SORGHUM MILLING: THE BOTSWANA EXPERIENCE,
and Progress toward Implementation
in Other African Countries

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I INTRODUCTION

The research and development work on sorghum milling in Botswana that IDRC supported through two projects between 1976 and 1980 has been part of an informal network of projects in Africa and other regions. The projects have revolved around the perceived need to promote the production and utilization of small grains and grain legumes, particularly sorghum and millet, that are well adapted to the drier parts of Africa and constitute the staple food for large rural populations. A major constraint to this development lies in the difficulty of dehulling the grains prior to grinding into flour. Thus the main focus of the projects has been on the development of a simple mechanical dehulling device. (The appendix contains descriptions of the devices developed.) In recent years the "network" has spread, and three dehullers based on essentially the same design but adapted to various operation modes and capacities, are now being tested and developed in eight African countries (and also in Bangladesh, on pulses). Thus the program is of considerable significance both in terms of past investment and future commitments and intentions.

The Botswana case has been chosen for this presentation because it offers an example of an extremely rapid progression from applied research through pilot project to dissemination and adoption of a technology.

II IDENTIFYING THE PROBLEM

A survey of rural food preferences in Botswana, conducted in 1974/75 revealed that changes were occurring in household food patterns. Estimates for the period 1955-60 had suggested that of cereals and cereal products consumed, sorghum represented 80% and maize 20%. The survey found that rice and wheat bread were becoming important in the urban areas and with wealthier rural people, and that overall rural consumption had changed to 65% maize products and only 35% sorghum. Readily available industrially milled, sifted and packaged maize meal, imported from South Africa, constituted a convenience food. No similar
product (flour) made from sorghum was available in the shops. Possessing good shelf life, the maize meal, while taking as long to cook into porridge as did sorghum, saved the housewife the tedious (at least two hours for 5 kg) manual dehulling and grinding it took to produce sorghum flour. The meal (flour) thus produced has to be eaten quickly, otherwise it becomes rancid because of the high moisture content--a result of the soaking which is an integral part of the traditional process.

These changes in food patterns were beginning to have a significant effect on Botswana's food security position and on her foreign exchange. Climatically, Botswana is better suited to the growing of the drought-resistant sorghum than to maize. However, as the demand for sorghum decreased, farmers began to grow less sorghum, often putting the land to no alternative arable use. Increasing amounts of foreign exchange were used to pay for the maize products imported from South Africa.

III THE FIRST RESEARCH STAGE

In the mid 1970's, the Botswana government decided to address its concern about this trend away from locally produced sorghums toward imported maize, mostly from the Republic of South Africa. The Ministry of Agriculture asked the Botswana Agriculture Marketing Board (BAMB) to investigate the possibilities of processing sorghum. BAMB, in turn, requested assistance from IDRC and a co-operative project was implemented. This first research stage aimed to

...develop a suitable village level milling system for processing sorghum to produce sorghum flour ... as acceptable in quality and price as imported maize meal.

The underlying policy objective of contributing to increasing basic food self-sufficiency is plainly stated in the project's objectives.

Between 1971 and 1975 a technology for mechanically dehulling small grains had been developed and tested in a series of IDRC-sponsored projects, mainly in Canada and Nigeria. Thus, it was possible to provide BAMB with equipment which would probably be appropriate for the problem.

A pilot mill was established at Pitsane, a large BAMB grain storage depot on the railway south of the capital Gaborone. The mill used two dehullers, a hammermill, a sifter, and a bagger, all driven by two diesel engines. The sorghum meal produced was sold in bags of
various sizes, from 2.5 kg to 60 kg. The mill's throughput in metric tonnes of grain rose from 85 tonnes during the initial three months in late 1977, to about 1,800 tonnes in 1982. The mill was operated with the assistance of IDRC advisors until June 1978, when local BAMB management took over. The mill has been running since, working about twelve hours a day producing about six tonnes of flour.

Even though the sorghum flour is higher in price than maize flour, (a result of pricing policy for sorghum, not of processing cost) there is a strong demand for the sorghum flour, supporting the results of the previous consumer preference survey and its interpretation that the trend away from sorghum to maize had been a phenomenon of urbanization and availability--quite simply, maize meal was on the shelf and sorghum flour was not.

IV THE SECOND RESEARCH STAGE

However, more than three-quarters of the Botswana people (Batswana) live in rural areas and the previously mentioned survey had indicated that most of these people prefer to eat flour from the sorghum they have grown themselves. To meet this need required modifying the milling system so that it could process smaller amounts in batches,--in other words, operate as a service unit as opposed to the commercial system at Pitsane. This then was the aim of the second research stage in Botswana:

... to determine the technical, operational and economic feasibility of "scaled-down" models of the Botswana milling system.

Responsibility for the necessary research, redesigning, and testing in village communities was given to the Rural Industries Innovation Centre (RIIC) in the village of Kanye in southern Botswana.

Between 1978 and 1980, the RIIC redesigned, developed and tested various prototypes of a scaled-down dehuller. The research had the happy outcome that, because the scaling-down allowed the dehuller to be operated at higher speeds, the throughput of the smaller model was no lower than the original larger version. The system established consisted of a dehuller that could operate on a batch (service) or continuous-flow (commercial milling) basis, incorporating a fan and cyclone for collecting the bran; a hammermill; and a diesel engine to drive both machines.
For village testing, one mill was set up at Kanye, where the RIIC is located, and milled 232 tonnes of grain between May and December, 1979. Current throughput is about 600 tonnes per year. Another mill was established at Gabane in late 1979, operated by the Pelagano Village Industries, a rural development organization. Operated as a commercial unit in the mornings and as a service mill in the afternoons, its current throughput is about 600 tonnes per year.

Particularly in Kanye, the demand for service milling was so insistent, that it was difficult to schedule mill time for further testing of performance parameters. However, the steady utilization of the mill provided useful business data, and provided vital information on the longevity and ruggedness of the machinery.

V WIDER SCALE DISSEMINATION IN BOTSWANA

A seminar in September 1979 was held for persons and groups who expected to invest in sorghum milling packages, and RIIC accepted orders at that time. A mill operator's handbook was written, to go with an owner's handbook (both available in Setswana and English). The first course for mill operators/owners took place in February 1980, and manufacture of three dehullers began early that year, followed by eight more in mid-1980.

By the end of 1981, seventeen systems were operational throughout Botswana. All were in the south and east of the country along the line of rail where most of the population is concentrated. It was expected that these seventeen systems would process an estimated 10,800 tonnes of grain in 1982. (The May/June 1982 harvest of sorghum was severely reduced by drought. Therefore actual tonnage processed was lower.)

Consumption estimates vary widely, but taking a middle estimate of 2 kg per family per day, this amounts to the sorghum requirements of about 15,000 families, already more than ten per cent of the Botswana population (130,000 families).

The RIIC now possesses the resources to manufacture the dehuller and to deliver an entire milling package. It is able to advise on mill building layout, and to provide an installation and routine maintenance service. Further, it is able to provide a familiarization course for potential mill owners and training courses for mill operators. The RIIC
has regular contact with a mill owners' (of the RIIC milling system) association which meets to discuss and solve mutual problems in all aspects of their operations.

Economic and business analyses provided by the RIIC have been used by government lending institutions to give loans to groups or individuals wishing to acquire such a small milling system.

The RIIC advises mill owners to initially offer only a milling service. The customer brings her/his own grain, supplies her own containers, and is charged a per kg milling fee. As the mill owner gains experience he/she seeks out bulk customers such as schools, hospitals, prisons and traders' shops for service milling. Later, as mill management skills increase, the mill may buy sorghum in bulk and sell flour in plastic or cloth bags to individuals or shops.

VI SOCIAL AND ECONOMIC EFFECTS

Two broad categories of benefits had been anticipated from the adoption of the milling system:
1. To facilitate increased consumption and thereby production of domestic sorghums, thus increasing food security and decreasing dependence on imports and on foreign exchange expenditure
2. To release women's and children's time for more economically and socially rewarding activities.

The RIIC conducted two surveys (August, 1981 and March, 1982) to assess the impact of the milling systems on four rural communities. Respondents indicated that these service mills saved them an average of 2½ hours per day.

IDRC's Office of Planning and Evaluation in January 1982 selected the Botswana case, and studied particularly the costs/benefits of the technology. The internal rate of return of an individual service mill was calculated at 30 per cent. Using a shadow foreign exchange rate (increasing the cost of all imported items by 25 per cent) reduces the rate of return to 18 per cent. A commercial mill requires a larger capital investment, and will, at least at present, depend in part on imported sorghum supplies. A cost/benefit analysis, based on actual local costs provides an internal rate of return of 26 per cent. Two
calculations were made using a shadow foreign exchange rate of 25 per cent. The cost benefit analysis, assuming only local grain, gives an internal rate of return of 79 per cent; assuming only imported grain, the rate of return drops to 40 per cent. The detailed analyses, including the assumptions made, can be found in the original paper.

The analyses lead to the conclusion that the net effect of the sorghum milling efforts on the social and economic welfare of Botswana has been and will be positive.

VII DISSEMINATION OF THE TECHNOLOGY TO OTHER THIRD WORLD COUNTRIES

The experience in Botswana demonstrates that before it is acceptable, a new technology has to be technically right, economically viable, and socially compatible. The technical performance of the dehuller, including ruggedness, is now quite well established. Enough information exists to permit the calculation of the breakeven point or, alternatively, the milling price to be charged under different conditions of machine utilization. Social conditions, food preferences and utilization differ markedly from country to country. While the experience from Botswana may be indicative, it provides more a methodology than a blueprint for other countries interested in the technology.

The experience in Botswana and elsewhere suggests the following sequence and type of applied research desirable, from introduction to wider dissemination of the dehulling technology:

Initial Food Utilization Survey
- does a processing problem exist, in rural or in urban area?
- does the bottleneck lie with dehulling or grinding?
- obtain basic data on existing home processing: who does it, how long does it take, how much material is removed in dehulling, is it a wet or a dry dehulling process, how coarse or fine is the end product?
- are national policies of grain pricing/grain subsidy, and rural food industry development supportive of the new technology?

Consumer Acceptance Survey
- establish operating parameters for the equipment so that the end product is identical to that from traditional processing
- will consumers accept, prepare, eat the machine-processed, dry-dehulled and ground product?
- are consumers able to/prepared to pay for service milling or to purchase the product?

**Village-based Pilot Mill**
- is the demand large enough? will the system be economically viable?
- does locally available management skill match the level demanded by the equipment?
- can the machinery be competently operated and maintained locally?
- what training is required?

**Technology Delivery System**
- develop local manufacturing competence and capacity
- develop local resource for technical support to future milling systems: installation service, trouble shooting, repair and maintenance, spare parts
- develop credit scheme for equipment purchase
- develop training courses for mill owners and operators
- develop local resource to support mill systems with business advice

**Follow up**
- after installation measure the impact of new mills on the surrounding area
- what changes are occurring to home life, planting decisions, trading patterns

**VIII PROGRESS TOWARD IMPLEMENTATION IN OTHER AFRICAN COUNTRIES**

The Nigeria/Niger Joint Commission have received estimates that 8,000-10,000 rural milling systems for the processing of millets and sorghums will be required. UNIDO have commissioned a Paris-based company to conduct a prefeasibility study concerning a) the selection of suitable dehulling and grinding machinery, and b) the capability of manufacturing the equipment in such numbers in the two countries. The company conducting the study was specifically directed by UNIDO to examine the dehulling equipment developed in the various IDRC sponsored research projects in Africa and elsewhere. The same company also studied the sorghum milling situation in Botswana.

The first continuous flow dehuller was installed in an IDRC-sponsored
research project in Maiduguri. The project demonstrated the effectiveness of the technology, did extensive utilization and consumer surveys and explored the creation of new food products from millet and sorghum flour. No further efforts were made toward a dissemination of the technology. However, in Kaduna the Nigeria Grains Production Company have had two dehullers in continuous use since 1978 for the dehulling of maize and cowpeas on a commercial basis and have recently ordered two additional dehullers.

In Sénégal, a continuous flow (PRL type) dehuller is being used in a commercial mode to supply millet flour to urban consumers. Interest is now being expressed in the local manufacture of the RIIC/PRL design.

In Zimbabwe, a rural development association is testing the technical, economic and social acceptability of an RIIC-style milling system in a rural location in a sorghum-growing area.

In Tanzania, the Small Industries Development Organization has developed experience with a commercial size two-dehuller (RIIC/PRL type) system in a rural location. A test of four ruraly located Botswana style milling systems is about to begin. If a wide-scale dissemination results from these tests, SIDO will have acquired the ability to deliver and support the technology. However, foreign exchange shortage, and petroleum product rationing may inhibit progress in that direction.

In Kenya, a private company has put its own resources into exploring the dissemination of dehullers. Three dehullers (RIIC/PRL design) manufactured in Kenya have been placed in development projects associated with the Arid and Semi Arid Lands program.

The Food Research Centre in the Sudan has acquired experience with a number of small dehullers, and also has a large scale milling system supplied by the Schule Company, through FAO. Although Sudan consumes an estimated 1.5 m tonnes of sorghum, it is not clear whether a rural need exists for sorghum processing. The FRC's activities have been aimed primarily at the urban market.

In Ethiopia, one RIIC-style system will shortly be tested in a rural location in a sorghum-growing area for technical, economic and social acceptability. Recommendations may arise for wider dissemination of the dehullers. At the same time the Ethiopia Nutrition Institute is exploring the appropriateness/usefulness of the mini dehuller in the
small village context.

Over the last 24 months inquiries about the dehullers have come from the Dominican Republic, Zambia, Malawi, Somalia, Togo and Uganda.

IDRC's interest is to promote and support research by indigenous personnel in each of the interested countries to the point of pilot implementation tests. The recipient country will then have acquired enough knowledge and local expertise to plan and execute its own implementation program.

IX LIST OF REFERENCES

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Chief Extension Officer, Kanye, Botswana. (March, 1982) *The Impact of Sorghum Mills in Four Rural Communities in Botswana: A follow-up survey.*

The technology

The design of the dehuller is a modification of a barley thresher. A dry abrasive principle is also applied in rice mills and in the large industrial sorghum/millet milling systems. However, effective and efficient dehulling with these systems depends on adjusting a clearance between the abrasive cylinder or cone and a surrounding screen. Consequently these systems work well only on lots of homogeneous grain size. The de hullers described below do not require any presorting by grain size, and are therefore suited to the heterogeneous mixture of cultivar sizes and types used by subsistence farmers.

Short description of three dehuller types

PRL dehuller

The Prairie Regional Laboratory (PRL) of the National Research Council of Canada provided the initial prototype of the dehuller. It consisted of thirteen carborundum stones of twelve inch diameter evenly spaced on a 36 inch long shaft. The bran was aspirated by fan to a cyclone. Dehullers of this design have been tested in Maiduguri (Nigeria), Ghana, Bambey (Sénégal), and Pitsane (Botswana). The dehuller is suited only for continuous flow operation, and has been extensively used on millet, sorghum, cowpease and maize.

RIIC/PRL dehuller

The major design changes from the PRL dehuller were a reduction of the stone diameter to ten inches, and the addition of a trapdoor to enable the dehuller barrel to be cleared when used for batch processing. It is being tested in pilot village mill settings in Botswana, Zimbabwe, Tanzania, Kenya, Ethiopia, Mali and Sudan (imminent). The dehuller's application for pulse milling is being tested in Bangladesh. A sketch of the dehuller is found on page 12.

The dehuller in association with a grinder is suited for deployment as a service mill in rural areas. However, it requires a daily throughput of at least 1.5 tonnes to be economically viable. It can also be deployed, in multiples in a commercial setting. Grain pre-cleaning equipment and packaging facilities would have to be added, as well as the operating cash for buying grain and the management skills needed for this more
more sophisticated operation. More details on planning a service or a commercial mill are provided in the booklet *An End to Pounding*.

It will be the choice of the recipient country to determine whether the priority need lies with saving rural home processing time, or with supplying urban areas with adequate supplies of flour from dehulled grain.

The mini dehuller

Originally designed by PRL for laboratory use, this dehuller has no aspiration system for the removal of the bran. After dehulling, the mixture of bran and kernels has to be sieved, usually by hand. The attraction of this dehuller lies in the smallness of the batch size (5-7 kg), low cost and simplicity of operation. This dehuller has been used with resinoid discs as well as with grinding stones as the abrasive agent.

It is being tested in the laboratory in: Upper Volta, Guatemala, Mali, India, Thailand, Ethiopia, Egypt, Philippines, and Tanzania. The usefulness of the device for small village applications is being explored in Gambia and Ethiopia.
RIIC DEHULLER