MAHANGU POST-HARVEST SYSTEMS

A SUMMARY OF CURRENT KNOWLEDGE ABOUT PEARL MILLET POST-HARVEST ISSUES IN NAMIBIA

Research Report

prepared for

Ministry of Agriculture, Water and Rural Development
Directorate of Planning
and
Namibian Agronomic Board

by

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Technical Support to the Small Scale Mahangu and Other Grain Processing and Marketing Industry in the Northern Communal Areas of Namibia

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It must be noted, however, that this research was based on available literature (in a printed form) and on the professional experience of the authors. As the research did not include specific fieldwork in the North, unpublished materials, 'grey literature' and farmers' knowledge could consequently not be systematically collected. (Maybe this could be considered in future...)

ACRONYMS AND ABBREVIATIONS

CIRAD	Centre de coopération internationale en recherche agronomique pour le développement (France) *International Co-operation Centre in Agronomic Research for Development*
CRIAA SA-DC	Centre for Research-Information-Action in Africa, Southern Africa - Development and Consulting
CSIR	Council for Scientific and Industrial Research (South Africa)
DCD	Division of Co-operative Development (MAWRD)
DfID	Department for International Development (UK)
DoP	Directorate of Planning (MAWRD)
FAO	Food and Agriculture Organisation (UN)
FSRE	Farming Systems Research and Extension
ha	hectare (10 000 m²)
hp	horse-power (0.7355 kW)
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
kJ	kiloJoule
kW	kiloWatt
MAWRD	Ministry of Agriculture, Water and Rural Development
MMIU	Mahangu Marketing Intelligence Unit
MRC	Multidisciplinary Research Centre (UNAM)
NAB	Namibian Agronomic Board
NCAs	Northern Communal Areas
NCRs	North Central Regions (Oshana, Oshikoto, Ohangwena and Omusati)
NDC	Namibia Development Corporation
N$	Namibia Dollars
NEWFIU	Namibia Early Warning and Food Information Unit (MAWRD)
NNFU	

	Namibia National Farmers' Union
NRC	Namibia Resource Consultants
NRI	Natural Resources Institute (UK)
Orstom	Institut de recherche pour le développement - IRD (formerly Orstom) (France)
PTO	Power take-off
RDC	Rural Development Centre
SACU	Southern Africa Customs Union
SADC	Southern African Development Community
t	tonne (1 000 kg)
UNAM	University of Namibia
UNICEF	United Nations Children Fund

ABSTRACT

In order to share information and disseminate findings, this paper condenses all the reports produced to date under the project « *Technical Support to the Small Scale Mahangu and Other Grain Processing and Marketing Industry in the Northern Communal Areas of Namibia* ». A list of reports appears in *Annex 1*. Results of other relevant work on pearl millet post-harvest issues are also included (see *Bibliography*).

The present world situation around mahangu (pearl millet) production and trade is described and a working definition of post-harvest systems is presented. National cereal production, including mahangu, is compared with national cereal consumption. The role of imports is quantified and described. Despite a strong consumer preference for mahangu in some sectors, cheap maize meal is very important because the price of cereals plays a crucial role in the food security, nutritional status and living standard of especially the poorest households.

Existing on-farm post-harvest systems are described for harvesting, drying, seed selection, threshing and winnowing, on-farm storage, household food processing and grain marketing, and related research and development needs are identified. The current trade in mahangu grain in various markets is characterised and partially quantified. The service and commercial mahangu milling sectors are described and quantified, and the constraints they face are elucidated (see *Maps 1-3*). Finally the summarised information is discussed in relations to mahangu promotion policy.

It is concluded that better post-harvest practices and technology can increase the effective national harvest and the efficiency of processing, but that sustainable growth of the secondary and tertiary mahangu sectors will ultimately need to be supported by increased primary production and/or more reliable and cheaper imports of mahangu grain, especially in drought years. However, many of the constraints on mahangu post-harvest systems have been identified and **addressing these constraints is therefore a priority area for immediate intervention.**

CHAPTER 1 INTRODUCTION

Background

The Ministry of Agriculture, Water and Rural Development (MAWRD), through its Directorate of Planning (DoP), has embarked on a project « *Technical Support to the Small Scale Mahangu and Other Grain Processing and Marketing Industry in the*

Northern Communal Areas (NCAs) of Namibia ». This project resulted from recent work, which recommended that Government focuses its support on the promotion of an emerging grain processing sector in the northern crop growing communal areas. The project, which started in June 1998, is managed by the Namibian Agronomic Board (NAB) and supported by a Steering Committee.

Through a tendering process, CRIAA SA-DC (a not-for-gain Namibian-registered development and consulting organisation) was commissioned to implement this project. Phase I was a comprehensive baseline study, which identified a large number of mills in Northern Namibia, as well as technical and operational difficulties. As a result of the findings the Steering Committee commissioned a second phase (1999-2000) to investigate the technical constraints and economics of small-scale mahangu milling. As part of the terms of reference of Phase II, the consultants were required to provide costed proposals for research into alleviating some of the critical technical constraints that hold back the development of farm and village level mahangu processing in NCAs. The outcome was the following recommendations:

A range of adaptive technical research addressing key constraints to mahangu processing by small farmers and small millers;

Preparation and delivery of training to small millers to improve the efficiency of and financial returns from milling;

A number of on-farm post-harvest practices identified during the study could be significantly improved to increase the volume of mahangu available for sale as surplus.

The list of project reports to date is shown in *Annex 1*.

The present research paper aims at condensing all the project reports to date in order to share information and disseminate findings and recommendations on the topic. Results of other relevant research and development work conducted in Namibia, or elsewhere, on pearl millet post-harvest issues are also included in this document, as far as they are known to the authors (see *Bibliography in Annex 1*) and relevant to the purpose of this synthesis.

Government policy and programmes for commercialising mahangu cannot be ignored in the context of this paper, but will not be its main focus. The National Agricultural Policy (*1995*) emphasises that the commercialisation of pearl millet is a strategy to alleviate poverty and improve the standard of living of small-scale farmers in the Northern Namibia. The MAWRD has also a clear vision that improved utilisation of this valuable resource can benefit household food security, agricultural industries and small and micro-enterprise development. It can also lead to novel agronomic and food industries development, since mahangu is tolerant to the marginal agricultural conditions prevailing in the North of Namibia, and can offer significant opportunities for strengthening the whole agricultural sector in Namibia. A workshop recently held at Mokuti Lodge stressed these points.

Pearl Millet in the World Today - A Brief Overview

Pearl millet, commonly named *Mahangu* in Namibia, is one of the most important human staple cereals grown in the world today after wheat, rice, maize, barley and sorghum. Its taxonomic name is *Pennisetum glaucum* (L.) R. Br. but it is also known as *P.*

americanum and *P. typhoides*. Bulrush millet, cattail millet and candle millet are also used as synonyms for pearl millet. However, pearl millet should not be confused with the other millets, such as finger millet (*Eleusine coracana*), foxtail millet (*Setaria italica*), common or proso millet (*Panicum miliaceum*), and fonio (*Digitaria exilis*) of West Africa, all of which are not grown in Namibia.

Pearl millet is a traditional staple food crop of the semi-arid tropical zones of Africa and Asia, and it is cultivated in areas with a rainfall ranging from 150 mm to 800 mm per annum (*CIRAD/Orstom, 1997*). It has a nutritional value superior to other cereals like maize, wheat or rice: it is digested more slowly and thus delays hunger pangs, it has a higher content of proteins and lipids, and its amino acid balance is better (*Labetoulle, 2000*). Pearl millet is the most drought tolerant cereal and can grow in soils with low fertility, which are unsuitable to other cereals. Being particularly resistant to moisture stress and adapted to high temperatures, it has a low yield, which also explains its high nutritional value compared to other cereals.

In traditional African agricultural systems, pearl millet is very often intercropped with pulse plants, such as groundnuts or cowpeas, and with cucurbits. Typically, livestock plays a crucial part in pearl millet based traditional farming systems. Pearl millet stover is a valuable source of animal feed, making it a dual-purpose crop for subsistence farmers (*Blench, 1997*). In some regions, the stover is also used as roofing or fencing materials. Pearl millet furthermore has excellent storage qualities, giving it an advantage over other crops where inter-annual food security is necessary (*Tyler & Bennett, 1993*).

In Africa, pearl millet is typically a "low-input/low-output" rain-fed crop of marginal agricultural areas. Average yields are estimated around 0.6 tonnes per hectare (around 0.8 t/ha in India) but range between 0.3 t/ha in Southern Africa to over 0.8 t/ha in Nigeria and Uganda under wetter conditions (*NRC, 1997*). It must be noted that a traditional pearl millet variety specific to the Senegal River Valley is grown counter-seasonally in wet soils left behind by receding floods (*CIRAD/Orstom, 1997*). This is also the case with some sorghum varieties in West Africa, as well as in Kavango along the river and East Caprivi in the Zambezi flood plains (where maize is also grown this way).

Although accurate statistical figures on pearl millet production are not available, FAO estimated that it was grown on over 30 million hectares in 1994, mainly in developing countries, and that world production was around 28 million tonnes. Africa accounted for 20 million hectares and a production of 11.9 million tonnes, and India, the leading world producer, 13.7 million hectares and 11 million tonnes. The world trade of pearl millet is only around 0.25 million tonnes a year and less than 1% of the world's millet production is internationally traded. In Africa, the largest producers of pearl millet are situated in the Sahel in West-Central Africa: Nigeria, Niger, Mali, Senegal, Burkina Faso and Chad. In East Africa, Uganda and Sudan are the largest producers. Only 5% to 10% of African production is estimated to enter the commercial market (*FAO/ICRISAT, 1996*), while in India, where pearl millet is grown commercially, an estimated 15% to 20% is marketed.

In the dryer parts of Southern Africa (in Angola, Namibia, Zimbabwe, Botswana, Zambia and South Africa), millet is traditionally grown as a staple and surpluses are hardly traded. However, cross-border trade from Southern Angola to Northern Namibia has been reported as significant in some years, even in the absence of official trade and customs figures. In Zimbabwe, pearl millet cultivation has been declining from over 250 000 ha in the 1980s to less than 150 000 ha in recent years, with average yields also declining.

« With 51 000 t produced annually and a yield of 0.4 t/ha (averages over the past 5 years), pearl millet accounts for approximately 2.4% of coarse grain production in Zimbabwe, where it is exclusively grown on smallholder and resettlement farms. In the 1998/99 marketing year, formal market deliveries were only 310 t (for a production of 29 900 t that year), 300 t to a commercial opaque beer brewer and an estimated 10 t as poultry feed. The Grain Marketing Board, a parastatal mandated to act as a residual buyer, has purchased virtually no pearl millet during the past 2 marketing seasons, and is unlikely to purchase any again this year (2000). ICRISAT's surveys generally indicate that pearl millet prices are 10 to 20% higher than the price of maize, even in areas of the country where pearl millet is a main staple. Pearl millet could potentially be used significantly more in the food and feed industries of Zimbabwe, but given its higher grain price, it is best targeted as a speciality product in urban markets and as a staple in rural producing areas » (adapted from *Rohrbach, 2000*).

In a study commissioned by MAWRD/NAB in 1997, *The World Market for Millet and the Potential for Imports into Namibia*, to determine the possibility of importing mahangu to facilitate the establishment of a substantive processing industry, NRC consultants concluded as follows.

« Most of the millet traded internationally is proso millet, which is used mainly as birdfeed. Virtually all of the world's production of pearl millet is by subsistence farmers for own-consumption; it is rarely traded.

Countries bordering Namibia are not regarded as suitable for securing millet when Namibia is short. The countries experience a similar climate and more than likely would also be in deficit. Also, most of the production in neighbouring countries is for subsistence and not for commercial marketing.

West Africa is a significant producer of pearl millet. However, it is all grown well in-land in areas bordering the Sahara desert, about 1 000 to 1 500 miles from the sea on very poor roads. The high cost of road transport to a seaport, as well as sea freight and import duties would make West African pearl millet prohibitively expensive. (...)

The only country that could supply Namibia with pearl millet in most years is India. Price models indicate that Indian pearl millet could be landed in Oshakati for prices between US$ 277 to 335 per tonne (N$ 1 330/t to N$ 1 608/t, 1997 prices). However, even at these factory gate prices, millet flour could be retailed at N$ 3.10/kg to N$ 3.40/kg, which is over twice as much as maize meal. (...)

Therefore, it must be concluded that it is impossible to import pearl millet and process it into flour in Namibia at a price which is competitive with maize meal. »

In the world, most pearl millet is grown for grain used for human consumption, but there is increasing interest in utilising it as a forage crop and feedgrain crop. This trend is developing in drier parts of the USA, Australia, South Africa and South America. In Brazil, pearl millet has been rapidly adopted by farmers as the ideal cover crop-cum-mulch for no-till soybean production. Over 1 million hectares are reported to be sown in Brazil, especially on acid savannah soil (*SAT News*).

Pearl millet is often considered as the subsistence crop of last resort in agricultural marginal areas and hostile environments, the production of which is virtually unimprovable. These considerations are only partly true. Firstly, smallholder farmers can potentially increase productivity, or render production more reliable, with genetically improved varieties (ICRISAT has been playing a major role for tropical areas) and improvements in cultivation techniques, such as draft animal power, as exemplified by the Indian experience. Pearl millet shows a high response to limited fertilisation with manure and/or nitrogen and phosphorus (*Matanyaire, 1998*), which are most often deficient in tropical soils. However, increasing the yield per hectare is taken as the ultimate criteria by most extensionists for improving smallholder cropping systems, while farm labour is most often the major bottleneck for peasant farmers, when farm land is not dramatically scarce and farming techniques are not much mechanised. The productivity of farm work (quantity harvested per unit of work applied) is often a more relevant criterion from a producer's perspective, but more difficult to measure (by researchers).

Secondly, a large number of African countries, especially in West Africa, have surprisingly managed to increase per capita production of pearl millet (as well as sorghum and other grains) since the last great drought of 1982-1985. The liberalisation of cereal markets jointly initiated in 1986 by Sahelian countries, with accompanying measures and substantial support from donor countries, had a positive impact on private grain trading operators and spin-off effects on primary agricultural production by rural producers. The devaluation of the CFA franc on 14 January 1994 unleashed the development of emerging small-scale processing enterprises providing new local products for the urban consumer markets (*T. Dauplais, pers. comm*.).

In Mali, where cereal production increased by over 50% after liberalisation in the late 1980s, the restructured market for locally produced grains, including pearl millet, has been managed by a large network of private traders (the State providing market information and keeping strategic reserve stocks). Village associations, mobile 'collectors' in rural areas and markets, 'assemblers' operating at urban or large rural market level, wholesalers and semi-wholesalers and retailers in urban areas, as well as processors, all played an important role in transferring cereals from main production areas to consuming areas and redistributing cash income to rural producers (*Kanté, 2000*). However, liberalisation did not render pearl millet price-competitive with maize or rice. The objective of supporting the prices of local cereals was abandoned in the late 1980s mainly because of the difficulty of financing the stock levels necessary to maintain prices in surplus years (*Coulter, 1994*).

Grain Post-Harvest Systems - A Definition

Post-harvest of cultivated cereals embraces all operations from harvest to final utilisation of the grain (food preparation being the main ultimate use for the purpose of this paper), including harvesting, drying, threshing, cleaning, storing, grading, marketing and processing.

From a technological angle, post-harvest operations are divided into crop processing (or primary processing) and food processing (or secondary processing). However, a technology analysis is not sufficient to characterise post-harvest systems, even if the important subject of farmers' knowledge systems is included. Economic issues are also crucial (demand, prices, markets, etc.). A micro-economic angle will focus on post-production at the individual farmer's level, while a meso- or a macro-economic angle will look at processing and marketing at regional or national level.

Post-harvest issues are therefore complex, involving different inter-linked levels of understanding, and requiring multi-disciplinary and multi-level analyses. Hence the reference to a systemic approach in « post-harvest systems ».

CHAPTER 2 NATIONAL MAHANGU PRODUCTION AND NATIONAL CEREAL CONSUMPTION

National Mahangu Grain Production

Mahangu is the main crop of the Northern Communal Areas (NCAs), specifically of the North Central Regions (NCRs), Kavango and the western part of Caprivi, where it is grown under rain-fed conditions. To a limited extent, it is also grown in some parts of the Otjozondjupa region, especially in the former West Bushmanland, and it has recently been cultivated by some 'commercial farmers' mainly in the Tsumeb-Grootfontein-Otavi Triangle.

In the NCAs, mahangu and sorghum are very often grown in the same fields, not necessarily inter-cropped (sorghum being grown in some patches of the main mahangu fields). This makes it difficult (and partly irrelevant) to segregate mahangu and sorghum hectarages. On average, however, sorghum is estimated to represent around 10% of the combined mahangu-sorghum production. Sorghum yields are estimated to be similar to those of mahangu.

In the NCAs there are around 120 000 mahangu/sorghum growing households cultivating these crops on between 250 000 and 280 000 hectares (*NEWFIU*), which gives an average cultivated area of between 2 and 2.5 ha per household. However, this average hides an uneven distribution between large cultivators (say over 5 ha cropped) and very small (less than 2 ha). A limited number of communal farmers, mainly in the Mangetti area in Oshikoto and around Katjinakatji in Kavango, cultivate much larger mahangu fields and are regular surplus producers.

Table 1 overleaf gives the 'official estimates' of mahangu and sorghum grain production for the past ten years (as published by NEWFIU). The ten-year records (production years from 1990/91 to 1999/2000) give an average production of 58 300 tonnes per annum and an average yield of 230 kg per ha. The past five-year averages give an annual production of 70 900 tonnes and a yield of 250 kg per ha. However, annual production has fluctuated significantly according to the weather conditions from a low 17 200 tonnes in 1991/92 to a peak of 117 100 tonnes in 1996/97. According to these data, annual mahangu/sorghum grain production per capita in northern Namibia has varied between 20 kg and 125 kg in the past ten years.

However, these official estimates of mahangu production need to be considered with care.

« Though efforts have been made to improve the quality of these estimates, the regional aggregates may underestimate the actual levels of sown area and yield. Farm surveys indicate that the national estimates published by NEWFIU underestimate the pearl millet area per household. For example, according to Matanyaire (*1996*), the average area sown to pearl millet in northern Namibia is 3.5 ha per household. The mean for the NCRs was 3.1 ha compared with 4.1 ha for Kavango. However, NEWFIU (*1997*) estimated the national average to be only 2.1 ha per household. » (*Rohrbach & al., 1999*)

As it is generally considered that for a cereal-based diet a consumption of 120 kg of grain per annum per capita is required to cover basic nutritional requirements, it is concluded that the NCAs have on average only reached global cereal self-sufficiency in one year during the last decade (*MAWRD, 2000*).

National Mahangu and Cereal Consumption

Namibia's annual cereal consumption has averaged about 204 000 tonnes for food use in the past ten years (and over 230 000 tonnes in the last five years, due to population growth). Maize represents around half of the total cereal consumption as foodstuff, in the form of white maize. Wheat consumption, which currently accounts for 20% of cereal consumption in Namibia, is believed to be growing rapidly as the country's population becomes more urbanised (*Fowler, 1997*). Mahangu and sorghum represent on average 30% of national cereal food utilisation. Mahangu is far from meeting the total cereal consumption requirements of the country. It does not even meet the needs of northern Namibia where over half of the population lives.

Consumption is met by both domestic production and imports. In most years Namibia has to import a considerable portion of its cereal requirements for food use, on average 111 000 tonnes per year in the past ten years, and 124 000 tonnes per year in the last 5 years (see *Table 2* below and *Table 3* overleaf). South Africa is the main producer country from which white maize and wheat have been imported.

Table 2 ***Namibia's Annual Cereal Consumption as Food (1990 - 2000)***

Average	Total cereals	Maize	Mahangu/sorghum	Wheat
10 years	204 110 t 100 %	100 660 t 49 %	58 190 t 29 %	45 260 t 22 %
Last 5 years	230 660 t 100 %	111 680 t 48 %	70 620 t 31 %	48 360 t 21 %

Source: Namibian Early Warning & Food Information Unit (MAWRD)

The national average per capita consumption of grain is estimated at around 120 kg - 135 kg per annum. But it is likely that this figure is higher for the rural population in the NCAs (where the diet is cereal-based) than for the rest of the country (where the diet is more diverse). Mahangu is the preferred cereal for a large part of the NCRs and Kavango population (as well as for most people originating from these regions and residing/working in southern parts of the country).

A recent consumption survey (*Kandando & Ngwira, 1999*) on a small sample of family households in three urban centres of the NCRs and in Windhoek confirmed that more than 95% of respondents prefer mahangu to all other grain-based products. The survey results also showed that over 90% of the respondents consume mahangu in the form of stiff porridge and *Oshikundu* (non-alcoholic fermented drink), but that a large proportion of respondents also eat rice (80%), bread (78%), breakfast cereals (57%), biscuits (50%) and pasta (43%), while 70% also drink *Omalovu* (sorghum beer). The survey also revealed that 76% of the respondents consumed their own mahangu (but a majority produced less than 500 kg per year), and that the majority of respondents (69%) were spending between N$ 20 and N$ 50 per month on buying mahangu.

There has been no comprehensive food consumption survey and market research in Namibia, especially related to mahangu and other cereal products, apart from the UNAM survey mentioned above (which had a limited coverage), and consumer preference tests carried out for the launching of a new industrial mahangu flour product. This issue has been highlighted recently by a team of CIRAD consultants on a mission to Namibia (*Goli & Ndiaye, 2000*):

« It is a crucial issue to have a better knowledge of food consumption habits and trends in Namibia, especially in town, and identify the actual market (size, segments and constraints) and demand (typology of consumers, quality criteria, food preferences, price acceptability, brand image and reputation) for the different processed products. »

Households in the NCAs balance their cereal production deficit by purchasing maize meal in most years (and every year for a good proportion of them). As Keyler (*1996*) reported from his study during 1992/93 in former Ovambo and Kavango regions:

« Research findings demonstrate that few farmers are millet self-sufficient and only 10% of millet production is commercially traded. Most people in the study zone prefer millet over maize. But millet's scarcity and high price leave imported maize to dominate the commercial food market and attracts millet imports from Angola. »

Commercial maize demand in Northern Namibia depends largely on the level of the mahangu harvest of the year (and also in Caprivi on the size of the local maize harvest). Maize demand also varies during the course of the year, with peak demand usually starting in December/January and stretching to the mahangu harvest around May. In this regard, maize has always had advantages over mahangu: it has been available in a processed form (mealie meal) throughout the year in urban and rural areas, well distributed through a competitive network of wholesalers, supermarkets and small shops, and it has been sold at stable and attractive prices compared to locally available mahangu flour or even grain. In 1997, researchers estimated from commercial processing sources that the annual maize meal consumption in the NCRs over the past few years was between 15 000 and 45 000 tonnes, depending on the year (*Mallet & El Obeid, 1997*).

The national annual per capita maize meal consumption is around 65-70 kg (*NEWFIU*). In the Northern Regions expenditure on maize meal as a proportion of total expenditure is two and half times that of the whole of Namibia. The poorest half of households in northern Namibia spent around 40% of their household budget on maize meal (*Low, 1995*). Hence the importance of both imported and locally produced cereals in the Namibian food security situation at national and household levels, as stressed in a recent Discussion Paper (*Fowler, 1997*):

« Among low-income households, food consumption (both cash expenditure and consumption in kind), especially of staple grains, accounts for over 50% of total consumption: in the northern regions, the purchase of mahangu, maize and other cereals by 'low-income' households accounted for 41% of total food expenditures, while among the 'very low-income' households the figure was 46%, compared to 24% amongst the 'better-off' households. Thus changes in consumer prices of these grains have an immediate impact on the living standards, food security and nutritional status of the poorest sections of the population. »

CHAPTER 3 ON-FARM MAHANGU POST-HARVEST SYSTEMS

This chapter examines the mahangu post-harvest systems in Northern Namibia at the level of rural households. Post-harvest operations include the following steps: harvesting and drying, selecting next season's planting seeds, threshing and winnowing, transport from the field and storage (intra- and inter-seasonal), home-processing and food utilisation, and marketing (including cash sale and bartering) of part of the household stock.

It must be said that household post-harvest systems in Namibia have not been thoroughly researched and there is only fragmented literature available on the topic. The very likely intra- and inter-regional differences in the northern communal areas are also not well documented. Further research and development is required as a matter of priority for a better understanding of post-harvest constraints faced by communal farmers, so that targeted solutions can be promoted.

Harvesting and Drying

Farmers usually wait for mahangu heads to dry partially in the field before harvesting, unless the crop lodges seriously. Mahangu harvesting generally takes place around May/June, depending on the rain pattern of the year and of the region, the earliness of the variety cultivated, etc. The stem is cut with a sharp knife just beneath the head. The heads are placed in large harvesting baskets and taken away for further drying before threshing. It has also been reported that in Uukwaludhi (Omusati region) farmers generally cut the early crops at the base and stook the plants in the field before it is completely dry; the harvesting of grain heads is done at a later stage (*Matanyaire, 1998*).

Harvesting generally takes place at physiological maturity of the crop, which may not be reached uniformly amongst the plants in the field (and may require harvesting in stages). At physiological maturity, the crop still contains a high percentage of moisture and is therefore vulnerable to damage during handling and subsequent pest attack. This is why the crop is often left to dry in the field beyond physiological maturity. However, leaving the crop in the field too long may have negative consequences: higher losses to birds and other field pests, increased insect infestation, etc. Harvesting is therefore done as soon as the crop has lost enough moisture to enable safe and easy handling and before excessive field losses have taken place. The timing of harvest is a compromise made by farmers balancing crop moisture and field loss, as well as availability of labour, risk of roaming grazing animals, etc.

Straight after harvesting mahangu heads are sun-dried, most often on a raised wooden platform near the fields and with a 24-hour watch against birds and other grain-eating animals. Drying can take a few weeks (to get the grain moisture content down to 10% or so). Drying on the threshing floor has also been reported, but the use of an elevated platform has the following advantages: contamination is minimised, with proper construction they can be made rodent-proof, and in the event of an end of season rain shower crop damage is minimised by quick re-drying due to the improved aeration (*Unicef/MAWRD, 1999*).

To our knowledge, there is no report on research done in Namibia on grain drying prior to threshing and no clear account of the drying parameters (duration, moisture content curve, etc.). This had led CRIAA SA-DC consultants to recommend that drying of grain, and mahangu in particular, prior to threshing be specifically researched (*CRIAA SA-DC, 1999a & 1999c*).

Next Season's Planting Seed

Keeping seeds from selected mahangu heads for planting the next season is a small but crucial part of post-harvest systems. Farmers seem to choose the large heads from the best-looking plants in their fields. These mahangu heads are thereafter carefully stored apart from the rest of the harvest (most often in an unthreshed form) in the homestead. There is limited literature in Namibia on what criteria farmers use in their fields to select the mahangu heads they will keep as seed for the next season.

Northern communal farmers manage a mixed 'portfolio' of short and long-cycle mahangu varieties, providing them with a desirable combination for spreading risks against unpredictable weather patterns and avoiding total crop failure (*Matanyaire, 1998*). Long-cycle varieties (average of 120 days) are the traditional landrace cultivars, selected by farmers over generations to preserve desired plant types and maintain genetic diversity (or heterogeneity). The early maturing Okashana-1 (85 days), a certified seed variety with higher yield potential, has been rapidly adopted since its release in 1989. By the 1996/97 cropping season, this variety was sown on an estimated 49% of the country's mahangu area (*Rohrbach & al., 1999*).

« Some farmers sow Okashana-1 at the beginning of the rainy season in order to obtain an early harvest, at the time when household grain stocks are low or exhausted altogether. (...) However, most farmers seem to be pursuing a practice of sowing their long-duration traditional varieties first (between October and December), with the early-season rains, and sowing Okashana-1 later in January-February. This allows them to benefit from the yield advantages of their traditional varieties if rainfall is consistent through the cropping season. If the rains are late, a larger proportion of land would be sown to Okashana-1; if the rains are early, more land may be sown to traditional varieties. » (*Rohrbach & al., 1999*)

However, as Matanyaire (*1998*) pointed out:

« (...) farmers had no intention of replacing all the landraces with Okashana-1. These findings provide clear signals farmers are more concerned about stable system productivity as opposed to yield maximisation, and that they recognise genetic diversity as a viable option. »

A study of Namibia's present and future requirements for seeds (*Balogun & Tripp, 1997*) mentioned that because it is difficult for farmers to maintain the genetic purity of short-duration mahangu varieties, the annual commercial demand for certified seeds (such as Okashana-1) can be expected to be maintained over the years. Farmers generally cultivate plots with a mixture of several varieties of mahangu (an open-pollinated crop), which may all flower at the same time:

« Such a crop management is not conducive to maintaining varietal purity of short duration varieties. The problem of maintaining short-duration varieties is further exacerbated by the practice of selecting large heads for seeds. Large heads are associated with long season length so farmers actually select against the main characteristic they value in Okashana-1. »

Two additional early maturing mahangu varieties, Kangara and Okashana-2, were released in April 1998 (*Rohrbach & al., 1999*). Together with Okashana-1 (and a new white sorghum variety, Macia), these varieties are multiplied and sold as certified seeds by the Northern Namibia Farmers Seed Growers Co-operative (NNFSGC), based in Mahenene. This means that northern communal farmers have access to a range of short-season varieties on the market, although Okashana-2 and Kangara germplasms are close to Okashana-1 (*Ipinge, 2000*) but with some different traits (see below), and that farmers will continue their own seed selection in the field, based on phenotypic characteristics.

Farmers' perceptions of the qualities and weaknesses of the improved mahangu varieties were assessed by agricultural researchers (*KFSRE, 1997*; *Rohrbach & al., 1999*; *Mukundu* in *MAWRD, 1999c*). When farmers were asked about the main reasons for their interest in Okashana-1, the most common response was its early maturity, followed by grain yield and grain size.

« Farmers perceive, at least, that this variety [Okashana-1] is more resistant to the range of different types of drought they commonly face - short seasons, limited rainfall, and mid-season dry spells » (*Rohrbach & al., 1999*)

Farmers have cited three main weaknesses of Okashana-1 compared to local varieties. The greatest problem is the weak stem, which causes plants to lodge at the end of the season (and reduces its value as building and fencing material). The second problem is the low stover yield (as livestock feed during the dry season). The third problem is the softness of the grain (which reduces its storability). Additional complaints are cited: the grey flour, which turns darker when cooked in porridge, and the tendency of the grain to shatter (the pericarp breaks into small pieces that are difficult to winnow) during dehulling (*Rohrbach & al., 1999)*. Farmers have, however, commented that Okashana-1 and -2 are easier to thresh (*KFSRE, 1997*; *Mukundu* in *MAWRD, 1999c*).

Farmers' ranking of grain traits compared to the local variety was summarised in *Rohrbach & al.* (*1999*) and is reproduced in *Table 4* below.

Table 4. Farmers' ranking of grain traits compared to the local variety (1993)

Trait	**Okashana-1**	**Kangara**
Grain size	Better: 90%; same: 10%; worse: 0%	Better: 70%; same: 30%; worse: 0%
Grain colour	Better: 20%; same: 30%; worse: 50%	Better: 80%; same: 20%; worse: 0%
Dehulling quality	Better: 100%; same: 0%; worse: 0%	Better: 100%; same: 0%; worse: 0%
Grinding quality	Better: 0%; same: 0%; worse: 100%	Better: 100%; same: 0%; worse: 0%
Food preparation	Better: 100%; same: 0%; worse: 0%	Better: 100%; same: 0%; worse: 0%
Taste	Better: 20%; same: 40%; worse: 40%	Better: 0%; same: 100%; worse: 0%

Source: Ipinge & al. (in ICRISAT, 1996).

Threshing and Winnowing
Threshing is the detachment of kernels from the rest of the head (or panicle). For

mahangu it also involves removing the chaff, which is carried out by winnowing, to obtain a clean grain. Threshing is very important in the small-holder post-harvest operations for on-farm grain storage and marketing. Properly threshed and cleaned grain is also critical to the trading and processing sector. Threshing is very often a work bottleneck in the small-holder farming calendar. Mechanisation of threshing is considered important not only for alleviating these time and work constraints, but also to reduce post-harvest grain infestation by pests, as well as grain contamination by sand, dust and micro-organisms.

To our knowledge, there has been no comprehensive study of mahangu (and other cereals) threshing in northern Namibia. The following paragraphs are an attempt to summarise what is known about it and what has been done to promote improved methods.

Pre-storage threshing

In northern Namibia, cereals and mahangu in particular are stored in grain form at the homestead. Threshing is therefore done before storage of the crop. Threshing is most often carried out in or near the crop fields at the drying place, which is often enclosed with wooden poles and/or thorny bush branches. Straight after threshing, the grain is brought to the homestead for storing.

Depending on when the rain stops and how long harvesting-drying requires, threshing generally starts around June. It can last until July/August in a bad harvest year, but it can continue into September/October in an especially good year when mechanised threshing is not available and labour is scarce. Manual threshing and winnowing are typically the work of household women, but men and children often join the family working team. It is also not uncommon that labour is hired to speed up the threshing operation.

There is limited data accounting for the time required by manual threshing (and other post-harvest operations) in the overall mahangu crop production of northern communal farmers. Studies account for labour time required per hectare for ploughing, planting, weeding and harvesting/threshing, but it is never clear what exact operations are included in the latter.

Although labour requirements are unclear in non-mechanised mahangu crop production systems, post-harvest operations and threshing in particular are considered work bottlenecks in a year of above-average harvest. This is so because threshing is labour intensive and competes with other on-farm and off-farm activities, and above all because it is desirable to bring back the threshed grain to the homestead as soon as possible to minimise the risk of loss and relieve scarce labour from guarding the unthreshed crop.

The different methods of threshing used in the Northern Communal Areas

The ‘traditional’ way to thresh is by using wooden sticks to beat the mahangu heads on the ground. In the NCRs, the heavy pounding pole (pestle), fitted with a cylindrical wooden piece at the end, is inverted and used for threshing. Otherwise, a straight wooden stick or pole is used. There are no accounts of flails or improved threshing frames being used. Mahangu heads are beaten directly on hardened and cleaned ground, sometimes on a compacted soil platform, or on a tarpaulin, or in a bag. Winnowing is carried out thereafter with special flat baskets, but also with other types of containers such as plastic dishes and galvanised basins, assisted by the breeze.

Dendy (*1993*) reported that the productivity of manual mahangu threshing (including winnowing) measured in Kavango (using light poles) was 5 to 10 kg of threshed grain per women-hour (5 to 10 women-hours per 50 kg bag). On three runs, the average 'out-turn' (weight of grain/weight of mahangu heads) was 77% (ranging from 70% to 83%). Winnowing represented between 34% and 40% of the total woman-time of threshing. Similar rates, ranging between 4.5 kg and 11 kg/hour, were observed for mahangu in Caprivi (*CRIAA, 1996*).

'Tractor treading' is another method used. Panicles are gathered on the ground in a ring or a heap over which a tractor runs. The rolling tractor tyres execute the threshing operation (to avoid breaking the grain, tyres are deflated or lighter tractors are used). People stand around the heap and push back the mahangu heads drawn aside. Winnowing must be carried out thereafter (*CRIAA SA-DC, 1999a*). This method seems to be used much more, especially in the NCRs, than one would have thought. A tractor service consultancy (*NRC, 1998*) mentioned that 82% of the tractor entrepreneurs interviewed in the NCRs (97 in total) provided this form of threshing service. Farmers were charged per heap, but unfortunately no estimate of the weight of a heap was provided. The performance of threshing by tractor trampling is not known and should be studied.

Manual or tractor threshing of mahangu heads directly on the ground results in sand (and dust) contamination of the grain. It is not easy to subsequently separate the sand from the grain and this has serious implications for commercial processing requirements. The advantage of mechanical threshers, beyond the increased productivity of operation, is that they have an in-built winnowing system, and discharge the clean grain directly to bags or baskets.

Mechanical threshing appears to be mainly performed on a service basis by urban and rural entrepreneurs, who are farmers themselves. There are two models of mahangu thresher most commonly used (*CRIAA SA-DC, 1999a*):

The ROVIC mahangu thresher is so far the only locally manufactured machine. It is a relatively light thresher run by a 3 hp petrol engine, which can be transported on a pick-up vehicle, or on a cart or a sledge. The manufacturer indicates a capacity of 400 kg per hour (confirmed by *Dendy, 1993*, on two runs of 10 minutes) but field data on longer periods of use suggest a lower throughput around 100 kg to 200 kg of threshed grain per hour. Some other technical performance and limitations have been reported, but because it is the only portable thresher manufactured and available in Namibia, its use has been spreading in the NCAs.

The much larger tractor-PTO driven thresher mounted on four wheels, with a capacity of around 1 tonne per hour, is better suited to farms with large mahangu fields and large harvests. These machines were originally designed for maize shelling and are converted to mahangu threshing with some adaptations, particularly by substituting a drum with smaller perforations. All these threshers are second-hand machines, imported from South Africa by local farm equipment dealers (who recondition and adapt them).

A technical field assessment of these two threshers has been recommended (*CRIAA SA-DC, 1999a & 1999c*).

Economic overview of threshing

It is not known what proportion of the annual mahangu harvest is threshed according to which method and how many farmers use which threshing technology. It is also not known how many mechanical threshers (and what models) are in operation in the northern communal areas. It is therefore impossible to accurately evaluate the present economic importance of mechanical threshing versus manual and tractor treading threshing. A hypothetical economic calculation was, however, attempted and it is presented in *Box 1* below (*CRIAA SA-DC, 1999a*).

Box 1 Economic Overview of Mahangu Threshing in NCAs

We consider that roughly 25 % of the mahangu harvest is mechanically threshed and we arbitrarily set a future target for mechanical threshing of 75 % of the national mahangu harvest. With this optimistic target, we assume the following:

- The annual total mahangu harvest is between 25 000 t and 100 000 t depending on the year, and the corresponding mechanical threshing targets are 18 750 t and 75 000 t;
- In bad years, threshing lasts 1 month (25 working days) and in good years, 4 months (100 working days);
- The Rovic machine threshes an average of 1 t per day (25 t per month, 100 t per 4 months);
- The PTO-driven machine threshes an average of 8 t per day (200t /month, 800 t /4 months);
- There will be one PTO thresher for eight Rovic machines.

With this target, the future need of threshing equipment in working order will be 374 Rovic threshers and 47 PTO-driven machines, representing an investment cost of some N$ 2 million. At an average threshing charge of N$ 100 per tonne (a low N$ 5 per 50 kg bag), the annual turnover of the threshing industry (covering 75% of the needs) could reach between N$ 1.87 million and N$ 7.5 million, depending on the year. With this mechanical threshing target of 75 % of the mahangu harvest as compared to 25 % estimated for the present, manual threshing time savings (at an average rate of 100 kg per work-day) would represent between 125 000 and 500 000 work-days per annum, which is considerable. In monetary terms, with a work-day valued at N$ 15, the time saved by the further mechanisation of threshing would represent a value of between N$ 1.9 million and N$ 7.5 million per year.

Legitimate concerns have been raised about the socio-economic impact of mahangu threshing mechanisation on manual work opportunities for low income people and especially women in a rural economy with limited job opportunities. Experience elsewhere in Africa shows that, on the contrary, the time freed by mechanisation is used for other cash generating activities. However, in the NCRs rural economy where the opportunity cost of labour is relatively low, manual threshing and mechanised threshing have a good chance to co-exist.

- At an opportunity cost of N$ 15 per day, manual threshing costs N$ 150 per tonne representing 15 % of the price of mahangu grain (for a market value of N$ 1 000 /t), which is very high;
- At N$ 10 per day, manual threshing costs N$ 100 per tonne, which could be at par with mechanised threshing service charges;

- At N$ 5 per day (N$ 50 /t), manual threshing would out-compete mechanical threshing on price;

It has been generally considered that mechanised threshing costs should be kept below 10 % of the market price of grain. It is concluded here that mechanised threshing would expand if its cost remains around or below 10% of the market price of grain, which would require efficient machinery and good management of threshing services.

In view of the limited range of threshing models available, the operational constraints experienced by farmers, threshing service entrepreneurs, traders and processors, and a lack of precise data on most technical and economic aspects of threshing, specific research in the form of a baseline survey was recommended to take place as soon as possible during the forthcoming threshing season.

Terms of reference were drafted (*CRIAA SA-DC, 1999a*) and comprised the following elements:

Technical field assessment of the different methods of drying and threshing in the NCAs;

Technological search for appropriate threshing (winnowing and pre-cleaning) technologies from the SADC region and elsewhere, to be imported or possibly locally manufactured (locally adapted or at least locally assembled);

Financial and operational assessment of service threshing in NCAs;

Defining a promotion strategy for improved mechanical threshing in NCAs.

On-Farm Storage

In a rain-fed cropping system based on one annual production cycle over a short rainy season, the harvest obviously needs to be stored for household consumption through the year. When rain patterns are unpredictable and 'droughts' can occur on a recurrent basis, as in northern Namibia, inter-annual storage of the staple cereal is a requirement for household food security.

From his field survey conducted in 1992/93 in the North Central and Kavango regions, Keyler (*1996*) reported on the effect that fear of drought had on household mahangu reserve levels (and decisions to market surplus). On average, farmers' fear in the NCRs translated into 'almost unrealistic' mahangu reserve targets of between 4 and 6½ years, meaning that household reserves had priority over commercial sales. Kavango households that never or only rarely sold millet preferred to have, on average, mahangu reserves that last 2 years. Kavango households that sold mahangu every year perceived a need to set their reserves at, on average, 3½ years.

Matanyaire (*undated*) confirmed the regional differences between the NCRs and Kavango in the way farmers managed their inter-annual mahangu reserves. The proportion of households opting for storing their mahangu in excess of annual food requirements was higher in the NCRs (81%) than in Kavango (54%). The majority of households (65%) also indicated that mahangu could be stored without losing 'food quality' for three or more years.

Northern communal farmers store threshed grain either in granaries in the homestead, or inside the home in different types of containers (bags, baskets, drums ...). Compared to the North Central Regions, traditional mahangu storage is much less documented in Caprivi and Kavango, where a variety of storage containers and structures are used, including granaries made of earth blocks or poles and mud, raised on a low platform and roofed with thatch.

« In a field study, Keyler (*1995*) revealed that in the NCRs 90% of the households stored their pearl millet grain in traditional storage baskets, while in Kavango the largest group (29%) kept it in jute or polypropylene bags, 21% used sealed drums and another 19% kept the bulk grain in storage huts. » (*Matanyaire, 1998*)

In the North Central Regions, the traditional granary consists of a large spherical woven 'basket' (or 'bin') made of Mopane (*Colophospermun mopane*) branches and interlaced with strips of Mopane bark. The interior of the bin is sealed with a light coat of 'mud', which is often made of termite hill soil mixed with water. The bin has a circular opening on top, through which the grain is loaded and removed, and is closed with a lid (which can be sealed with mud). The bin is raised on a wooden-legged circular cradle. A thatched roof, under which the bin is placed, is the last part of the granary. Bins vary in size from 0.3 m³ (holding approximately 250 kg of grain) to over 2 m diameter structures (*NRI, 1997*), that is around 4 m³, holding over 3 tonnes of grain.

There is anecdotal evidence in the North Central regions of innovative grain storage containers being made by farmers: small concrete 'silos' (similar to a water reservoir) and thick baskets with lids made of Makalani palm leaves (*Hyphaene petersiana*).

In the Shambyu area of Kavango (Mupapama river terrace community), two types of granary have been reported and photographed (*Eirola & Bradley, 1990*). The first type is made of poles and plastered with clay, raised on a wooden platform (some 60 cm above the ground) and thatched like a traditional hut. A small entrance leads to the inside. These granaries are located outside the homestead enclosure. The second type consists of large grain 'baskets' made of split river reeds (as sleeping mats are made), raised on a wooden floor and covered by a thatch roof. These storage baskets vary in size with an average capacity of about 400 kg of grain. They are located inside the homestead. In the same area, a variant of the first type was captured on a picture (*Yaron & al, 1992*). The inside of the granary has two compartments, which are accessed from two small openings in the wall. There is no clear account on the 'ownership' and management of household grain reserves, apart of the following report from Kavango:

« Just as the husband and wife or wives have their own fields, they also have their own mahangu storage places. The wife's or wives' mahangu supplies are used first and only then the husband's. » (*Eirola & Bradley, 1990*)

Households of the NCRs own one or more granaries according to the size of their fields and quantity of mahangu produced. When a family has only one granary, it is filled with the last harvest. If grain from the preceding year remains, it is placed on top of the new grain or placed in another container. But if a family has several granaries, the different harvests are kept separate. If stored mahangu had not been completely consumed by the time of the new harvest, families most often prefer to finish the old harvest stock, because new grain is much harder to pound (*Labetoulle, 2000*).

Farmers in both North Central and Kavango regions reported varying degrees of storage losses (*Keyler, 1996; Matanyaire, 1998*). As Hindmarsh (*2000*) noted:

« On-farm storage losses for mahangu appear to be unusually high due to practise of storing the grain threshed and retaining surpluses on farm to provide about two years' supplies. Since the oldest crop is eaten first, insect infestations have two years to develop in storage. »

Nevertheless, a third of Kavango farmers and 82% of NCRs farmers were taking measures against insect infestations in their grain, roughly 12% of farmers in both zones were using chemical insecticides, while the rest of the farmers were using traditional methods like ash or leaves (*Keyler, 1996*). These traditional methods are not well documented. Mopane wood ash seems to be the most commonly used. The ash is put in layers in the grain when the granary or the container is loaded, or the ash is spread at the top on the grain when flying insects appear.

The most significant mahangu storage pest causing losses is reported to be *Corcyra cephalonica*.

« These moth infestations result in masses of grain held together by webbing (silk) produced by the larvae as they move through the grain seeking a pupation site. Many individual grains have their embryos removed by the feeding larvae. In order to use the grain, they have to be rubbed and sieved to remove the webbing, or alternatively the masses of clumped grain are fed to chickens. » (*NRI, 1997*)

On-farm physical losses in grain weight have not been assessed, but were crudely estimated to range from 10% after one storage year to more than 30% over longer storage periods (*NRI, 1997*). Farmers, especially in the NCRs, have complained about the poor storability of the improved varieties, such as Okashana-1 (*Matanyaire, 1998*). Grains with large, soft endosperms and thinner pericarps - characteristics of the improved varieties released in Namibia - are more susceptible to insect damage (especially by feeding moth caterpillars) than the small, hard landrace types.

On-station trials conducted during the 1999-2000 storage period by the FSRE Unit in collaboration

with NRI proved that infestations by the moth *Corcyra cephalonica* actually started in the field before the grain was brought to storage. It was concluded (*Hindmarsh, 2000*):

« Physical barriers surrounding the content of the storage container are not effective, since infestations are active on the grain before storage. We can assume that the infestation would not have been localised at the surface when the bins were filled (because of thorough mixing of samples). Therefore, it is safe to conclude that *C. cephalonica* larvae migrate vertically to the surface of the grain bulk to pupate. Discussions between researchers and farmers invited to the initial opening of the containers led to the proposal that a layer of wood ash placed near the top of the grain bulk would intercept migrating larvae and could prevent pupation and emergence as sexually active adults. (...) Such a treatment [wood ash] could be cheap and very effective, and it is likely to be acceptable to farmers. Sieving and washing to remove ash residues are normal practice for households before the grain is pounded into a meal. »

The price of Mopane storage baskets has become relatively high and a shortage of local materials to build them has been reported. NRI (*1997*) recommended developing, testing and promoting cheaper and improved on-farm storage structures, galvanised iron bins, fibreglass and plastic containers, which had proved viable in other countries. This was also recommended by Hindmarsh (*2000*). The Rural Development Centre (RDC) in Ongwediva has embarked on manufacturing and selling storage containers made of corrugated metal sheets. The RDC recently reported having sold 68 units over the past three years or so (*F. Msati, pers. comm.*), but in the absence of field monitoring it is not possible to assess the impact of this technology on household grain storage.

Household Food Processing
The presentation below distinguishes between primary processing - processing of the whole grain into a consumable product to be cooked - and secondary processing, which refers to further processing and/or food preparation. It is by no means a comprehensive presentation. It ignores inter- and intra-regional differences and the diversity of individual recipes at households level. It can be taken, however, as a summarised account of the 'traditional way' in food processing, with a special focus on the North Central Regions, which has been documented more extensively (especially in *Labetoulle, 2000*).

Mahangu primary processing
Mahangu grain is processed into flour in two stages: first dehulling, then pounding into flour (pulverising or size reduction). In northern Namibia, mahangu processing is mainly done manually, using wooden mortar and pestle. Dehulling separates the bran, consisting of the outside envelopes (pericarp, testa ...) and a portion of the germ, from the endosperm (mainly consisting of starch). The average composition of pearl millet grain is shown in *Table 5* below.

Table 5. Average composition of pearl millet grains (percentage of total weight)

	Large grain	**Medium grain**	**Small grain**
Whole grain	100	100	100
Endosperm	76,0	75,0	74,0
Germ	17,0	17,5	15,5
Pericarp	7,0	7,5	10,5

Adapted from Abrasive-Disk Dehullers in Africa (1989)

Millet and sorghum contain nutritional inhibitors, the level of which has to be reduced before consumption. The presence of polyphenols (or tannins) gives the grain its bitter taste and reduces its digestibility. In the field, the bitterness makes the grain less attractive to birds and reduces pre-harvest losses. Phytic acid is also found in millet and sorghum grain, mainly in the aleurone layer (a thin layer rich in protein and fat found between the endosperm and the pericarp). Phytic acid has anti-nutritional effects on minerals and affects the digestibility of proteins and starch. It can be reduced significantly by dehulling.

Tannin and phytic acid bind minerals and proteins, preventing absorption into the body:

« To reduce the undesirable tastes due to the presence of polyphenols in sorghum and millet, the rural housewife dehulls the grains and often allows the processed product to ferment. These processing techniques - dehulling and fermentation - lower the polyphenol levels in the grains, In other cases, however, where grains with high polyphenol levels are unacceptable for food preparation, they are fermented into beer. (...) Phytic acid forms insoluble compounds (phytates) with such mineral elements as calcium, iron, magnesium, sodium, and zinc, making them unavailable for use by humans. Phytic acid can also combine strongly with proteins at certain pH levels. » (*Bassey & Schmidt, 1989*)

Grain dehulling, by separating the endosperm from the outer envelopes:

Reduces the fibre content and improves the taste, texture and nutritional value of the finished product;

Removes the bitterness (tannins) that is found mainly in the pericarp and the testa, the layer situated immediately below the pericarp.

Both dehulling and pounding into flour can be mechanised and different models of machines exist. However, their use by rural families is not widespread in northern Namibia. To our knowledge there is no hand-operated grain grinding machine being used at household level in the NCAs. Rural families use mechanised service mills when they have cash available and especially when there is too much work in the fields, and if the mills are not located too far away. When women bring their mahangu grain to a service mill, it is in the form of home-dehulled grain, which has very often been soaked and fermented, and is still wet. Milling of wet materials has technical and economic implications for mills with equipment designed to process dry cereal (see next Chapter).

Dendy (*1993*) reported that Okashana-1 as compared to local mahangu varieties has the following processing features:

It is easier to dehull (due to slightly looser hull);
It is harder to pound;
It takes longer to soak (to soften the grain before pounding);
Overall, it takes longer to process into meal and the out-turn is lower.

The comparative physical characteristics of Okashana-1 compared with different traditional varieties are provided in *Table 6* below.

Table 6. Physical characteristics of Okashana-1 and local mahangu varieties (Kavango)

	Okashana 1	**Large grain (local)**	**Small grain (local)**
Bulk density	1 250 ml /kg	1 225 ml / kg	1 333 ml / kg
Thousand grain weight	11.2 ± 0.5 g	9.4 ± 1.8 g	4.5 ± 0.2 g

Source: Dendy, 1993

Okashana-1 and the recently released mahangu varieties had the following characteristics (*MAWRD, 1998; Rohrbach, 2000*):

Okashana-1: large grain, grey to grey-yellow in colour, milling yield of 81.4% - 86.2%;

Okashana-2 (Kakunya): medium panicle length (18-25 cm), large grain (13.3 g per 1000 grain weight), grey to dark grey in colour, milling yield of 82.3% - 93.4%;

Kangara: medium panicle length (16-22 cm), large grain (over 12 g per 1000 grain weight), cream yellow in colour, milling yield of 84.5% - 92.0%.

Measurements of hand-pounding rates in Kavango (*Dendy, 1993*) showed that in household preparation of meals, production is only 700 g/women-hour for local mahangu varieties and 600 g for Okashana (see *Table 7*). The household out-turn of meal is about 50%, much lower than for machine milling:

« A surprising conclusion from these results is the measurement of the loss as bran and 'middlings'. The bran [envelops and part of the germ] makes up approximately 15% by weight of the grain. By hand-pounding, some 30% of the endosperm (that part which is desired for food and is around 80%-90% of a grain) is being "lost" in the bran. This is used for brewing and, eventually, as feed. However, in terms of food value, this is a very high loss compared to the optimum machine out-turns of over 80% - i.e. 20% bran. »

Table 7. Comparison of Okashana-1 with local variety by hand-pounding (on 6 runs)

	Okashana 1	Local variety
Stage 1: dehulling (woman mn / kg grain)	19.4	20.6
Stage 2: pounding to meal (woman mn / kg grain)	29.1	21.7
% dehulled % meal obtained	72.0 49.1	72.8 54.6
Rate of production: kg meal / woman-hour	0.60	0.70

Source: Dendy, 1993

The above dehulling productivity of around 3 kg per hour seems low compared to the operations seen at Kamalanga's Mill in Kavango, where women were manually dehulling Okashana-1 grain (piece-work for cash) at a rate of 6 kg to 9.5 kg per hour, over a 9 hour work-day (*CRIAA SA-DC, 1999a*). The overall hand-pounding productivity of around 0.6 - 0.7 kg of meal per hour seems also low compared to the figures provided below, but could be explained by the high level of loss in the bran reported by Dendy.

Field survey reports suggest that families do not prepare mahangu flour every day, but rather once, twice, or thrice a week (or sometimes more). The frequency depends on the season (agricultural calendar), on the availability of home reserves of mahangu, and on the number of persons at home (*Kroll, 1991; Pitois & Helmstetter, 1996; Labetoulle, 2000*).

In Uukwaluudhi (Omusati region), Kroll (*1991*) reported a processing rate of 8 kg of mahangu grain per hour involving 3 women (that is around 2.7 kg per woman-hour). For an average family size of 9 (4 adults and 5 children), 3 women were each working close to 13 hours per week on mahangu processing (a total of 39 women-hours per week). The average mahangu grain consumption was 37 kg per week, equivalent to 4 kg per person per week, and to 570 g per person per day. Pitois & Helmstetter (*1996*) reported very similar processing and consumption figures in Onamutanda (Ohangwena region). These data would translate into an annual consumption of over 200 kg of mahangu grain per capita, which is much above the figures given by the national consumption statistics (110 kg - 135 kg of cereals). It is plausible that the level of loss in manual processing, as reported by Dendy, would explain the difference, i.e. an annual consumption of some 200 kg of grain represents an actual consumption of about half in flour form. But the national statistics on mahangu and other grain utilisation might be underestimated, which would concur with the opinion that national production statistics are also underestimated, as presented in the previous chapter.

It is nevertheless clear that hand-pounding mahangu is one of the major burdens of women in rural areas. In Onamutanda, it was reported was 44% of surveyed households were hiring people to pound their mahangu and the average payment was around N$ 3.00 per lata (or N$ 0.20 per kg) in 1995 (*Pitois & Helmstetter, 1996*).

The traditional preparation of mahangu flour follows a number of steps, which lengthens the process and would make it difficult to mechanise entirely. The traditional slightly fermented mahangu flour is, however, the product that receives overwhelming preference from mahangu consumers. The main steps, from the whole grain to the final flour (or meal) ready to be cooked, are presented in *Table 8* below with their respective by-products.

Table 8. Traditional Preparation of Mahangu Flour

Processing step	Method/tools	Product	By-product	Use of by-product
1. Winnowing and screening grain	Flat winnowing basket and by hand	Clean whole grain	Foreign matter + badly damaged grain, insects and webbing	Waste + poultry feed
2. Dehulling	Wetted grain pounded in mortar, then dried and winnowed	Dehulled grain	Yellowish bran + pounding loss and winnowing dust	Traditional drinks + poultry feed
3. Fermenting	Soaking in water (few hours to 1 day) + already fermented pounded grain added as starter (*from 5.*), then trickled and sun-dried	Fermented dehulled grain (whiter and tastier)	Waste liquid	Thrown away or given to pigs (other use?)
4. First pounding into flour + sieving	Mortar and pestle + hand sieve	First white flour + grits to be pounded again	Pounding loss	Poultry feed
5. Second pounding + sieving	Mortar and pestle + hand sieve	Second white flour and some partly pounded grain kept for next day(s) fermenting (*to 3.*)	Pounding loss + remaining bran and germs	Poultry feed
6. Drying of flour	In flat basket or on cloth in the sun	Dried fermented flour to be cooked or stored (few days)	(Loss by wind)	

Source: Mallet M. & Amutse F. (CRIAA SA-DC, unpublished)

Soaking and fermentation of grain before final grinding to flour is a traditional practice to improve digestibility and nutritional value of grain products, improve taste and texture and to extend the shelf life of flour:

« Soaking is the initial step of malting and fermentation. The common time of soaking grain is 24-48 hours in lukewarm water in traditional food processing. Soaking of grain in water for 24 hours before milling is enough to increase the amount of soluble iron up to 10 times. During the time of soaking, the lactic acid fermentation is developing and the pH drops. (...) The changes occurring during the fermentation process are mainly due to enzymatic activity brought about by the micro-organisms (yeast and bacteria) and/or the indigenous enzymes in the grain. The two major types of bacteria in cereal fermentation are lactic acid- and acetic acid-producing bacteria. The micro-organisms involved in natural fermentation of cereals are essentially the surface flora of the seeds. During fermentation the pH drops from about 6.5 to 3.6. This effectively inhibits the growth of other bacteria that cause decomposition and food spoilage. They will also have a strong inhibitional effect on diarrhoea-causing pathogens (...). Lactic bacteria are reported to contain proteolytic activity capable of degrading more complex proteins into simple proteins, peptides and amino acids. This might explain the favourable effect on protein digestibility found after lactic fermentation of cereal grains. Fermentation of cereals inhibits the negative effects of phytic acids and tannin. It is evident that fermentation is an effective and low-cost method of preventing/reducing diseases caused by deficiency of important nutrients in regions where cereals form a major part of the diet. » (*Jonsson & al., 1994*)

Mahangu secondary processing and food preparation

Mahangu is mainly consumed in stiff porridge and fermented drinks, but there are other food preparations, which have been documented for the North Central Regions (*Labetoulle, 2000*).

In summary these basic food preparations are as follows (with their Oshindonga names in italic):

Stiff porridge (*Oshithima* or *Oshifima* in Oshikwanyama): mahangu flour cooked in water.

Pancakes or unleavened bread ('Owambo bread', *Oshikwiila*): mahangu flour mixed with water and seasoned with salt and/or sugar, moulded in large flattened balls, are either pan-fried, roasted on coals or boiled in water (the balls being put in plastic bags).

Uncooked flour mixed with sour milk (*Olumbololo*).
Boiled grain, most often dehulled (*Onona*).
Thin porridge or gruel (*Etete*): prepared the same way as the stiff porridge with less flour.
It must be noted that rolled products, such as "couscous", are not traditional in Namibia.

Mahangu (and sorghum) form part of the composition of various traditional fermented beverages. Sorghum is used in malted flour form, while mahangu is very rarely malted in the NCRs. These home-prepared drinks are very popular in North Central Namibia and are consumed by a large part of the population. These are:

Ontaku (or *Oshikundu* in Oshikwanyama): a non-alcoholic fermented drink (lactic fermentation) made from malted red sorghum flour, mahangu bran and mahangu flour. This drink maintains an important place is the diet of the NCRs population, where it is consumed daily by adults and children alike.

The opaque beer (*Omalovu*) made from malted red sorghum flour and mahangu flour.

In addition, the traditional *Tombo* (made of malted red sorghum and brown sugar) and

Epwaka (made of mahangu bran and brown sugar) are much more fermented and alcoholic drinks, which are either prepared for special social occasions or marketed in 'Cuca shops'.

Malting is a process during which the whole grain is soaked and then germinated:

« During this process a number of enzymes including phytases are activated provided the pH is kept within 4.5-5.5. At this pH level, ground malted cereals will have almost all phytic acid degraded. (...) Germination, the start of the growth of the seed to a plant, releases other enzymes from the germ in addition to phytase. The germinated grain is called malt and is rich in enzymes breaking down the starchy, white part of the grain to sugar. If yeast is present, either by addition or native in the grain, then water is added to the ground malt and the sugar will break down to alcohol. This is the principle of beer making (...). Ground malt which contains the enzyme amylase is also used in porridge to increase nutritional value of baby food by increasing the actual nutrition per spoonful and to make desirable and healthy drinks (...). » (*Jonsson & al., 1994*)

In the NCRs, mahangu is generally used as the main ingredient in weaning foods, most often in a specially prepared *Ontaku*, or in a thin porridge (with or without sour milk and possibly sweetened with sugar) (*Labetoulle, 2000*).

As most rural households in the NCAs are not self-sufficient in mahangu, maize meal is purchased and consumed in porridge either as a substitute for mahangu or mixed with it. Some families prefer to buy mahangu grain rather than maize meal, and some others buy maize meal even when their mahangu grain stock is sufficient, to save time and labour (*Labetoulle, 2000*).

Rohrbach (*ICRISAT, 1995*) reported on a survey (from the Namibia Millet Subsector Project) on households grain buying in December 1992 (seven months after the 1992 harvest in a severe drought year), which gives indications of the importance of maize purchase. The two tables are reproduced below.

Table 9. Proportion of households buying grain, Dec. 1992

Regions	Buying grain	Buying mahangu grain	Buying mahangu meal	Buying maize grain	Buying maize meal
NCRs	73.0%	12.5%	6.0%	14.0%	56.5%
Kavango	83.3%	39.2%	13.4%	24.2%	66.7%

Source: ICRISAT, 1995

Table 10. Proportion of grain purchased, Dec. 1992

Regions	Mahangu grain	Mahangu meal	Maize grain	Maize meal	Sorghum grain
NCRs	12.8%	4.4%	16.8%	64.2%	1.7%
Kavango	28.1%	5.0%	12.1%	52.6%	2.0%

Source: ICRISAT, 1995

Because the price of maize meal generally compared well with the cost of mahangu grain plus milling service, it was concluded that poorer households tended to rely on maize meal to resolve their production deficits in both good and poor years. Only wealthier wage earners were willing to pay the premium price for mahangu (*Rohrbach & al., 1999*).

Household Grain Marketing

Since the study carried out by Stefan Keyler during the 1992/93 production year, there has been very limited field-work conducted on mahangu marketing at household level. Some significant results from Keyler's work are recalled below and are assumed to still be relevant to the present situation. It is not clear what significant socio-economic changes may have happened at household level since then, and how commercial mahangu milling and marketing facilitation intervention may have impacted on mahangu grain supply from farmers in the NCAs.

Keyler (in *ICRISAT, 1995*) estimated the volume of Namibian mahangu traded in 1993 at 7 200 tonnes (excluding 1 700 t imported from Angola), virtually all in unprocessed form. It was further noted that older grain surpluses were offered to the market only when the new harvest arrived and storage containers became scarce. The main reason for selling mahangu was given as the urgent need for money and goods. A large proportion of households only sold mahangu after a good harvest. Most of it is sold within village areas. After neighbours, the next largest category of buyer was travelling traders. Only a small proportion was traded through markets.

« The most important finding about millet marketing on the household level is that about 70% of farmers in Ovambo (and 28% in Kavango) never sell millet, while the remaining sell millet only in small quantities every other year. Most of the farmers that market millet sell it informally to their neighbour. » (*Keyler, 1996*)

Keyler further discussed mahangu selling limitations (in *ICRISAT, 1995*):

« The majority of rural households indicated that their millet trade is mainly limited by the amount of grain they produced and the fear of drought. However, marketing constraints were additionally mentioned by those households that sold millet every year or at least in some years. Larger portions of millet selling households of both study zones [NCRs and Kavango] mentioned long trading distances, the lack of transport, and high cost of hired transport also as limiting factors. In Kavango the lack of local markets was an important constraint among those households that sold millet every year. »

Sullivan (in *ICRISAT, 1995*) summarised the situation as it was understood at the time. It is very likely that it still applies to the present situation.

« The small quantities coming on the local markets do not necessarily come from farmers producing surpluses, but rather from producers with an immediate requirement for cash for the purchase of consumer goods or school fees etc. The millet sold is substituted for, at a later stage mainly, with maize meal as the product most readily available. (...) A relatively small number of farmers, perhaps no more than 3 to 4%, produce a surplus of millet for sale. Even in good growing seasons such surpluses range up to 5 tonnes while a few farmers produce up to 25 tonnes or more. These farmers are at the forefront in demanding a formal market for their crop. »

Disposing of mahangu grain in small quantity to traders, relatives or neighbours - for cash, as gift or in barter - is still common in the NCAs. In a study of four villages in the

NCRs (*Labetoulle, 2000*), it was reported that bartering was widely used to procure foodstuffs. Mahangu grain was the principal means of exchange, followed by sorghum and other agricultural produce. The most common barter transactions were mahangu for meat or fish, and mahangu for animal fat or clothes.

Concluding Remarks

On-farm mahangu post-harvest practices are extremely important for household food security of the rural population in northern Namibia. Mahangu post-harvest issues are also critical to the development of a mahangu commercial sector, as the mahangu surplus that is traded mainly originates from rural households (although only a small proportion of them market mahangu regularly). Improving the quality of grain stored on-farm is important for the trading and processing industry, which has very often complained about the unsuitable quality of mahangu grain marketed by farmers.

As we have seen in this chapter, a number of issues are not well documented and warrant further applied field research:

Mahangu crop drying after harvest.
Seed selection and storage of mahangu for re-planting the next season.
Threshing methods used by farmers.
Storage and other post-harvest losses.
Nutritional aspects of fermented mahangu (flour and beverages) processing.
Diversity and richness of traditional food preparation recipes (especially in Kavango and Caprivi regions, which are not well documented), consumer preferences, etc.

Farmers' post-harvest constraints that need to be addressed by research and development (R&D), can be summarised as follows:

Table 11. R&D needs for addressing farmers' post-harvest constraints

Farmers' Post-Harvest Constraints	**Research and Development Needs**
Long and labour intensive post-harvest practices	Need for mechanising the operations
Poor threshing	Need for improved threshing methods, including mechanised threshing service
High price of traditional storage bins and shortage of materials for their construction	Need for improved and cheaper storage containers
Poor quality of grain after long storage	Need for reducing storage and post-harvest losses (quantity and quality)
Poor quality of grain marketed	Need for pre-cleaning technology and price premium for quality grain
Not enough grain storage capacity for surplus producers	Need to develop improved bulk storage and/or rapid access to market
No easy access to market	Need to develop decentralised trading network for quick cash intake
No extension services on post-harvest issues	Need to develop extension messages from applied R&D
Mahangu processing labour intensive	Need to promote home milling technologies, and develop decentralised service milling (including dehulling)

Traditional wet processing of mahangu not adapted to available mechanised milling	Need to adapt improved/mechanised processing appropriate for the preparation of fermented mahangu flour

CHAPTER 4 GRAIN TRADING AND PROCESSING SECTOR

This chapter looks at the procurement and utilisation of mahangu from the perspective of the trading and processing sector. It describes the state of development of the sector and analyses the constraints it is facing.

Mahangu Grain Trade and Markets

Mahangu grain is regularly traded although in relatively small quantities compared to the overall production, which is mainly home-consumed. In the absence of accurate figures, it is estimated that roughly 10% of production is traded (*Keyler, 1996*). Volumes traded vary according to the year's harvest, but even in years of global deficit some grain is traded. Traded grain is not only surpluses from large communal farmers (even if they would provide the largest part) but also includes small decentralised transactions at rural village level.

The mahangu grain market appears stratified, with little transfer assumed to take place between segments (*Presland, 1997*). Attempts to quantify volumes and values of the different market segments were made but they remain hazardous in the absence of accurate data. The mahangu market structure can, however, be described as follows (adapted from *Presland, 1997*; *Mallet & El Obeid, 1997*; *Keyler, 1996*).

Local barter or exchange market

At rural household level, grain is bartered for local food stuffs and clothing between neighbours. It is also used to pay church fees in kind. The exchange unit is very often the lata (around 15 kg) and the price or its barter equivalent are high (from around N$ 20 to N$ 30 per lata). This kind of exchange can extend to family members in urban areas. Traditional mahangu-based fermented beverages are also locally traded or exchanged. Such transactions in grain and in processed products involve small quantities, but they are likely to be widespread and may represent a significant (although unknown) volume in total.

Informal trade market

Mahangu grain is sold by producing households for cash to cover basic and urgent needs (school and clinic fees, etc.). Limited quantities of mahangu grain are seasonally traded in the periodic 'Pension-Day' markets in rural areas. Local traders (Cuca shops and retail outlets) and mobile traders buy mahangu grain for cash or in exchange for consumer goods. The terms of exchange do not seem to favour the producers and low cash buying prices have been reported, while re-selling prices are high, making this trade quite profitable for traders even if volumes are likely to be limited. Grain traders indicated a lack of working capital as a limitation to this business (*Keyler, 1996*). Furthermore, mahangu grain and home-processed flour are traded in latas and cups respectively on rural and urban markets. All reports on this informal trade suggest that only limited quantities are marketed.

Formal trade

Different types of operators have been trading mahangu on the local market. Grain traders indicated the period between August and December in the NCRs and between October and December in Kavango as the best time for mahangu transactions. Traders correlated the beginning of the peak selling period with the emptying of rural households' old mahangu stock. Most commercial mahangu traders intend to store mahangu for less than a year (*Keyler, 1996*).

A mahangu grain marketing survey conducted in the NCRs in July-September 1997, after the bumper harvest of the decade, found literally no mahangu grain transactions taking place and commercial buyers unwilling to acquire grain at that time, most probably because the demand for grain would have been extremely low after such a good harvest (*Mallet & El Obeid, 1997*).

Most formal traders are northern-based entrepreneurs, for whom mahangu trading is only a small part of their multiple business activities. Farmers' co-operatives have been playing no, or an insignificant, role in the mahangu trade and there seems to be a very limited number of medium-scale traders specialising in buying mahangu grain from rural areas.

Government has bought mahangu grain locally for its drought relief food distribution programmes, as an attempt to encourage production. The schemes were implemented by the NDC or private traders and had an important impact in some years over the last decade, less for the quantities involved than for the high buying price of mahangu grain, which were reported as having significantly raised price expectations from farmers and thus depressed private trade .

The Mahangu Marketing Intelligence Unit, which monitors and facilitates mahangu transactions, reported on a total value of N$ 3 155 000 for mahangu traded during the year May 1999 - April 2000 (*Mahangu News*). At an average price of N$ 1 100 per tonne, the corresponding traded quantity was just below 3 000 tonnes.

Since Keyler's study in 1992 and 1993, small-scale commercial mahangu millers in the North have emerged as the most consistent and regular buyer of mahangu grain in northern Namibia. Quantities processed have, however, remained relatively low, around 60 tonnes per month in 1999 and around 80 tonnes per month in 2000 (*Mahangu News*; *CRIAA SA-DC, 1999a, 1999c & 2000b*). Most of these small-scale commercial millers are large farmers themselves and process their own harvest before buying additional grain. It is not clear what quantities of mahangu grain are bought on the local market in addition to their own harvests.

As a newcomer, Namib Mills, the largest industrial processor of maize and wheat in Namibia, has started buying sizeable quantities of mahangu grain in Ondangwa and Rundu during the 2000 marketing season (perhaps over 800 t - 900 t) for their new dry-processed mahangu meal launched in July 2000 and traded as 'Meme Mahangu' (the meal contains an undisclosed quantity of maize meal, probably around 20%). The two buying depots were equipped with South-African pre-cleaners and mahangu grain was bought at N$ 1 100 per tonne after cleaning (*F. Meyer, pers. comm.*). The long-term consumer demand for this new product is not yet established (it has been selling at a rate of around 50 tonnes per month since its launch in July 2000).

Inter-regional and international trade

Inter-regional trade in mahangu is hampered by long distances and high transport costs, especially for grain from Caprivi. A Windhoek-based animal feed company has occasionally bought mahangu from Caprivi using back-load freight, but in irregular and limited quantities (36 tonnes at a time).

Cross-border trade of mahangu from Angola to the NCRs has been reported but has not been clearly quantified. The recent lifting of the SACU tariff on mahangu imports may have an impact on this trade or at least make import statistics more reliable by reducing the need for shadow or smuggled importation.

For the past two years or so, South Africa has been a regular importer of Namibian mahangu (around 1 000 t per year) for animal feed and planting as fodder crop. Very recently, according to the MMIU (*Mahangu News, Nov. 2000*), a large quantity of pearl millet grain, produced under irrigation in the Northern Province of South Africa, was prospectively offered for sale to Namibia. Depending on the landed cost of this grain, it could be a major new source of mahangu grain for Namibia. But no transaction has taken place to date and the price asked for this grain seemed too high to be attractive.

No direct exports of mahangu (raw or processed) have been reported to the high-value food speciality market in the northern hemisphere, where a demand exists (*C. Lombard, J. Hoffmann, B. Bennett, pers. comm.*). Recently, 30 tonnes of mahangu from Caprivi were traded to the USA through Botswana for an unknown market, assumed to be either for seeds or health food (*DoP, MAWRD*). Demand also exists for the whole panicles in Europe and North America for decoration (sold in flower shops for dry-flower arrangement) and for hanging in birdcages to entertain pet birds; retail prices in these countries appear high (*B. Bennett, pers. comm.*).

E = mc² (Empowerment = mahangu x cash²) ?

One important element of mahangu grain trading relates to prices in the different market segments:

- Relatively high prices can be obtained by producers in the micro-economy at rural village level, although for small quantities.
- Bartering and informal trading does not necessarily ensure a fair price to cash-strapped rural producers, but traders in rural areas could argue about their high transaction costs (cash payment, transport costs and time, storage, etc.) for limited unit quantities traded.
- The price of mahangu grain in most formal trade transactions is around N$ 1 000 - N$ 1 200 per tonne (or N$ 15 to N$ 18 per lata), which remains largely unattractive to significantly stimulate commercial surplus production by small-holding farmers, but is essential to the viability of the commercial processing sector (see section below on commercial mahangu milling).
- Although not directly linked by any price setting mechanism, mahangu price formation is dependent on the price of maize in the formal grain market, because maize is the closest substitute for mahangu. The maize price in Namibia is itself directly linked to the import parity price of South African maize. Mahangu grain has generally been traded in formal markets at a price 10% to 20% higher than white maize grain.

What appears surprising from the monthly price information published by the MMIU is the relative stability of mahangu prices in the 'formal market' transactions recorded by the unit throughout the years and between years, with variations in price of less than 20% between periods of abundance and times of scarcity. It must be said that these records do not take into account the more decentralised and informal sales occurring at farm level and in remote rural areas. But this intra- and inter-annual stability of mahangu prices does not appear to be a stimulating factor for private operators, who would struggle to recover the costs incurred in financing and storing stock for re-selling at a later stage. The 'market' seems to behave as if mahangu grain trade collapses nearly completely when its price tends to rise too high, with maize products taking over.

In conclusion, the existing constraints to mahangu grain trading can be summarised as follows:

Low and variable production by smallholder farmers rendering marketed surpluses limited and irregular.

Very low returns to labour at the current levels of agricultural productivity in NCAs.

High price expectations from producers related to the low productivity and unreliability of the crop production, but also to a push-up effect from Government mahangu purchase drought relief schemes.

Quality of grain traded is not standardised and prices are not related to grain quality.

Information is lacking in the trade (at both producers' and traders' levels) on market demand, prices and quality required by the industry.

Producers (who are also the main consumers) are dispersed in rural areas along poor roads at long distances from main towns, making it expensive for traders to assemble or sell in these places.

Few traders in mahangu grain and no integrated network of rural assembly traders and wholesaler specialising in mahangu trade.

High financing and storage cost of mahangu grain for the periods between buying and selling, with an unreliable demand for mahangu at time of scarcity when prices are pushed up.

Mahangu grain is more expensive than maize grain, its direct substitute, throughout the year.

Untapped opportunities in higher-value mahangu grain (and products) for the local and export market.

The Service Milling Sector

A service mill (or toll mill) is a business processing the grain of customers against a charge. It is different from commercial milling, where the grain and the processed product belong to the miller and the business consists of processing and selling a product for the market. The commercial milling sector will be looked at in the next section. It must be noted that a number of mills operating in northern Namibia are neither service mills nor commercial mills. They are classified as 'private mills' in the sense that they mainly operate for the own-use of the owners, who can be communal farmers, institutions such as church missions and schools, or NDC farms. Fieldwork indicated that there is a significant number of these mills. However, they are not reported in the present document.

A comprehensive baseline survey in the 6 northern crop-growing regions in July-September 1998 inventoried 87 service mills (*CRIAA SA-DC, 1998*). This resulted in the establishment of a small millers database at the MMIU to monitor the evolution of the small-milling sector. An update survey was carried out in October-November 1999 and identified a total of 128 service mills in northern Namibia (*CRIAA SA-DC, 2000b*). Anecdotal evidence suggests that this was an under-estimate. Regional distribution maps of the mills in Caprivi, Kavango and the North Central Regions are shown in *Annex 2*.

The most important features of the service-milling sector are presented below.

Distribution of service mills and evolution in the past years
Based on the figures of the two surveys mentioned above, the growth rate of the service-milling sector (with nearly 60 % of all small milling businesses less than three years old) has been 56% on average from 1998 to 1999, over a 16 to 17 month period. With a simple arithmetical adjustment, the annual growth rate (over a 12-month period) can be estimated at (at least) 40%. Information collected from various sources in 2000 indicates that this growth trend is continuing.

With a total of 116 service mills and an average growth rate of 61 % since the last survey, the NCRs concentrate the bulk of the service milling industry (90 % of service mills and 96 % of new ones). However, the growth rate appears lower in Ohangwena compared to the three other regions: Oshana, Oshikoto and Omusati. With 2 and 0 new mills respectively, Caprivi and Kavango regions are clearly lagging behind.

For each region, the ratio between the number of service mills and the population was calculated as an indicator of the regional 'density' of service mills (*CRIAA SA-DC, 2000b*). The ratios varied from 1/3 000 in Oshana, the most 'densely serviced' region, to 1/58 500 in Kavango, the most 'poorly serviced' region. Surprisingly, densities in Ohangwena and Caprivi were the same (1/9 000). The high density of service mills in the Oshana region was mainly due to a large number of service mills in and around the three major towns (Oshakati, Ongwediva and Ondangwa), which have access to good services, particularly electrical power supply.

Out of the 96 non-urban based mills inventoried in the NCRs (there might be more), 39 were concentrated in 17 secondary rural 'towns'. This is significant in terms of the service milling competition developing in these places, which are electrified and are important service centres for rural areas. But it also means that the other rural centres and the rural areas proper are not sufficiently serviced by mills. It was concluded that service milling, a proximity service, has considerable room for expansion, especially in rural and non-electrified areas (*CRIAA SA-DC, 2000b*).

The two surveys also revealed that service-milling charges had not changed much between 1998 and 1999. In the NCRs, mahangu milling fees generally ranged from N$ 7.50 per lata (N$ 0.50/kg) to N$ 10.00 per lata (N$ 0.70/kg), but could be as high as N$

12.00 per lata (N$ 0.80/kg).

Technology used and technical constraints
Almost all service mills are only equipped with hammermills. Most of them have one hammermill operating and a few have two. The survey found only three service mills offering dehulling services.

Most hammermills (83%) are Drotsky models from South Africa and 50% of all hammermills are the popular M16 models. The other machines used are imported from neighbouring Southern African countries. A large majority of these hammermills are powered by three-phase electrical motors, 15 kW to 22 kW for the M16 model. Few are driven by petrol or diesel engines, or by tractor PTO.

Hammermills can only pulverise the grain, reducing it into flour. For mahangu, the whole grain must be dehulled before milling (while it is not necessarily required for maize). Customers of service mills are therefore bringing home-dehulled and fermented mahangu grain, which is most often still wet (as reported in the previous chapter). As customers prefer a very fine flour, millers equip their hammermills with fine sieves of 0.8 mm. Hammermilling of wet grain through such fine sieves requires more time and energy than dry grain. It is therefore not surprising that service mills are generally equipped with relatively big machines (such as the M16 with a 15 kW or 22 kW motor) and that the milling throughput is around half (or even less) of the capacity indicated by manufacturers.

Optimum capacities of the main models of hammermills used in the North were tested by CRIAA SA-DC consultants measuring the actual throughput in real conditions in a sample of mahangu mills (*CRIAA SA-DC, 1999a*). The results have been made available to small millers in the form of an information package, which also includes other useful data and recommendations and was launched in mid-1999 during information and consultation workshops for small millers held in the six northern crop-growing regions (*CRIAA SA-DC, 1999b*).

During these consultation workshops, the most acute need expressed was for support measures and technical back-up services in the service milling sector (*CRIAA SA-DC, 1999d*). The baseline survey of 1998 revealed that more than half of the mills were either not working or experienced technical problems, despite more than 40% being less than two years old. In comparison with 1998, the 1999 survey showed a decrease in the number of service mills not running and an improvement of the situation after one year. The main reasons are improved installation and connection to electrical supply. However, delayed installation or electrical supply connection still remain major causes of problems.

Rural electrification has been progressing in the North Central Regions. It is clear that electricity, when available at the mill, is the cheapest power source and the easiest to handle. Although the national grid is growing, many villages in the North are not yet connected to the grid, especially in Caprivi and Kavango. But some new electrical power lines, especially in the NCRs, have been extended in 220 V single-phase. These are erected to provide basic electrical supply to households and small businesses, but they will bring (and already have brought) new problems for small millers planning to run hammermills. Firstly, the conventional (three-phased) motors cannot be run with single-phase power supply; and secondly, the electrical power delivered by these lines might not always be sufficient to run (single-phase) motors of milling machines and is often too weak to start the motors.

Examples of maintenance and technical problems identified during the CRIAA SA-DC surveys include:

Mill owners buy oversized mills that have motors too large for the available electricity supply and are uneconomical to operate.

Suppliers of processing equipment do not provide mill owners and/or operators with sufficient technical and operational training to avoid simple problems.

Suppliers are generally not present at the mill to commission the equipment when electricians connect and start the mill.

A lack of maintenance skills causes easily preventable problems like hammers not replaced early enough, reversible hammers not turned around when worn out, hammers not replaced as a set (causing imbalance and destructive vibration as a result), wrong pulley alignment and/or belt tension, inadequate or (more often) excessive greasing of bearings, etc. - this leads to exaggerated maintenance and repair costs.

Some spare parts are hard to find and/or expensive.

There are very few skilled specialist repairers of grain-processing equipment in the regions.

No technical manuals or information sheets on operations and maintenance are available, which exacerbates the effects of the lack of technical training.

Mill owners are ignorant about guarantees on new or reconditioned equipment.

Service mill (as well as commercial mill) owners and managers interviewed during these surveys expressed needs for technical training and support, and information on equipment, specifications, spares and suppliers (*CRIAA SA-DC, 1999d*). The lack of specific technical expertise regarding grain-processing equipment is part of a general shortage of technical skills in the NCAs resulting from lack of technical exposure and training. A training programme for small millers has been designed (*CRIAA SA-DC, 1999e*) and is pending implementation.

Notwithstanding all these technical difficulties, service milling can be a very profitable business as long as the turnover is kept above a threshold and technical difficulties, such as major breakdowns leading to stoppages, can be minimised or avoided. This potential profitability would explain the continuous growth in the number of service mills in the North. Another factor could be that service milling is a way for wage earners and local business people to re-invest higher disposable income into such a new economic activity. For instance, the small millers' database reveals that some entrepreneurs run a number of service-milling businesses in different parts of the NCRs.

Financial viability of service milling
CRIAA SA-DC consultants carried out an assessment of the financial viability of service mahangu milling in 1999 (*CRIAA SA-DC, 1999a*).

For mahangu service milling, a detailed analysis is provided for the M16A (electric) hammermill (the most common model). It shows that a service milling charge below N$

7.50 per lata (or N$ 0.50 per kg) is an achievable objective for M16A service mills in the NCRs running at a medium turnover of above 20 latas (300 kg) per day under proper technical and managerial conditions. However, the business is not viable below an average of 9 latas (135 kg) per day, unless an exorbitant fee above N$ 12.50 per lata (N$ 0.83/kg) is charged. It is also shown that it is technically and financially feasible for higher turnover service mills, over 42 latas (630 kg) per day, to charge much less, around N$ 4.50 per lata (N$ 0.30 /kg). Other models of hammermills were not all suitable for service milling in northern Namibia, due to technical, purchase costs and other financial viability reasons.

As the demand for service milling is very likely to continue to expand, further research into specific aspects of mahangu service milling was recommended by CRIAA SA-DC consultants, including an assessment of technical options and financial conditions of service milling in non-electrified areas using alternative power sources (*CRIAA SA-DC, 1999a & 1999c*).

Economic importance of service milling

The development of the service-milling sector has mainly been the results of private sector initiatives with very limited direct support from Government and development aid. However, this development was made possible by a conducive environment provided by Government encouraging the private sector, developing basic infrastructure, such as the electrification in Northern Namibia, and facilitating access to credit for small entrepreneurs.

Although employment figures in the service-milling sector may look modest (direct employment has been estimated at around 350 at end of 1999), its contribution to the Northern economy is far from marginal. Furthermore, by their numbers service mills provide the ‘market size’ that makes possible the provision of private sector services to the small-scale milling sector, commercial mills included.

It is not clear at present if service dehulling has a good chance to develop in Northern Namibia. As explained in the previous chapter, the majority of mahangu consumers prefer the fermented flour, which implies, in traditional food processing, the soaking of the dehulled grain before milling. Customers of service mills would have to bring their grain for dehulling, then take it back home for soaking, and bring the fermented grain back to the mill (a second time) to get the flour. Unless customers drop their food preparation customs (which seems unlikely and nutritionally detrimental) or entrust millers to soak their grain at the mill (which might not be logistically easy and may not be accepted by customers), the development of service dehulling will mean having customers going to the mill twice, once for dehulling and later for milling.

In conclusion, service mills have the most pressing technical problems and difficulties in business planning and management, they are by far the highest number of processing units and their number is growing regularly with new installations. It was estimated that the actual throughputs of service mills do not exceed 25% of their optimum technical capacity. This has detrimental implications for their viability. Improving the efficiency of service mills will facilitate a reduction in service charges in the Northern Communal Areas. This will not only benefit customers, but increase demand and thus improve the turnover of the mills (which seldom run at capacity). Reliable and affordable service milling saves rural women the drudgery of manually pounding grain for the daily meals and frees them to pursue more productive activities, directly benefiting farm family well-being.

The Commercial Milling Sector

CRIAA SA-DC consultants identified 13 small-scale commercial mills operating in the NCAs at the end of 1999. Six of them were only milling maize, three were mixed units processing both maize and mahangu (dry process), and four were only milling mahangu (wet process), two of which were less than one year old.

Maize milling, carried out with the same type of machinery as mahangu milling but also with rollermills, is not discussed further in this report. It must be noted, however, that the installed capacity of small commercial maize mills in the NCAs exceeds the present demand and that at least three other milling companies further south also supply the Northern market with maize meal.

Most of the constraints experienced by service millers are also faced by commercial mahangu millers and they will not be repeated. In addition, commercial mahangu processors experience specific difficulties, which are presented below.

Regional distribution of small commercial mahangu mills and installed capacity

The mahangu commercial mills are few in number and can therefore be named. At the end of 1999, there were two in Kavango (Kamalanga Milling at Katjinakatji and I.J. Mills at Nkurenkuru), one in Oshikoto (ABC Mill at Onyaanya), and two in Omusati (Okavu Mill at Outapi and M.N. Mill in Uukwaludhi). Two new commercial mahangu mills started operating in 2000, TS Properties near Oshikango and Sun Moonlight at Ohangwena.

With the type and number of processing equipment used in these commercial mills, the installed capacity was 88 tonnes per month in 1999, or around 1 000 tonnes per annum. The actual production in 1999 was estimated between 45 tonnes and 53 tonnes per month (540 t to 640 t per annum). The mahangu meal installed capacity and current production remained marginal compared to maize meal (*CRIAA SA-DC, 2000b*).

Factory gate prices in 1999 for the 'wet process' mahangu meal were between N$ 2.40 per kg (large bags) and N$ 3.20 per kg (small bags). These prices remain much higher than for maize meal (*CRIAA SA-DC, 1999a & 2000b*), as shown in Table 12 below.

Table 12. Comparative Prices (N$ / tonne) of Maize Meal in North Central Namibia (1999)

Whole hammermilled	Dehulled and hammermilled	Industrial unsifed *	Small-scale rollermilled	Industrial sifted *	Industrial special sifted *
1 400	1 600	1 400	1 600	1 800	2 000

*** Wholesale price, otherwise factory price when produced in North Central Namibia**

Source: Trade survey (CRIAA SA-DC, 1999a).

The different commercial methods of processing mahangu

There are currently two mahangu processing methods followed by commercial mahangu millers in (northern) Namibia:

Dry processing, in which mahangu grain is pre-cleaned, mechanically dehulled with an abrasive dehuller, hammermilled and bagged straight away. At no stage is the mahangu humidified.

The wet process, in which mahangu is soaked and (slightly) fermented after dehulling and before milling. At some stage(s) in the process, the product must be dried to avoid the bagged end-product rotting. This is a much more complex way of processing than the dry method, but the product has a higher value on the market. The wet processing was initiated, on a small-scale commercial basis, by Mr and Mrs Kamalanga, and is still being developed and improved (*Special Annex* in *CRIAA SA-DC, 1999a*). The consumer market is very sensitive to the quality of the fermented mahangu meal (colour, taste, odour, texture, etc.); there could be as many different meals as there are processors, each following its own recipe.

Technology used and technical constraints on commercial mahangu processing
Processing pearl millet is more difficult than milling maize (and sorghum): mahangu grains are smaller in size, they must be dehulled at a lower extraction rate and the milling yield is lower. The average composition of pearl millet grain, as compared to sorghum and maize, is provided in *Table 13* below. Furthermore, mahangu has a higher oil content than maize (and sorghum). Mahangu bran, which contains part of the oil-rich germ, easily sticks to dehullers parts, particularly to the bran extraction system and can block it, as can be witnessed on most mahangu dehullers operating in northern Namibia.

Table 13. Average composition of cereal grains (percentage of total dry weight)

	Pearl millet	**Sorghum**	**Maize**
Whole grain	100	100	100
Endosperm	75	82	82
Germ	16	10	13
Bran	9	8	5

Adapted from Abrasive-Disk Dehullers in Africa (1989) and Small-Scale Milling (1994)

Mechanical dehulling remains a bottleneck in increasing the output of commercial mahangu mills. The different models of (abrasive) dehullers used in the NCAs were tested by CRIAA SA-DC consultants by measuring the optimum throughput in real conditions at a sample of mills (*CRIAA SA-DC, 1999a*). The conclusions were that although one model was performing better than the others, none were adapted to and satisfactorily processing mahangu. Research into and development (or adaptation) of appropriate mahangu dehullers was therefore recommended as priorities.

CIRAD consultants noted that due to the small size of mahangu grain no perfect balance had ever been found with small-scale dehullers between polishing, cleaning and high throughput. They further explained that developing a new dehuller is a complex task, due to at least ten technical design parameters to be taken into account, and requires a rigorous technological approach. R&D costs may only be recovered if the number of machines manufactured and disseminated is sufficient. Testing, adapting and improving available equipment might be an easier path, but still requires professional technological skills. The CIRAD consultants further noted that in commercial milling, two or three medium-sized dehullers running in parallel should be preferable to one large-sized dehuller, as they would give more flexibility and would allow service dehulling aside (*Goli & Ndiaye, 2000*).

Other major difficulties experienced by 'wet' mahangu millers are the handling of soaked grain and the drying of the flour, for which no appropriate mechanised option (or at least improved handling method) is presently available.

As mentioned earlier in this report, commercial millers have often complained about the quality of mahangu grain purchased from farmers and the contamination of grain with sand, other foreign matter and insect infestation. To provide a regulatory framework, the national standards for mahangu grain were recently promulgated in the Government Gazette (*Republic of Namibia, 2000*).

Among all the commercial mahangu mills, only two mills were using grain pre-cleaners in 1999, while the rest experienced excessive equipment wear caused by abrasive sand and dust. The electrical vibrating-sieve models used were, however, not efficiently cleaning the mahangu grain due to poor design (an additional sieve lacking) and required additional labour to manually remove foreign matter of larger size.

Financial viability of commercial mahangu milling
CRIAA SA-DC consultants carried out an assessment of the financial viability of commercial mahangu milling in 1999 (*CRIAA SA-DC, 1999a*). It was concluded that the dehulling extraction rate had some influence on the cost of the end product, but much less than the cost of raw material procurement. Over 60 % of the production cost of mahangu flour is represented by the costs of the raw material, and its financing and storing. The price of mahangu and the cleanness of the grain are the main cost factors of commercial mahangu milling (dry and wet process).

According to this financial appraisal, at a raw material price of N$ 1 000 per tonne for uncleaned mahangu grain, the total production costs (bran income deducted) of dry processed mahangu flour cannot be lower than N$ 1 950 per tonne. If a reasonable enterprise profit (before tax) of 20% is added, the ex-factory price of mahangu flour cannot be lower than N$ 2 300 per tonne. With maize meal wholesale prices generally ranging from N$ 1 400-1 600 per tonne for unsifted meal to N$ 1 900-2 000 per tonne for sifted meal, the commercial production of mahangu flour, through the dry processing method, **at a parity price with maize meal**, is not viable.

With mechanised dehulling, the financial analysis showed that it is difficult, if not unfeasible, to produce commercial wet processed mahangu meal below a break-even cost (bran income deduction included) of N$ 2 000 - 2 100 per tonne, and consequently to sell it, in bulk (50 kg bags) at the factory gate, at a price below N$ 2 400 per tonne, if a profit (before tax) of around 20 % is expected (all other costs being covered). The same conclusion was drawn for the wet processing method, for which the production of mahangu meal **at a parity price with maize meal** is also not viable.

Further research and development needed
The technical and financial appraisal of wet mahangu processing operations shows room for improvement from a productivity and financial point of view. CRIAA SA-DC consultants recommended further research and support into improving the commercial mahangu wet processing technology. In view of promoting high-value products from

mahangu processing, it was also recommended to extend the research to other processing methods and products other than flour or meal. A preliminary list of potentially interesting products was established, but it was noted that consumer acceptance for these products would have to be assessed at an initial stage, before expensive research and development efforts are invested into these new product lines (*CRIAA SA-DC, 1999a*).

The slightly fermented (acid/lactic fermentation) mahangu meal remains a 'luxury' product for a specific segment of the market. Soaking and fermentation are, however, reported in the literature to improve the digestibility and the nutritional content of cereals, which gives higher value to such products. CRIAA SA-DC consultants recommended that further research be conducted into soaking/fermenting of dehulled mahangu grain, and into the nutritional composition of wet-processed flour compared to dry-processed flour (*CRIAA SA-DC, 1999a*).

CIRAD consultants concurred with the above recommendations and noted that fermentation processes have been studied in most West African countries. Most often, 'hetero-fermentative' fermentation takes place, the main strain being *Lactobacillus plantarum*. Fermentation could be accelerated and standardised using a starter (selected cultures or an inoculum from a previous batch) and maintaining the temperature above 25°C (*Goli & Ndiaye, 2000*). The consultants from CIRAD also stressed the importance of ensuring a regular quality of processed products, particularly the wet processed flour, through specifications and standards, and promoting good manufacturing practices.

A nutritional analysis of Kamalanga's flour was organised by the Namibian Agronomic Board (see *Table 14* below). Unfortunately, there is no such analysis for a dry process mahangu meal as a basis for comparison.

Table 14. Analysis of a mahangu flour sample from Kamalanga Mill (May 1998)

Component (method)	**Units**	**Results**
Moisture	g / 100 g	13.1
Ash	g / 100 g	1.30
Dietary fibre (total) Carbohydrate (by difference)	g / 100 g g / 100 g	6.48 63.3
Fat (acid hydrolysis)	g / 100 g	5.00
Protein (N x 6.25)	g / 100 g	10.8
Energy (calculated)	kJ / 100 g	1 381
Calcium	mg / 100 g	163
Phosphorus	mg / 100 g	196
Potassium	mg / 100 g	177
Iron	mg / 100 g	6.52
Magnesium	mg / 100 g	63.8
Niacin (Vit. B3/PP)	mg / 100 g	1.15
Riboflavin (Vit. B2)	mg / 100 g	0.056
Thiamin (Vit. B1)	mg / 100 g	0.22

Source: Division of Food Science and Technology, CSIR (Pretoria), courtesy of NAB.

Utilisation of commercial mahangu mill products

Mahangu products from small-scale commercial mills in Northern Namibia have so far been essentially consumed in the form of meal for home consumption, as is the new mahangu-maize mixed meal of Namib Mills.

Namib Mills' meal is on the shelves of a good number of supermarkets and medium-sized retail shops in Windhoek, in the North and in major urban mahangu consumption centres, alongside the range of maize meals usually distributed in Namibia. Mahangu meals from small-scale commercial mills are also available in northern supermarkets and retail shops, as well as in Windhoek (particularly in the medium-sized supermarkets of Katutura) and in major urban centres. Northern commercial millers seem to have specific market niches, since only one brand is generally found in a particular retail outlet (often alongside the Namib Mills mahangu mix).

As was pointed out above, small commercial mahangu mills currently produce and market at most 100 tonnes of flour per month and the new Namib Mills mix only sells at around 50 tonnes per month. The present domestic consumption of commercial mahangu meal can therefore be estimated at around 150 tonnes per month, at most. Consumption figures may change in future. It could also increase further in the present marketing year as consumers tend to purchase milled products at a higher rate towards the end of the calendar year and in the first semester of the new year before the new harvest. It is presently not clear, at the current price of mahangu meal and with the current quality of products offered on the market, whether the domestic market for mahangu flour has been saturated or whether there is room for expansion. Certainly, in-depth consumer surveys would provide a better understanding of this issue. It is known that commercial mahangu millers presently face marketing difficulties and have to restrict their production to immediately marketable levels, because of the relatively short shelf life of their products.

The institutional demand (schools, hospitals, prisons, army, mines, etc.) has not yet been significantly tapped by commercial mahangu millers, who have faced various difficulties in accessing these potentially sizeable markets. One major difficulty has been that these institutions procure foodstuffs on tender through catering companies, which bid for and ultimately procure the cheapest products. Maize meal always had a price advantage over mahangu meal. Efforts by Government to give preference to mahangu meal on Government institution tenders have not yet brought results. It has, however, been set as a priority intervention of Government to stimulate the commercialisation of the crop, encourage the development of commercial processing and justify investing into improved processing technology. The major constrain has been the higher cost of procuring mahangu by caterers, which would ultimately be passed on to Government. Compulsory inclusion of mahangu products in Government procurement tenders would also face two types of difficulties. Firstly, mahangu is not preferred by all the Namibian population and is often negatively perceived as a backward traditional food (of the rural North). Secondly, there is limited capacity and human resources in Government to actually control the composition of rations supplied by caterers.

On a more positive note, it must be mentioned that a major mining company and Kamalanga Mill have been discussing the supply of mahangu meal to mine canteens on a regular basis (around 20 tonnes per month).

New products made of mahangu are still at an infant stage (bread with 20% mahangu flour, biscuits or pasta with mahangu flour), with the exception of the 'Oshikundu' beverage of Namibia Breweries, which has so far not sold at the level expected by the company. The Tunweni Brewery in Tsumeb has been manufacturing a fermented drink made with mahangu meal, sugar, lactic acid and water, pasteurised and packaged in 500 ml cardboard packs, and traded as 'Oshikundu'. It is currently only using 1.5 tonnes per month of wet processed mahangu flour bought from Kamalanga mill in Kavango (*J. Dammert* in *MAWRD, 2000*).

It could be argued that as long as the potential domestic demand for mahangu flour has not been satisfied, there is no need to embark on developing new mahangu products. This consideration is strengthened by the fact that the supply of mahangu raw material at a commercially viable cost is presently a limiting factor to the industry. But it could also be argued that higher-value products could better accommodate supply price variations and could also respond better to the changing demand patterns of consumers, especially in urban areas.

CHAPTER 5 MAHANGU PROMOTION POLICY HIGHLIGHTS AND DISCUSSION

From the *Workshop to Develop a Strategy for the Multiple Use of Mahangu and Sorghum in Namibia* referred to in *Chapter 1*, a 'Strategy and Action Plan' was elaborated by MAWRD and stakeholders (*MAWRD, 2001*). A large portion of this strategy deals with post-harvest issues, which will not be elaborated in detail below as it was in the main text of this document.

Institutional arrangements, progress review and re-planning
This research report has tried to demonstrate from a post-harvest angle that constrains to mahangu promotion are numerous and largely interlinked. It is typically a complex problem, which requires a multi-pronged approach. As room for manoeuvre is limited at all the identified constraint levels, the strategy must be holistic and the action plan targeted at lifting sets of bottlenecks. The strategy therefore needs to be not only relevant and multi-disciplinary, but also prioritised (as opposed to loosely multi-directional), while the implementation of the action plan needs to be co-ordinated and from time to time evaluated. The Action Plan recommended the formation of a Mahangu (and Sorghum) Task Team (MSTT) lead by MAWRD and including governmental institutions and non-governmental organisations.

Primary agricultural production
Although it was not the focus of this research, low and variable primary production remains a fundamental problem hampering the commercialisation of mahangu. There is certainly room for increasing agricultural productivity (not only the yield per hectare but also the return to labour) through improved cultivars, mechanisation (animal traction and tractor services), increased manure restitution to cultivated soils, etc. There are also opportunities to spread risks and diversify the 'cropping basket' in such adverse agro-ecological conditions as in Northern Namibia. These constitute the primary mandate of

the agricultural extension service fed by recommendations from agricultural research and farming system research units.

It must be stressed that only marginal productivity gains may be possible because of agro-ecological limitations, but such gains might still be significant overall if spread among a large portion of communal farming households. In the very densely populated areas of Ohangwena and Oshana regions, where rural population densities can reach 100 inhabitants per square kilometre, absolute limits on the availability of land for cultivation (relative to cereal consumption in these areas) might further restrict the commercial impacts of increasing yields and/or returns to labour.

The mahangu promotion strategy advocates as one of its component encouraging increased market-orientated production of mahangu (and sorghum) on land where these crops have not been traditionally grown. Knowing the agro-ecological potential of Namibia, these areas can only be the 'commercial farming' areas of the maize triangle, where production of maize and other food crops (rain-fed and irrigated) has been constantly shrinking with the gradual liberalisation of Namibian trade in agronomic commodities. The strategy is not clear about whether this new commercial mahangu production should be encouraged amongst the existing better-off 'commercial farmers' or should be the basis of the settlement of small-scale farmers orientated towards commercial mahangu (and other cash crops) production. It is not the purpose of this research paper to enter into this debate, which concerns another set of policies, but it must be highlighted as it is relevant to the present mahangu strategy.

Post-harvest processing and grain storage
Going back to post-harvest issues, an important component of the strategy is the reduction of post-harvest losses by improving traditional drying, threshing and storage methods. This is certainly a priority area because problems have been clearly identified, the impact can be widespread amongst producers, and it has the potential to increase the effective harvest (and its quality) available for home-consumption and marketing. The strategy stressed the lack of applied research into post-harvest issues and the subsequent lack of extension recommendations as major impediments. It is expected that the creation of a post-harvest research focus group or sub-division with MAWRD as recommended during the Mokuti Workshop, as well as the integration of post-harvest issues in FSRE and extension services work, will address these shortcomings.

Mahangu grain marketing and processing
As a result of low primary production, very limited quantities of mahangu are available nationally for trading, which in turn retards the development of marketing systems and severely restricts the options for secondary processing and value-adding. Combined with the fact that pearl millet is not readily available on the international market and cannot be imported at a price competitive with maize, the limited trade in mahangu grain renders processing businesses very vulnerable to failure due to an interrupted supply of raw material. The grain marketed is often of poor and variable quality, resulting in unacceptably high processing losses. These constraints are reflected in the nature of the recent growth that has occurred in the processing sector: it has primarily been focused on service milling rather than commercial milling.

On the other side of this vicious circle, the underdeveloped commercial mahangu processing industry has contributed significantly to the absence of a market incentive to increase primary production and trading. A major positive consideration is the very strong consumer preference, and thus demand, for mahangu products, especially the slightly fermented mahangu meal produced by wet processing. Low production and high demand theoretically translate into higher prices, a trend confirmed by the premium price realised by such mahangu meal in urban markets.

The main strategies that have been suggested as ways to facilitate and support increased trade in and processing of mahangu include:

to support mahangu grain marketing through better market information to sellers and buyers (e.g. strengthening of MMIU), improved off-farm storage and trading facilities (assembly depots in surplus producing areas, wholesale rural markets), encouragement to local processing, support to mahangu grain traders and marketing co-operatives (loans, ...).

to investigate increased imports of mahangu from southern Angola in years of national deficit and encourage the inter-annual stockpiling of mahangu grain to ensure supply in drought years.

to require that a minimum percentage of mahangu-based products be included in Government and other institutional food-supply contracts.

to develop technical and business training for the small-scale milling sector, to provide improved technological options for processing equipment.

Value-adding and product development

Only very limited quantities of Namibian mahangu (and sorghum) are currently used to make value-added products for **formal** markets (if mahangu meal is excluded, the quantities are insignificant). It has been suggested that the development of innovative, high-value products will stimulate increased mahangu (and sorghum) production, marketing and pre-processing, by providing a constant and lucrative market for grain, meal and malt. Since it is not possible to produce mahangu cheaper than imported maize, there is a need to develop higher-value mahangu products that will fetch a premium price in niche markets.

The main strategies that have been recommended in this regard are:

product development.
market promotion (generic and brand-specific).
incentives schemes to manufactures.

In pursuing the product-development approach to mahangu (and sorghum) promotion it is important to guard against disrupting the numerous informal-sector micro-enterprises currently producing traditional beverages and foods from these grains. This can be done by ensuring that the new products are truly innovative and compete in different market segments.

Developing new products and successfully marketing them require that a set of conditions be fulfilled. These include formulating good quality products that meet the expectations of consumers (in-depth understanding of consumer perceptions is essential), and targeted promotion campaigns at the launch.

Conclusion
Improving mahangu post-harvest systems is a necessary condition for the growth and expansion of the mahangu industry in Namibia, but it is not in itself a sufficient condition. Better post-harvest practices and technology can increase the effective national harvest and the efficiency of processing, but ultimately the sustainable growth of the secondary and tertiary mahangu sectors will need to be supported by increased primary production and/or more reliable and cheaper imports of mahangu grain, especially in drought years. However, many of the constraints on mahangu post-harvest systems have been identified and **addressing these constraints is therefore a priority area for immediate intervention.**

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