Promoting Indigenous Fruit in Namibia

Final Report

on

Phase Two

of the

Marula Juice and Pulp Pilot Project (MJP^3)

submitted to the

Indigenous Plant Task Team

IPTT

by

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Windhoek

September 2007

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Acronyms and Abbreviations

Acronyms

ADC	Agricultural Development Centre
AFVP	Association Française des Volontaires du Progrès
CBNRM	Community-Based Natural Resource Management
CIRAD	International Centre of Research in Agronomy for Development
COSDEC	Community Skills Development Centre
CRIAA SA-DC	Centre for Research, Information, Action in Africa - Southern Africa Development and Consulting
DoF	Directorate of Forestry
EWC	Eudafano Women Co-operative Ltd
IPTT	Indigenous Plant Task Team
KAP	Katutura Artisans' Project
MAWF	Ministry of Agriculture, Water and Forestry (formerly MAWRD)
MAWRD	Ministry of Agriculture, Water and Rural Development
MCA	Millennium Challenge Account
MJP^3	Marula Juice and Pulp Pilot Production Project
MTA	Material Transfer Agreement
NBRI	National Botanical Research Institute
NCRs	North Central Regions
NOREESP	Northern Research, Extension and Epidemiology Support Project
PIF	Promoting Indigenous Fruit in Namibia
R&D	Research and Development
SMEs	Small and Medium Enterprises

Abbreviations

avg	average
h	hour
L	litre
mn	minute
V	Volt
w/w	weight for weight (i.e. mass/mass)

1) Background

The *Strategy and Action Plan for Promoting Indigenous Fruit in Namibia* envisaged that Phase 2 of the Promoting Indigenous Fruit project would include pilot processing aimed at commercial opportunities identified during Phase 1. The marula (*Sclerocarya birrea*) fruit resource in the North Central Regions (NCRs) was identified in the *PIF Phase One Final Report* as the top priority for such pilot-scale processing.

In March 2003 the IPTT therefore authorised a budget of N$701334 for Phase One of the Marula Juice and Pulp Pilot Production (MJP^3) project, primarily to answer major outstanding questions related to commercially viable production of marula juice and pulp. Key results and outputs of MJP^3 Phase One were verbally reported to the IPTT at its 24th meeting on 17 April 2003. The main outcome was that the project could only buy 11.2 tons of fruit out of a target of 334 tons. While this was partly due to the cumulative effects of the 2002 and 2003 droughts it also showed that efficient organisation of an adequate fruit supply chain would be a key issue for successful marula fruit commercialisation. For lesson learned, see *Final Report on Phase One and Proposal for Phase Two of the Marula Juice and Pulp Pilot Project (MJP^3)* submitted to the IPTT in February 2005.

In 2004 negotiations (ultimately unfruitful) with the French research institution CIRAD about processing technology development delayed progress until it was too late in the fruiting season to do any meaningful processing work. The ten KAPMOND10 presses used during Phase One were however distributed to various MAWRD ADCs for demonstrations and *omaongo* production, and work started on the Eudafano Women's Cooperative (EWC) factory in Ondangwa, holding out the promise of a possible solution to the supply chain problem.

Instead of funding the work at CIRAD, French Cooperation/NOREESP donated Euro30 000 to co-fund with IPTT the local development of a processing technology package. In choosing the technology package for Phase Two versatility was accorded priority over total production capacity, or smooth process flow, resulting in a set of equipment that could produce (or so it was hoped) many different mixes of marula juice, fruit pulp and/or skin pulp samples to allow market exploration. For details of this technology package see *Marula Fruit Processing Equipment: Final report on developing a technology package for the second phase of the Marula Juice and Pulp Pilot Production Project (MJP^3 Phase Two)* submitted to the IPTT in February 2005.

An important aim of Phase Two was to test the peak capacity of the different technology components in this package for further planning, with the aim of gathering sufficient data to process engineer a permanent marula fruit processing facility in 2006 or 2007.

2) MJP^3 Phase Two proposal

The proposal for MJP^3 Phase Two stated the following strategic approach:

> *Before marula fruit processing in Namibia can be placed on a fully commercial footing the following issues still need to be addressed:*

a) *The equipment that has already been purchased must be tested on marula fruit to determine its production capacity and throughput, and further modified if necessary*
b) *The unique and potentially valuable characteristics of marula fruit must be analysed in more detail so that future negotiations with commercial partners can be conducted from an informed footing*
c) *Commercial R&D partners must be supplied with a range of potential product samples for evaluation and their views on likely market volumes must be obtained*
d) *The question of fruit supply logistics must be resolved*
e) *An appropriate scale of operations must be chosen for commercial processing*
f) *A financial and business plan must be drawn up and adequate operating capital must be sourced*
g) *A processing facility (or facilities) must be planned in detail and equipped*

Issues a, b and c (equipment, analyses and samples) are relatively easily addressed from within a project framework and are therefore proposed as the core work to be done under MJP[3] Phase Two.

Issue d (fruit supply) is best tackled in close cooperation with a large and well-organised body of marula producers such as EWC and its eventual resolution depends to a significant extent on the projected volumes required by markets. It is nevertheless possible to advance the issue of fruit supply logistics during Phase Two through discussions with EWC (and other organised suppliers such as the national CBNRM movement).

Issues e, f and g (scale, business planning, commercial facility) are inter-connected and can only be progressed to a significant extent after the preceding issues have been resolved. It is therefore suggested that the information gathered during Phase Two be fed into this process and further advanced under the business planning processes envisaged for the proposed new natural products company and the EWC marula factory in Ondangwa.

3) Results

3.1) Objective: Testing and modifying equipment

There was a need to make 100% certain that the equipment procured in 2004 with support from French Cooperation/NOREESP was fully appropriate for marula processing, because it was bought/made outside the marula season and could not be tried under realistic operational conditions (and the pasteuriser could not be tested at KAP at all due to an inadequate electrical power supply).

The equipment was moved from KAP to Ondangwa and temporarily installed at COSDEC. Each piece of equipment was tested to see whether and how well it works, and to determine its actual productivity and yield. The results are summarised by Roger Gamond in Box 1 below.

Box 1

MARULA FRUIT PROCESSING:

Major findings and figures (2005)

- **Average fruit composition percentage** (w/w):

- Skin	**44%**
- Pips	**26%**
- Juice	**26%**
- Pulp	**4%**

Comment: 74% of the fruit can be processed

- **Processing:**

Fruit sorting: it is a long operation. In order to minimize/suppress this sequence, the bakkie collecting the fruit is loaded with 2 crates: one for the still unripe fruit and one for the ripe ones (overripe fruit are discarded at the collection stage). A further quick sorting is done at the washing stage (damaged or floating fruit are discarded).

Wooden crates capacity and suitability:
Capacity: 250 kg of fruit. These crates are well adapted for transport in a 4x4 bakkie (2 crates full of fruit weigh about 600 kg and easily fit at the back) as well as for fruit storage. The pallet lifter is handy to move the full crates.

Fruit washing and rinsing: using the stainless steel tanks and baskets made for this specific purpose.

Fruit pressing:
Average quantity of fruit pressed within 8 hours**: 440 kg/press = 55kg/h/press** (1 operator filling and unloading himself his press)**.**
If press fed by a helper and juice removed by the same helper when the bucket is nearly full, the processing rate can be anticipated at **1kg/mn** (1 kg of whole fruit pressed every minute), leading to 480 kg of fruit processed/day/press.
Average juice extraction rate: 26% (**125 kg/L of juice/press/day**).
Weight of pressed fruit (basis 480 kg of whole fruit): **355 kg/press/day.**

Skin-pips separation: done on special stainless steel tables: **10 kg/h/person** of pressed fruit if skins are just separated from pips and damaged ones discarded (separation for further crushing of the skins).
If all the skins have to be processed, 4 persons/press are needed to separate pips and skins.
211 kg of skin are to be extracted.

Juice and pulp pasteurization:
The capacity of the pasteurizer is roughly **100 to 120L of material/hour, meaning about 900L/day,** corresponding to the daily production of 3 presses (375 L of juice and 633 kg of crushed skins).
The pasteurization trials were satisfactorily with juice (and 5L plastic bottles) but skin pulp pasteurization was difficult because of the plastic fold back pipes at each end of the machine repetitively jumping off and conducing to make a quite liquid pulp (30% skin, 70% juice).
[*Note: these troublesome pipe bends were later replaced with stainless steel versions, which have much stronger flanges.*]

Skin pulp production:
The fruit mill supplied for this purpose did not work at all, neither with whole fruit nor with skins only.
The brush pulper was not better in pureeing the skins (it was later used to produce the very fibrous fruit pulp).

Fortunately, a small hammermill was taken to COSDEC as a spare machine for this purpose. After lots of trials and alterations, an acceptable skin pulp could have been produced with little juice added to skins (pulp sticking to the outside walls of the milling chamber) with, however, a low throughput (best throughput 30 kg/hour).
A specific machine has to be designed to increase the skin pulp production.

Fruit pulp:
As indicated in the fruit components break down, the fruit pulp represents about 4% of the whole fruit weight.
Several trials were conduced to get the best results.
It has to be stressed that most of the highly fibrous white pulp is rejected with the clean pips (and does not pass through the holes of the perforated drum) and thus has to be collected manually afterwards.

Definition of a rational production unit

The major processing constraint is pasteurization with the lowest throughput at a bit less than one ton per day and a quite high electricity supply demand (380V - 40 Amps). It is useful to recall that 60 Amps is the limit of what could be named affordable supply (BUS-3, Business Medium Usage). Over 60 Amps, connection, basic charge and consumption become expensive (maximum demand).
2 pasteurizers lead to fall in the Large Power User tariff (over than 60 Amps).
Another solution would be to use the pasteurizer for two shifts (16/24h).

If we start from this assumption, one pasteurizer could roughly process the production of 3 presses in 8 hours, meaning 1440 kg of whole fruit = 375 kg of juice and 634 kg of skin pulp (± 1000 kg/day). These quantities can be doubled if presses and pasteurizer are operated for 2 shifts (2880 kg of fruit, 750 kg of juice and 1268 kg of skin pulp/day).

The first assumption leads to a monthly production of:
22 days x (375+634) = 22'198 kg of pulp and juice;
the second one to the double: 44'396 kg of pulp and juice.

These assumptions also mean that the skin crusher/pulper should have a minimum throughput of 80-100 kg/h and should also work double shift to achieve the second assumption.

AFVP volunteer Julien Gallardo was of invaluable assistance during processing and recorded the results of juice, pulp and skin production trials in great detail (see ***Annexes 1 to 3***).

Conclusions about equipment:

- All the peripheral equipment for fruit handling, washing and sorting worked as expected and can be used "as is" for further processing work.
- The fruit mill and brush pulper are not at all suitable for marula processing and should instead be tried with other fruits.
- The pasteuriser required modification (which was done by replacing the plastic joints between pipes with stainless steel fittings) and could handle the production of up to 8 Kapmond-10 small presses if only the juice was pasteurised.
- Until there is a clear market for pulped skin the processing of skins should focus on using whole skins (fresh or dried).
- If/when a demand for pulped skins develops an appropriate stainless steel hammermill should be designed and built.

3.2) Objective: Analysing marula for potentially valuable characteristics

During MJP[3] Phase One research into potential markets for marula products led to the conclusion that one of the most marketable qualities of a new fruit juice product in world markets would be strong scientific evidence of significant anti-oxidant activity.

MJP[3] Phase Two proposed to commission combined assays of hydrophilic ORAC (Oxygen Radical Absorption Capacity), total phenolics and total anthocyanins from Brunswick Laboratories in the USA (which is widely respected as the leading international service provider in this specialised field). Three separate samples (juice, fruit pulp and skin pulp) were to be submitted for analysis.

This was not done, for the following reasons:

- These analyses are very expensive (US$650/set) and sending them to the USA incurs high transaction costs (they have to be sent under cover of a Homeland Security registration certificate permitting shipment of biological samples to the US, which can be done through PhytoTrade Africa's London office but is not to be done lightly).

- In what at the time appeared to be a fortuitous synchronicity, Prof Hakon Karlsson of Malmo University in Sweden approached the project and expressed an interest in researching marula's anti-oxidant properties, and its potential as a tropical flavour. Not only was he prepared to do this for free, but he was already collaborating with a Swedish company that would possibly support commercialisation if they liked the research results. An internet search revealed the Prof Karlsson indeed had a credible academic record and so a material transfer agreement was signed (with NBRI) and juice, pulp and skin samples were sent to Sweden, with the recipient paying the shipping costs. Naturally the Brunswick Laboratories analyses were then held back until early results became known, so as to better target the available analysis budget.

- To cut a long story short, repeated attempts by the Project Coordinator to progress this relationship proved fruitless, and became especially difficult after explaining that it would not be possible to send marula oil samples for similar analysis because of the exclusive R&D partnership with Aldivia. Emails went unanswered, offers to visit Sweden for discussions on a possible partnership were rebuffed and eventually – after Dr Gillian Maggs-Kolling wrote to him and reminded him of the MTA – Prof Karlsson sent a curt note saying they did not find any interesting anti-oxidants except for levels of Vitamin C much higher than those reported in the literature, and the flavour was not interesting either because it did not carry through strongly when diluted. A request for a more detailed sharing of research results went unanswered.

- By the time this sorry saga had resolved itself it no longer seemed like a good idea to send samples to Brunswick Laboratories, because:
  - The samples were by then several months old and despite having been kept in cold storage in dark bottles their contents had probably started to oxidise enough to distort the results
  - The samples were in any event from a single, very average tree and the results would therefore be of limited value

- PhytoTrade Africa raised the possibility of organising a wider regional sampling exercise to assess natural variability and set wide product specification parameters
- An article in *Nutraceutical News* suggested that consumers were getting picky about anti-oxidant claims and that more differentiating analyses were needed.

- It also seemed like a good idea to focus first on sorting out the technical limitations of the technology package, as detailed above.

Conclusion about analyses:

- In 2008 a systematic sampling and analysis exercise should be carried out, preferably coordinated with other PhytoTrade Africa members.

3.3) Objective: Supplying samples to potential commercial R&D partners

In addition to the samples sent to Sweden the following results were obtained:

- A botanical extracts company in South Africa that also owns a subsidiary specialising in the business-to-business supply of ready-to-mix fruit juice blends to high-end clients such as Ceres received stabilised marula juice, as well as stabilised skin pulp and dried skins for extracting marula fruit flavour. Surprisingly, the flavour extracted from the dried skins received very positive feedback from clients and the company now wants another 600kg of dried marula skins to continue this work. This company also works with PhytoTrade Africa on other resources, so it is well aware of the regional situation. It accepts that as much value-adding as possible should eventually be done in Namibia.

- Samples of juice and of juice mixed with 30% skin pulp were sent to a small distillery in Germany that produces premium schnapps from exotic fruits. This potential clients liked the flavour well enough but found the sugar content too low and the price too high (partly due to the cost of shipping to Germany) for marula to be a viable raw material for distillation.

- A top-ten flavour and fragrance company based in France that for a few years had been trying unsuccessfully to source a reliable supply of stabilised marula products was offered samples, but after showing initial interest it went through an internal re-organisation, the contact person we had been dealing with was moved to another department and the collaboration went nowhere.

- One of the largest blenders and distributors of tropical fruit juices in eastern Europe, based in Poland, found the projected FOB Poland price too high.

Conclusions about samples for clients:

- In 2008 the emphasis should be placed on skin samples (fresh and dried) for flavour extraction trials.

3.4) Non-objectives: Fruit supply, scale, business planning and commercial processing facility

The *MJP[3] Phase Two Proposal* identified fruit supply, scale, business planning and the enterprise formation challenges around the establishment of a commercial processing facility as crucially important to the eventual success of marula fruit processing in Namibia, but also pointed out that they were not easily resolved within a project framework and were moreover bound up with a number of unclear and/or dynamic developments underway at the time. It therefore proposed "*that additional time be included in the project coordination component of the budget for further consultation and strategising around these key considerations, accompanied by a large dose of realism about what can and can't be achieved within the scope and timeframe of MJP[3]*". In this regard the following can be reported (as at September 2007):

a) Fruit Supply:

- The 2005 marula season was early and relatively poor. Most fruits were processed at homestead level and producers were not very keen to sell fruits.

- After opening in April 2005 the EWC factory started fruit processing in earnest in 2006, pressing around 50 tons of fruit. The cooperative used its own truck and labourers to collect fruits from members and some members delivered fruit directly to the factory. A relatively haphazard flow of raw material resulted in significant spoilage. In an effort to increase the supply and extend the season EWC sourced fruit from as far away as Tsumeb and Otavi. Some problems were experienced with marketing the juice quickly enough in local and national informal markets.

- In 2007 even less fruit was processed and a part of the production fermented when the cold room malfunctioned over a weekend.

- The quantities processed in Namibia should be compared to the South African figures of 300 tons/year supplied by Marula Natural Products (for processing by a commercial partner) and 3000 tons/year processed for Amarula Cream.

- Apart from a small-scale technology demonstration conducted in Caprivi in 2006 by the Community Forestry in North-Eastern Namibia (CFNEN) project, involving a few tons of fruit, no organised marula supply capacity has materialised out of the CBNRM movement yet (although on-going business planning and enterprise support initiatives by various stakeholders and projects might still see such capacity being developed over the next two or three years). The processing in Caprivi was not repeated in 2007 because a large part of the marula production area was flooded.

- At time and in places there are indeed local surpluses of marula fruit in North-Central Namibia, but such surpluses are unpredictable (inter-annually, seasonally according to rainfall and temperature, locally as a function of competition for household labour and access to small juice presses). ***At this stage it must therefore regrettably be concluded that the current marula fruit supply situation in Namibia does not lend itself to the successful establishment of a centralised medium-scale (over 300 tons/year) marula processing facility.***

RECOMMENDATIONS about fruit supply:

- Appreciate the positive aspects of limited surpluses – to a large extent they result from the increasing availability of small juice presses and the higher margins earned in informal markets; more local processing has also helped to prevent serious and abrupt disruptions to marula kernel supply. Encourage local micro- and small-scale processing as much as possible (as markets will bear). Investigate the feasibility of establishing more enterprises at the 50-ton scale.

- Re-investigate the feasibility of mobile processing as a way to "mop up" more of the dispersed surpluses that undoubtedly occur. What technical innovations would make mobile processing viable?

- Add more value to small local processing by pursuing a flavour-extraction market for marula skins (dried at homestead level?).

- While the longer-term DoF marula selection trial runs it course, significantly increase more immediate extension efforts aimed at encouraging farmers to grow many more of their best local marula trees, using vegetative techniques to shorten time to fruiting. Ideally such a planting programme should be planned so as to also earn carbon credits and breeder's rights for participating farmers. In this regard it is worth mentioning that South Africa's Limpopo Province has plans to plant at least a million marula trees and establish several SMEs around this resource base.

b) Scale:

"Right-sizing" the scale of a commercial marula processing facility in Namibia becomes moot once it is obvious that fruit supply logistics is the main constraint to industry growth. For the foreseeable future – at least until increased cultivation literally starts bearing fruits – the only rational approach is to start small and local, and to let the market grow from there. At all scales, however, producers would benefit from a flavour-extraction market for skins, which are currently not used optimally.

c) Business planning

Developments in this regard have been reported in the *MCA Proposal* circulated to the IPTT. Unless and until the fruit supply situation is sorted out this aspect is less important.

d) Commercial processing facility

It is interesting that the EWC factory moved marula fruit processing outdoors in 2007, partly due to more pressing oil processing needs and partly to avoid the problems caused by vinegar flies. While a full-scale marula fruit processing facility in Namibia is still some years off it would nevertheless be useful to expand the EWC premises so as to use it as a "proof-of-principle" facility in the interim.

4) Conclusions

To promote the further commercialisation of marula fruit products in Namibia the IPTT should as priorities support:

- More local value-adding with small presses and other technologies
- Further work on using the skins for flavour extraction
- A scaled-up extension effort aimed at encouraging vegetative propagation of superior local marula trees (incentivised by carbon credits)
- A re-evaluation of the feasibility of mobile processing.

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ANNEX 1

JUICE TRIALS DATA

Different trials were conducted to assess the productivity of pressing marula fruits into juice. One Kapmond-10 press was used. The entire processing was performed by one operator (cleaning, loading and pressing). Before starting to press 40 minutes are needed to take out marula fruits out of the cold room, to fill the tanks in order to clean the fruits, and to set the pressing equipment.

For each batch, we have recorded the quality of the fruits (all of them were ripe), the weight of the fruits to be pressed, the quantity of juice extracted, the juice extraction rate and the time needed for pressing. For each sample, we have also recorded the number of batches processed, the total quantity of fruits used and the total quantity of juice extracted. Finally, we have calculated the averages for the quantity of fruits per batch (w/w) and the quantity of juice per batch (w/w), the average juice extraction rate and the average time to process a batch.

SAMPLE 1:

Date	Batch	Quality	Fruit (kg)	Juice (kg)	Juice (%)	Time (mn)
14/03/05	1	Ripe	11.40	2.84	24.91	no record
	2	Ripe	11.40	2.84	24.91	"
	3	Ripe	11.42	2.90	25.39	"
	4	Ripe	11.40	3.40	29.82	"
	5	Ripe	11.48	2.93	25.52	"
	6	Ripe	11.04	3.02	27.36	12
	7	Ripe	11.18	2.90	25.94	11
	8	Ripe	10.98	2.98	27.14	12
	9	Ripe	11.50	3.20	27.83	10
	10	Ripe	11.04	2.86	25.91	11
	11	Ripe	11.46	2.88	25.13	12
	12	Ripe	11.74	3.08	26.24	12
	13	Ripe	11.64	3.14	26.98	10
	14	Ripe	11.56	3.04	26.30	11
	15	Ripe	11.56	3.14	27.16	11
	16	Ripe	11.46	3.06	26.70	11
	17	Ripe	12.20	2.92	23.93	10
	18	Ripe	11.78	3.06	25.98	9
	19	Ripe	10.78	2.86	26.53	12
TOTAL	19		217.02	57.05		
			avg batch	avg juice	avg %	avg time
		Avg	**11.4**	**3.0**	**26.3**	**11.0**

SAMPLE 2:

Date	Batch	Quality	Fruit (kg)	Juice (kg)	Juice (%)	Time (mn)
15/03/05	1	Ripe	10.78	2.66	24.68	10
	2	Ripe	11.40	2.90	25.44	8
	3	Ripe	11.54	2.94	25.48	8
	4	Ripe	11.46	2.80	24.43	9
	5	Ripe	11.34	2.88	25.40	10
	6	Ripe	11.08	2.92	26.35	x
	7	Ripe	11.40	3.14	27.54	11
	8	Ripe	11.50	3.30	28.70	14
	9	Ripe	11.42	3.02	26.44	12
TOTAL	9		101.92	26.56		
			avg batch	avg juice	avg %	avg time
		Avg	11.3	3.0	26.1	10.3

SAMPLE 3:

Date	Batch	Quality	Fruit (kg)	Juice (kg)	Juice (%)	Time (mn)
16/03/05	1	Ripe	11.76	2.88	24.49	9
	2	Ripe	11.88	3.18	26.77	10
	3	Ripe	11.80	3.12	26.44	10
	4	Ripe	11.78	3.26	27.67	11
	5	Ripe	11.78	2.98	25.30	8
	6	Ripe	11.30	3.00	26.55	15
	7	Ripe	12.18	3.40	27.91	11
	8	Ripe	11.86	3.02	25.46	12
	9	Ripe	12.02	3.14	26.12	10
	10	Ripe	12.20	3.08	25.25	15
	11	Ripe	11.58	3.06	26.42	12
	12	Ripe	11.62	3.26	28.06	11
	13	Ripe	11.80	3.22	27.29	11
	14	Ripe	11.74	3.20	27.26	10
	15	Ripe	11.76	3.08	26.19	12
	16	Ripe	11.42	3.04	26.62	15
	17	Ripe	11.74	3.12	26.58	11
TOTAL	17		200.22	53.04		
			avg batch	avg juice	avg %	avg time
		Avg	11.8	3.1	26.5	11.4

SAMPLE 4:

Date	Batch	Quality	Fruit (kg)	Juice (kg)	Juice (%)	Time (mn)
16bis/03	1	Ripe	11.34	2.78	24.51	9
	2	Ripe	11.82	3.06	25.89	9
	3	Ripe	11.56	3.12	26.99	10
	4	Ripe	11.76	3.16	26.87	16
	5	Ripe	11.24	3.00	26.69	10
TOTAL	5		57.72	15.12		
			avg batch	avg juice	avg %	avg time
		Avg	11.5	3.0	26.2	10.8

SAMPLE 5:

Date	Batch	Quality	Fruit (kg)	Juice (kg)	Juice (%)	Time (mn)
18/03/05	1	Ripe	10.48	2.50	23.85	8
	2	Ripe	11.20	2.78	24.82	10
	3	Ripe	11.20	2.72	24.29	9
	4	Ripe	11.04	2.72	24.64	10
	5	Ripe	*5.58*	*1.46*	*26.16*	*10*
TOTAL	5		49.50	12.18		
			avg batch	avg juice	avg %	avg time
		Avg	*11.0*	*2.7*	24.8	9.4

SAMPLE 6:

Date	Batch	Quality	Fruit (kg)	Juice (kg)	Juice (%)	Time (mn)
22/03/05	1	Ripe	11.00	3.74	34.00	12
	2	Ripe	11.26	4.06	36.06	17
	3	Ripe	11.06	3.96	35.80	11
	4	Ripe	11.54	4.12	35.70	10
	5	Ripe	11.66	4.06	34.82	10
	6	Ripe	11.34	4.04	35.63	7
TOTAL	6		67.86	23.98		
			avg batch	avg juice	avg %	avg time
		Avg	11.3	4.0	35.3	11.2

SAMPLE 7:

Date	Batch	Quality	Fruit (kg)	Juice (kg)	Juice (%)	Time (mn)
24/03/05	1	Ripe	10.96	3.84	35.04	8
	2	Ripe	10.80	3.86	35.74	8
	3	Ripe	11.00	4.00	36.36	9
	4	Ripe	11.00	4.06	36.91	9
	5	Ripe	11.08	4.10	37.00	10
	6	Ripe	11.50	4.28	37.22	9
	7	Ripe	11.04	4.02	36.41	8
	8	Ripe	9.78	3.62	37.01	9
	9	Ripe	8.94	3.38	37.81	9
TOTAL	9		96.10	35.16		
			avg batch	avg juice	avg %	avg time
		Avg	10.7	3.9	36.6	8.8

SAMPLE 8:

Date	Batch	Quality	Fruit (kg)	Juice (kg)	Juice (%)	Time (mn)
30/03/05	1	Ripe	10.58	3.46	32.70	8
	2	Ripe	10.98	3.67	33.42	9
	3	Ripe	11.12	3.66	32.91	11
	4	Ripe	8.26	2.78	33.66	10
TOTAL	4		40.94	13.57		
			avg batch	avg juice	avg %	avg time
		Avg	10.2	3.4	33.2	9.5

SAMPLE 9:

Date	Batch	Quality	Fruit (kg)	Juice (kg)	Juice (%)	Time (mn)
31/03/05	1	Ripe	11.06	3.54	32.01	6
	2	Ripe	11.02	3.00	27.22	16
	3	Ripe	11.32	3.66	32.33	9
	4	Ripe	11.54	3.77	32.67	8
	5	Ripe	11.22	3.68	32.80	10
	6	Ripe	11.38	3.58	31.46	9
	7	Ripe	11.42	3.72	32.57	10
	8	Ripe	9.56	3.14	32.85	9
TOTAL	8		88.52	28.09		
			avg batch	avg juice	avg %	avg time
		Avg	11.1	3.5	31.7	9.6

SAMPLE 10:

Date	Batch	Quality	Fruit (kg)	Juice (kg)	Juice (%)	Time (mn)
01/04/05	1	Ripe	10.98	2.34	21.31	11
	2	Ripe	11.10	2.88	25.95	11
	3	Ripe	11.20	2.50	22.32	14
	4	Ripe	10.20	2.32	22.75	13
	5	Ripe	10.42	2.86	27.45	10
	6	Ripe	10.90	2.85	26.15	11
	7	Ripe	11.10	2.86	25.77	12
	8	Ripe	10.84	2.78	25.65	10
	9	Ripe	11.16	2.88	25.81	10
	10	Ripe	11.00	2.92	26.55	10
	11	Ripe	11.00	2.84	25.82	9
	12	Ripe	11.02	2.76	25.05	10
	13	Ripe	11.70	3.16	27.01	11
	14	Ripe	10.78	2.85	26.44	13
	15	Ripe	11.04	3.02	27.36	11
	16	Ripe	11.12	3.14	28.24	9
	17	Ripe	11.20	3.17	28.30	11
	18	Ripe	10.66	2.68	25.14	11
	19	Ripe	10.88	2.88	26.47	10
	20	Ripe	11.10	3.08	27.75	10
	21	Ripe	11.00	3.04	27.64	11
	22	Ripe	11.06	2.94	26.58	11
	23	Ripe	11.04	2.94	26.63	10
	24	Ripe	10.30	2.80	27.18	10
TOTAL	24		262.80	68.49		
			avg batch	avg juice	avg %	avg time
		Avg	11.0	2.9	26.1	10.8

SAMPLE 11:

Date	Batch	Quality	Fruit (kg)	Juice (kg)	Juice (%)
04/04/05	1	Ripe	10.26	3.32	32.36
	2	Ripe	11.60	3.56	30.69
	3	Ripe	10.84	3.44	31.73
	4	Ripe	11.14	3.44	30.88
	5	Ripe	10.94	3.34	30.53
	6	Ripe	11.46	3.38	29.49
	7	Ripe	10.82	3.26	30.13
	8	Ripe	12.30	2.90	23.58
	9	Ripe	10.93	3.00	27.45
	10	Ripe	10.94	3.02	27.61
	11	Ripe	11.00	2.86	26.00
	12	Ripe	10.90	3.06	28.07
	13	Ripe	11.46	3.16	27.57
	14	Ripe	11.24	3.00	26.69
	15	Ripe	10.78	2.86	26.53
	16	Ripe	10.78	2.88	26.72
	17	Ripe	10.50	2.98	28.38
	18	Ripe	10.98	2.78	25.32
	19	Ripe	11.06	2.96	26.76
	20	Ripe	9.42	2.52	26.75
	21	Ripe	11.06	2.74	24.77
	22	Ripe	11.04	2.72	24.64
	23	Ripe	10.48	2.58	24.62
	24	Ripe	10.76	2.70	25.09
	25	Ripe	10.94	2.54	23.22
	26	Ripe	10.86	2.60	23.94
	27	Ripe	11.06	2.64	23.87
	28	Ripe	11.20	2.80	25.00
TOTAL	28		306.75	83.04	
			avg batch	avg juice	avg %
		Avg	11.0	3.0	27.1

SAMPLE 12:

Date	Batch	Quality	Fruit (kg)	Juice (kg)	Juice (%)
05/04/05	1	Ripe	10.90	2.94	26.97
	2	Ripe	10.56	2.96	28.03
	3	Ripe	10.58	2.70	25.52
	4	Ripe	10.40	2.96	28.46
	5	Ripe	10.66	2.92	27.39
	6	Ripe	10.86	3.02	27.81
	7	Ripe	10.60	2.90	27.36
	8	Ripe	10.54	2.58	24.48
	9	Ripe	10.48	2.54	24.24
	10	Ripe	10.52	2.66	25.29
	11	Ripe	10.76	2.90	26.95
	12	Ripe	10.48	2.58	24.62
	13	Ripe	10.50	2.78	26.48
	14	Ripe	9.56	2.70	28.24
	15	Ripe	10.50	2.52	24.00
	16	Ripe	10.76	2.49	23.14
	17	Ripe	10.80	2.56	23.70
	18	Ripe	10.46	2.62	25.05
	19	Ripe	10.78	2.74	25.42
	20	Ripe	10.74	2.96	27.56
	21	Ripe	10.84	2.72	25.09
	22	Ripe	7.98	2.26	28.32
TOTAL	22		230.26	60.01	
			avg batch	avg juice	avg %
		Avg	10.5	2.7	26.1

SAMPLE 13:

Date	Batch	Quality	Fruit (kg)	Juice (kg)	Juice (%)	Time (mn)
06/04/05	1	Ripe	11.04	2.68	24.28	x
	2	Ripe	10.98	2.76	25.14	8
	3	Ripe	10.50	2.66	25.33	11
	4	Ripe	12.32	2.62	21.27	x
	5	Ripe	11.34	2.82	24.87	x
	6	Ripe	11.04	2.90	26.27	x
	7	Ripe	11.18	2.96	26.48	12
	8	Ripe	11.24	3.01	26.78	22
	9	Ripe	10.92	2.82	25.82	14
	10	Ripe	11.12	2.82	25.36	10
	11	Ripe	11.46	2.84	24.78	11
	12	Ripe	11.38	2.86	25.13	18
	13	Ripe	11.44	3.00	26.22	6
	14	Ripe	11.08	2.96	26.71	19
	15	Ripe	11.34	2.92	25.75	11
	16	Ripe	11.36	2.76	24.30	10
	17	Ripe	11.42	2.86	25.04	11
	18	Ripe	11.30	2.76	24.42	11
	19	Ripe	11.40	2.66	23.33	11
TOTAL	19		213.86	53.67		
			avg batch	avg juice	avg %	avg time
		Avg	11.3	2.8	25.1	11.6

SAMPLE 14:

Date	Batch	Quality	Fruit (kg)	Juice (kg)	Juice (%)
07/04/05	1	Ripe	11.52	2.86	24.83
	2	Ripe	11.38	3.00	26.36
	3	Ripe	11.48	3.10	27.00
	4	Ripe	11.22	3.02	26.92
	5	Ripe	11.32	3.04	26.86
	6	Ripe	11.56	3.26	28.20
	7	Ripe	10.94	2.48	22.67
	8	Ripe	10.76	2.54	23.61
	9	Ripe	11.32	2.76	24.38
	10	Ripe	10.82	2.32	21.44
	11	Ripe	10.78	2.50	23.19
	12	Ripe	11.04	2.46	22.28
TOTAL	12		134.14	33.34	
			avg batch	avg juice	avg %
		Avg	11.2	2.8	24.8

SAMPLE 15:

Date	Batch	Quality	Fruit (kg)	Juice (kg)	Juice (%)
08/04/05	1	Ripe	11.30	2.58	22.83
	2	Ripe	11.28	2.28	20.21
	3	Ripe	10.98	2.58	23.50
	4	Ripe	11.16	2.46	22.04
	5	Ripe	11.00	2.44	22.18
	6	Ripe	10.96	2.38	21.72
	7	Ripe	11.02	2.38	21.60
	8	Ripe	11.24	2.62	23.31
	9	Ripe	11.14	2.48	22.26
	10	Ripe	11.04	2.68	24.28
TOTAL	10		111.12	24.88	
			avg batch	avg juice	avg %
		Avg	11.1	2.5	22.4

SYNTHESIS

Sample No	Fruit (kg)	Juice (kg)	Juice (%)	Average kg / batch)	Average time (mn)
1	217.02	57.05	26.29	11.4	11.0
2	101.92	26.56	26.06	11.3	10.3
3	200.22	53.04	26.49	11.8	11.4
4	57.72	15.12	26.20	11.5	10.8
5	49.50	12.18	24.61	11.0	9.4
6	67.86	23.98	35.34	11.3	11.2
7	96.10	35.16	36.59	10.7	8.8
8	40.94	13.57	33.15	10.2	9.5
9	88.52	28.09	31.73	11.1	9.6
10	262.80	68.49	26.06	11.0	10.8
11	306.75	83.04	27.07	11.0	x
12	230.26	60.01	26.06	10.5	x
13	213.86	53.67	25.10	11.3	11.6
14	134.14	33.34	24.85	11.2	x
15	111.12	24.88	22.39	11.1	x
TOTAL	**2'178.73**	**588.18**	**27.87**	**11.1**	**10.4**

A total quantity of 2'178.73kg of cleaned marula fruits were pressed into 588.17kg of juice. The juice extraction rate was 27.87%. The average batch with the Kapmond-10 press was 11.kg and 10.4 mn are needed to press a batch.

The assessment of the cleaning losses remains to be done.

ANNEX 2

PULP TRIALS DATA

Four different trials were conducted to assess the productivity of separating the pulp from the pips. The process was as follows: mechanical separation with the brush pulper where some water is added to help this process, and thereafter completed with a manual separation.

Table "Brush pulper": fruit pips and water (input), pulp extracted (output).

Table "Manual separation": after brush-pulping, quantity of pulp extracted manually.

Table "Net pulp extraction quantity": quantity of pulp extracted after mechanical and manual separation minus the water added (to help the mechanical process).

Table "Net pulp extraction rate": percentage of pulp extracted compared to quantity of pips.

SAMPLE 1 (18 March 2005)

BRUSH PULPER			
	PIPS	PULP	WATER
INPUT (kg)	55.26		6.27
OUTPUT (Kg)		7.38	
MANUAL SEPARATION			
OUTPUT (kg)	47.24	5.84	
NET PULP EXTRACTION QUANTITY (kg) (without water)			
6.95			
NET PULP EXTRACTION RATE (%) (w/w)			
12.58			

The pips came from fruits pressed at least two days before and stored in the cold room.

SAMPLE 2 (18 March 2005)

BRUSH PULPER			
	PIPS	PULP	WATER
INPUT (kg)	14.46		0.90
OUTPUT (Kg)		1.10	
MANUAL SEPARATION			
OUTPUT (kg)	11.76	1.82	
NET PULP EXTRACTION QUANTITY (kg) (without water)			
2.02			
NET PULP EXTRACTION RATE (%) (w/w)			
13.97			

The pulp was freshly extracted from fruits pressed the same day.

SAMPLE 3 (22 March 2005)

BRUSH PULPER			
	PIPS	PULP	WATER
INPUT (kg)	33.72		1.84
OUTPUT (Kg)		1.26	
MANUAL SEPARATION			
OUTPUT (kg)	29.04	4.28	
NET PULP EXTRACTION QUANTITY (kg) (without water)			
3.7			
NET PULP EXTRACTION RATE (%) (w/w)			
10.97			

The pulp was freshly extracted from fruits pressed the same day.

SAMPLE 4 (23 March 2005)

BRUSH PULPER			
	PIPS	PULP	WATER
INPUT (kg)	34.22		0.80
OUTPUT (Kg)		0.98	
MANUAL SEPARATION			
OUTPUT (kg)	30.30	3.00	
NET PULP EXTRACTION QUANTITY (kg) (without water)			
3.18			
NET PULP EXTRACTION RATE (%) (w/w)			
9.29			

The pulp was freshly extracted from fruits pressed the same day.

SYNTHESIS

SAMPLE No.	**NET PULP EXTRACTION RATE (%)**
1	12.58
2	13.97
3	10.97
4	9.29
AVERAGE	**11.70**

ANNEX 3

SKINS TRIALS DATA

After juice processing, the skins and pips were sorted out. The aims were to produce samples of marula skins for further use, and determine the time and quantity that one person can process.

In addition, the trials results allowed quantifying the composition of the constituents of marula fruits (i.e. juice, pip and skin). However, to be representative this assessment should be repeated on a wider sample of fruits.

SAMPLE 1 (15 March 2005)

TYPE		WEIGHT Kg	%
SKINS	clean	10.24	47.0
	waste	2.18	10.0
	Total	12.42	57.0
PIPS + PULP		9.36	43.0
TOTAL		21.78	100.0

TIME	1.25
PERSONS	2

PRODUCTIVITY Fruits already pressed	
Per hour	17.42
Per person-hour	8.71
PRODUCTIVITY Skins	
Per hour	8.19
Per person-hour	4.10
PRODUCTIVITY Pips	
Per hour	7.49
Per person-hour	3.74

SAMPLE 2 (15 March 2005)

TYPE		WEIGHT Kg	%
SKINS	clean	9.16	42.1
	waste	3.42	15.7
	Total	12.58	57.8
PIPS + PULP		9.20	42.2
TOTAL		21.78	100.0

TIME	1.1
PERSONS	3

PRODUCTIVITY Fruits already pressed	
Per hour	19.80
Per person-hour	6.60
PRODUCTIVITY Skins	
Per hour	8.33
Per person-hour	2.78

PRODUCTIVITY Pips	
Per hour	8.36
Per person-hour	2.79

SAMPLE 3 (16 March 2005)

TYPE		WEIGHT Kg	%
SKINS	clean	11.30	47.2
	waste	2.96	12.4
	Total	14.26	59.5
PIPS + PULP		9.70	40.5
TOTAL		23.96	100.0

TIME	1.165
PERSONS	3

PRODUCTIVITY Fruit already pressed	
Per hour	20.57
Per person-hour	6.86
PRODUCTIVITY Skins	
Per hour	9.70
Per person-hour	3.23
PRODUCTIVITY Pips	
Per hour	8.33
Per person-hour	2.78

SAMPLE 4 (16 March 2005)

TYPE		WEIGHT Kg	%
SKINS	clean	27.26	43.9
	waste	9.20	14.8
	Total	36.46	58.7
PIPS + PULP		25.64	41.3
TOTAL		62.10	100.0

TIME	2.825
PERSONS	2.5

PRODUCTIVITY Fruit already pressed	
Per hour	21.98
Per person-hour	8.79
PRODUCTIVITY Skins	
Per hour	9.65
Per person-hour	3.86
PRODUCTIVITY Pips	
Per hour	9.08
Per person-hour	3.63

SAMPLE 5 (16 March 2005)

TYPE		WEIGHT Kg	%
SKINS	clean	20.16	44.2
	waste	6.80	14.9
	Total	26.96	59.0
PIPS + PULP		18.70	41.0
TOTAL		45.66	100.0

TIME	1.825
PERSONS	3

PRODUCTIVITY Fruit already pressed	
Per hour	25.02
Per person-hour	8.34
PRODUCTIVITY Skins	
Per hour	11.05
Per person-hour	3.68
PRODUCTIVITY Pips	
Per hour	10.25
Per person-hour	3.42

SAMPLE 6 (16 March 2005)

TYPE		WEIGHT Kg	%
SKINS	clean	9.20	42.5
	waste	3.82	17.7
	Total	13.02	60.2
PIPS + PULP		8.62	39.8
TOTAL		21.64	100.0

TIME	0.66
PERSONS	4

PRODUCTIVITY Fruit already pressed	
Per hour	32.79
Per person-hour	8.20
PRODUCTIVITY Skins	
Per hour	13.94
Per person-hour	3.48
PRODUCTIVITY Pips	
Per hour	13.06
Per person-hour	3.27

SYNTHESIS OF PRODUCTIVITY

PRODUCTIVITY (per person-hour)			
Kg of / Sample No.	FRUITS	SKINS	PIPS
1	8.7	4.1	3.7
2	6.6	2.8	2.8
3	6.9	3.2	2.8
4	8.8	3.9	3.6
5	8.3	3.7	3.4
6	8.2	3.5	3.3
AVERAGE	**7.9**	**3.5**	**3.3**

One person can process 7.9kg of pressed fruits in one hour getting 3.5kg of skins and 3.3 kg of pips and pulp (what is left is waste).

SYNTHESIS OF FRUIT COMPOSITION

1- Pressed fruits	SKIN (%)			PIPS (%)	TOTAL (%)
SAMPLE	Yellow & green	Waste	Total		
1	47	10	57	43	100
2	42	16	58	42	100
3	47	12	60	41	100
4	44	15	59	41	100
5	44	15	59	41	100
6	43	18	60	40	100
AVERAGE	**44**	**14**	**59**	**41**	**100**

2- Whole fruit	
Juice	28.0 %
Pip	29.5 %
Skin	42.5 %
Fruit	100.0 %

Pip+Skin+Juice = 100
Pip+Skin = 100 - Juice

Pip+Skin = 72 Pip = (41:100) x 72
Skin = (59:100) x 72

WITH	**100.0**	Kg	FRESH MARULA FRUITS
you get	28.0	Kg	of juice
	72.0	Kg	of pressed fruits
WITH	72.0	Kg	of pressed fruits
you get	36.7	Kg	of skins
	35.3	Kg	of pips
WITH	36.7	Kg	of skins
you get	6.1	Kg	of dry skins
FOR	**100.0**	Kg	OF DRY SKINS
you need	600.0	Kg	of fresh marula fruits
you get	156.0	Kg	of juice
	246.0	Kg	of pips

Annex 4

Marula Juice & Pulp Pilot Project (MJP³)

FINAL FINANCIAL REPORT OF PHASE-2

Expenditure Period: 14 March - 31 December 2005

Submitted to IPTT / NAB (UPDP funds)
By CRIAA SA-DC (Namibia)

1. Consultancy contract:

- Signed on 28 April 2005
- Contract amount: N$604'164 (including unspent balance of N$45'323.50 carried forward from Phase-1)
- First and only payment received from NAB: N$196'342.25 (40%) on 29 April 2005
- Total funds available for Phase-2: N$241'667.40 (= 45'325.15 + 196'342.25)

2. Summary table of project expenses (Phase-2) compared to budget:

- Detailed financial report provided to NAB (January 2006).

No	Budget item	Budget N$	Expenses N$	Variance N$
1.	**Project management & applied research costs:**			
1.1	Human resources	235 100	155 600.00	79 500.00
1.2	Per diems	43 500	24 860.00	18 640.00
1.3	Transport	49 000	21 998.86	27 001.14
1.4	Research costs	66 000	695.52	65 304.48
	Sub-total:	***393 600***	***203 154.38***	***190 445.62***
2.	**Business equipment and production costs:**			
2.1	Capital equipment	24 000	20 221.62	3 778.38
2.2	Facilities	4 500	2 500.00	2 000.00
2.3	Consumables	12 000	6 421.49	5 578.51
2.4	Casual labour	6 000	3 172.50	2 827.50
2.5	Fruit purchase	37 500	1 165.00	36 335.00
	Sub-total:	***84 000***	***33 480.61***	***50 519.39***
3.	**Contingencies (10%):**	***47 760***	**-**	***47 760.00***
4.	**Administration (15%):**	***78 804***	***35 495.25***	***43 308.75***
	TOTAL :	**604 164**	**272 130.24**	**332 033.76**

3. Balance funds received less expenses:

- N$ 241'667.40 - 272'130.24 = **N$ - 30'462.84**

4. Detailed time sheets and related costs of project personnel:

Roger Gamond (Technologist)

Year	Activity	Dates	Fees	Perdiems	Travel
2005	Fieldwork: Cosdec Ondangwa[1]	14/03-15/04	24 days[2]	27[3]	Toyota N94243W: 1403km[1]
2005	Monitoring product samples (Whk)	May-June	1	-	-
Total:			**25 days**	**27**	

Notes: [1] field work from end of Phase-1 (14/03/2005). [2] excludes Sundays. [3] total of 32 perdiems less 5 already allocated to IGLV Phase-1 project.

Thomas Ambinga (Technician KAP)

Year	Activity	Dates	Fees	Perdiems	Travel
2005	Fieldwork: Cosdec Ondangwa	14/03-15/04[1]	32 days	32	-
Total:			**32 days**	**32**	

Notes: [1] field work from end of Phase-1 (14/03/2005).

Julien Gallardo (Volunteer)

Year	Activity	Dates	Fees	Perdiems	Travel
2005	Fieldwork: Cosdec Ondangwa[1]	14/03-16/04[1]	30 days	33	Mazda N91494W: 2316km
Total:			**30 days**	**33**	

Notes: [1] field work from end of Phase-1 (14/03/2005).

Pierre du Plessis (Project Co-ordinator)

Year	Activity	Dates	Fees	Perdiems	Travel
2005	Fieldwork: Cosdec Ondangwa	23-28/03	4 days	5	Toyota N16415W: 1595km
2005	Project co-ordination & market liaison	Apr.-Sep.	26 days	-	-
2005	Market liaison & project progress reporting (to IPTT)	Oct.-Dec.	4 days	-	-
Total:			**34 days**	**5**	

Michel Mallet (Executive Director)

Year	Activity	Dates	Fees	Perdiems	Travel
2005	Project support, contract management & financial supervision (Whk)	Mar.-Dec.	4 days	-	-
Total:			**4 days**	**-**	

5. Capital equipment:

- Capital equipment (remaining the property of MAWF as per contract) reflected in Table below.
- Small equipment and materials (buckets, jugs, plastic food containers etc.) of low value and with short life-span not considered as capital equipment.

Payment date	Description	Invoice	Purchase value N$	Status
18/03/05	12m 4-core electrical cable for pasteuriser	M. Pupkewitz no 04178239	266.62	At KAP with pasteuriser
11/04/05	2nd-hand 6m storage container (for storing equipment)	Unitainer no WB057S	15 985.00	At EWC factory in Ondangwa
13/07/05	5x 16mm s/s union bends & linkage tubes for pasteuriser	Fruits of Africa no 0002	3 970.00	At KAP with pasteuriser
		Total:	**20 221.62**	

In Windhoek, 25 January 2006

Michel Mallet
Executive Director