can be easily compared in quality with other vegetable oils commonly used by pople.

Since vegetable oil is a very important part of the nutrition of the Sudanese population the additional quantities of Balanites oil will be neither untreated or refined of an enormous importance.

The Mesocarp, as mentioned above will be of less importance, before utilized for other products. But by its high content of carbohydrates and as an addition to feedmeal tests have shown that for the beginning of processing of Balanites fruits a successful utilization of the Mesocarp can be done in this manner.

The shells of the nuts with high calorific value can be used very well for the production of the required steam for the processing of Balanites ae. But using a steam turbine or steam generator even the generation of electricity should be possible. In any way it will help to save firewood and fueloil.

As a matter of fact this byproduct is valuable and can be properly used.

9.3.) Market prices.

Primarily it must be stated that prices are based on the exchange rate in June 1989. **1 US$ = 4,50 LS**

In comparison with other oils it was estimated that Balanites oil could be sold for appr. the same retail price as groundnut oil which means:

1 t of edible Balanites oil = 7.960 LS(US$ 1.769.--)

The press cake estimated with a market price due to the half of the price of groundnut cake (because of its high content of shells, appr. 12%) therefore could be sold for:

1 t of Balanites presscake = 1.000 LS(US$ 222.--)

Since oilseeds and their products are articles of the Chikago-stock exchange the international prices could be taken as a guideline for the oil- and meal prices in the Sudan.
But in general and due to our opinion the prices in the Sudan will be due to supply and demand.This will facilitate to find a marketable price for products from Balanites aegyptiaca which satisfies the customer as well as the producer.

10.) CONCLUSIONS.

The extraordinary potential of Balanites aegyptiaca (Lalobe) in the Sudan could help to start a completely new group of industries in this country. The new source of vegetable oil and protein meal will be of considerable assistance to cover the increasing demand of the population for such commodities.

As a matter of fact it depends now on the assistance of UNIDO if this project can be realized. Only if the required financial support by raising of funds or other kind of financing can be arranged the Sudan will be able to order the required machinery and equipment as well as spare parts, to start the Balanites-project.

As soon as possible it should be tried together with the governement of the Sudan, the IRCC and the owner of the oil-factory at Abu Gubeiha to realize the adaptation of this oil-mill to start processing of Balanites ae.
It will depend on this first, initial step that a Balanites industry can be realized in the Sudan in the next future.

10.1.) Technical evaluation of project.

As a matter of fact an enormous investment in brain and skill, time, manpower and engineering had to be put into this agro-industrial project to develop all the basic data as well as the economical and technical requirements and a new technology for the processing of Balanites aegyptiaca.

Since Balanites grows in the whole Sahel Zone of Africa and in other tropical countries with similar climate the Sudan starting the Balanites business will have a great advantage to the newcomers. This advantage in Know How and technology could be transferred very profitable to the other countries if they will start their own Balanites industry.Selling Know How will turn out to be very valuable in times to come for the Sudan.

10.2.) Economic and financial aspects.

The target of the project is the utilization of a valuable raw material, Balanites aegyptiaca, mostly unused as far as today but available in huge quantities in some areas in the Sudan. The realization of the project will certainly be followed by the development of new rural areas. It will bring employment and labour to the local people. New sources of income will be generated, living- and social standard of the inhabitants will be increased. The introduction of a new industry as well as a technology will improve the the technical education of the people and thus lead to further industrial development.

The project in its consequence will satisfy the requirements for edible oil and feedmeal for reasonable prices which is of importance when taking into consideration the increasing population and contemporary growing number of animals.

Last but not least the Sudan could save expensive valuta by reduction of costs for imports of fuel oil and feedmeal, processing these products in the own country. Generally spoken the realization of the Balanites ae.- project will bring considerable creation of value into the Sudan.

10.3.) Aspects of rural development.

The utilization of Balanites aegyptiaca will have an increasing rural development as a consequence. It will initiate the planting and growing of new Balanites trees maybe lateron even in plantages, to facilitate the collection of raw material. These trees will help to keep the rain water in the ground and by this way the soil becomes fertile again. The fertile ground will be able to produce grass which can be used as natural pasture for animals. The growing of grain and vegetable will be possible again. More animals, more grain, more vegetable will increase the nutrition of the population. Better nutrition will help to increase the health of the people. The new agricultural utilization of the involved areas will stop the extension of the deserts.

This example could show how the utilization of only one new fruit can change the environment of a whole country and contemporary increase the living conditions of its inhabitants. It shows additionally how by proper planning and intensive research a project of national importance could be initiated and realized within a relatively short period of time.

11.) APPENDICES.

This item contains a sketch of a mechanical oil extraction plantand some pctures of the most important equipment of such a plant.

11.1.) Economic evaluation based on COMFAR-system.

12.) BIBLIOGRAPHY.

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