IDRC-TS2

Maiduguri Mill Project

Grain milling and utilization in West Africa

ABSTRACT

The Maiduguri mill project deals with the postharvest food-grain system in rural Nigeria, and has been implemented in two phases. The first phase is devoted to the setup, operation, and management of a pilot flour mill; the second to quality control, product development testing, and the establishment of a bakery for the preparation of Nigerian-style bread containing sorghum flour. The project employs a systems approach whereby the various postharvest activities are combined to form a whole and made to operate in unison.

RESUME

Le projet de la minoterie de Maiduguri porte sur le système post-messial des céréales alimentaires dans les régions rurales du Nigeria. Sa mise en oeuvre a comporté deux phases, la première consacrée à l'établissement, au fonctionnement et à la gestion d'une minoterie-pilote et la seconde, au contrôle de la qualité, à l'amélioration du produit et à l'établissement d'une boulangerie servant à la fabrication d'un pain nigerian à base de farine de sorgho. Le project utilise une approche par systèmes qui intègre les différentes opérations post-messiales de façon à les coordonner en une activité globale.

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Grain milling and utilization in West Africa

A project report prepared by the Agriculture, Food and Nutrition Sciences Division of the International Development Research Centre, in consultation with Nigerian authorities.

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INTRODUCTION

Established in the capital city of the North Eastern State of Nigeria, the Maiduguri mill project is a joint venture of Nigeria's Federal Ministry of Agriculture and Natural Resources, the North Eastern State's Ministry of Agriculture and Natural Resources and Ministry of Cooperatives and Community Development, and the International Development Research Centre (IDRC). The project is concerned with the postharvest food-grain system in rural Nigeria. Its design and implementation illustrates that the total postharvest-technology grain system is composed of various components that combine to form a whole and operate in unison. A modern, yet simple, milling unit is the main component of the system, and as such, it plays an essential role in the efficient flow of harvested grain to the consumer. The principal activities associated with the mill's operation are grain handling, processing, packaging, marketing, and utilization. Figure 1 is a schematic diagram of the total postharvest system.

The project was established in two phases, the first phase being devoted to the setup, operation, and management of a pilot flour mill. Associated activities included consumer grain-preference and marketing studies, milled product evaluation, and new food development in the test kitchen. The second phase monitors the operation of the pilot flour mill, specifically quality control and product development testing. In addition, the setup, operation, and management of a bakery for the preparation of Nigerian-style bread, containing sorghum flour, is a major activity of this phase.

BACKGROUND

In the traditional postharvest systems of most developing countries, grain is purchased, stored, transported, processed, and sold by numerous speculators on its way from the farmers to the consumers. This results in higher costs to consumers and in less money being available to the farmer. Consequently, there is a reduced incentive for the farmer to produce more grain than he requires for his subsistence. Furthermore, improper grain handling and inadequate storage facilities contribute to high losses of both unprocessed and processed grain as a result of insect infestation, microbial contamination, dirt, and spillage.

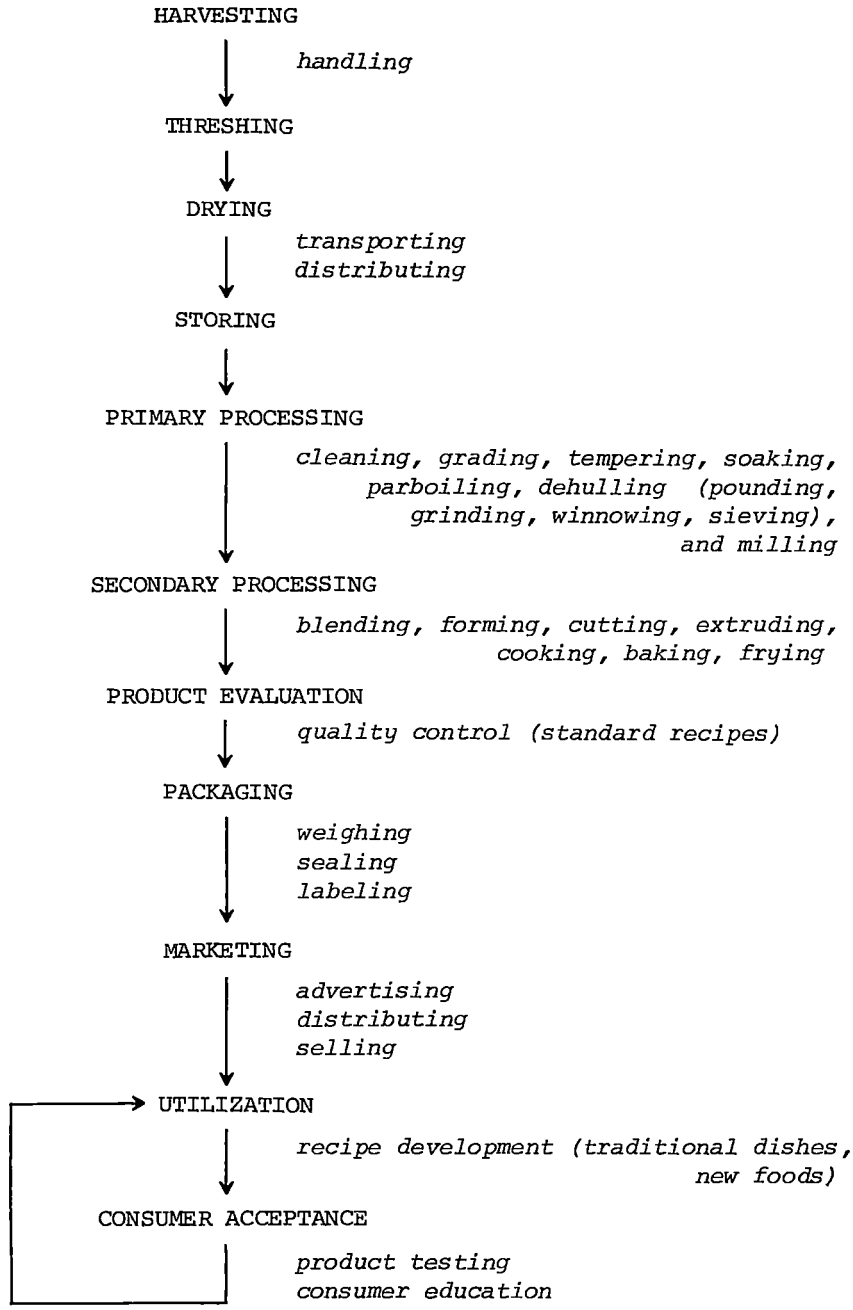

Fig. 1. Schematic diagram of a total postharvest grain system.

The purpose of this project was to establish an improved rural milling system capable of processing locally grown grain into acceptable flours. Maiduguri, the site of the pilot mill, is a rapidly growing city with a population of over 150,000 that is located near the centre of the crop-growing area. The main crops in this area are sorghum (Guinea corn) and millet although smaller amounts of maize, wheat, and cowpeas are also produced.

Throughout the project, assistance and advice from the Agricultural Engineering and Agricultural Economics Departments at the University of Alberta were provided via consultant surveys.

Since a systems approach was to be followed in the project's growth and development, the initial task was to obtain information on the existing postharvest food-grain system in the North Eastern State. The findings of an agricultural economist's survey on food-grains production, marketing, and consumption, conducted in April 1972, provided important criteria for implementation of the project. Producers kept most of the food grains for their needs, and only an estimated 10 to 15 percent entered market channels. Most of the grain moved from the initial market place to secondary and terminal markets for sale as either processed or whole grain. Speculation resulted in price instability, and in four regional markets, price differences of 30 to 40 percent were observed for sorghum, the most important food grain.

An additional fact uncovered by the agricultural economist's survey was that, with proper promotion and support from the government, the farmers' cooperative unions could remove the food-grain handling functions from the control of speculators. Thus, this survey enabled a meaningful approach to be used for establishing project priorities and activities.

The first phase of the project was devoted to the setup, operation, and management of a pilot flour mill.

PHASE I

The initial project was formalized in May 1972. The Nigerian government was responsible for building construction and maintenance costs, and the IDRC was to supply the mill machinery and technical assistance. The mill was built on the compound of the North Eastern State's Ministry of Natural Resources, and the Ministry assumed responsibility for the mill's management and operation. Cooperatives handled the purchase of raw grain and the sale of milled products.

The initial survey indicated that information on grain processing and preparation would be necessary to establish guidelines for the type of milled products, the packaging methods, and the marketing techniques that were required. Accordingly, a preliminary consumer grain-preference study was initiated in July 1972. This investigation identified the resources available to the North Eastern State for carrying out the study and, in addition, provided information on household methods of processing cereal and legume products. An in-depth consumer-preference study was to follow.

Later in 1972, a mill management committee, comprised of members of the Ministry of Natural Resources and the Ministry of Co-operatives and Community Development, was formed to take charge of the grain mill and future related studies. In accordance with the consultant's April report, a CUSO (Canadian University Service Overseas) volunteer was provided to the mill. Although the volunteer was to act as a resident mill advisor, his major work concerned forthcoming grain and grain-legume system studies that would describe the present market and production systems. Harvesting, storage, and distribution of grains in the Maiduguri region were covered. His role as a Canadian representative was invaluable in maintaining liaison between all those involved in the project. During this time, two Nigerian engineering technicians were trained in Canada in the design, operation, and maintenance of the milling equipment.

The pilot mill itself was a comparatively unsophisticated model that was available in Canada. It consisted of four units: a precleaner, a dehuller, plate and hammer mills, and a flour sifter. A unit for heat-sealing plastic bags was also included. Power requirements, totaling 30 horsepower, were supplied by two slow-speed diesel engines. The straightforward system for mechanically processing sorghum, millet, and maize began by cleaning the grain to remove foreign matter. Because traditional

dehulling was done manually, the mechanical dehulling unit represented a technological innovation in grain processing. The dehulled grain was ground in the plate and hammer mills. The sifter subsequently separated the milled grain into three fractions: fine flour, semolina (grits), and middlings.

During construction of the mill building and the installation of the machinery in early 1973, the initial baseline study of consumer preference for household products was expanded. The IDRC home economist was assisted by a nutrition and food marketing specialist from the Government of Alberta, Department of Agriculture, Marketing Division, in the design of the survey. The purpose of this study was twofold: (1) to determine the type and volume of flour to produce in the experimental mill; and (2) to develop a consumer education program for improving household utilization of cereals and grain legumes in the diet. This survey included 1100 households in Maiduguri. The entire Home Economics Department of the North Eastern State was involved in the study.

This consumer preference study showed a trend toward urbanization as indicated by both an increase in the use of

Information gathered on production, marketing, and consumption provided important criteria for implementation of the project.

packaged flours for preparing traditional staple cereal foods and a shift to processed foods. The potential for developing nutritious foods from cereal and legume flours was evident. The survey also indicated that nontraditional foods derived from prepared flours are gaining popularity as part of the Nigerian food pattern; for example, bread is becoming a popular breakfast food. At the time of the survey, 64 percent of the households were purchasing bread, more than half of which was being purchased daily.

Specifically, three areas offered potential for further development and interaction: (1) consumer education; (2) food processing; and (3) the pilot mill and milling program.

The increased choice offered by new convenience foods, plus the continuing preference for traditional cereal foods suggested that a consumer education program should include: (1) supplementation of traditional cereal dishes with high-protein dishes; (2) substitution of sorghum, millet, and cowpea flours for wheat in traditional foods; and (3) development of new dishes containing sorghum, millet, and cowpea flours. With respect to food processing, further study and development in the area of snack-food preparation and consumption and the traditional food processing techniques used by local food sellers was encouraged. Findings related to the applied activities of the pilot mill and its program suggested four main areas of concentration: (1) sorghum and millet flour milling; (2) bread and cereal snack foods; (3) milling and utilization of flour fractions; and (4) potential new products.

An important distinction was made between the preference for finely ground flour and coarse-ground flour (grits) in specific dishes. In most Maiduguri households (92.5 percent), flour is prepared from purchased grain. It is usually prepared two or three times per week. The most common practice for dehulling is hand-pounding in a mortar with a pestle, followed by winnowing to remove the hulls. A large majority of the households (80 percent) send the dehulled grain to local mills for grinding into flour or grits. This latter practice was promoted by the introduction of plate mills approximately 15 years ago. Fifty percent of the households purchase flour, primarily wheat flour and coarse maize flour (grits). The preferred package size is about two kilograms (five pounds).

It was discovered that children in 40 percent of the households received money for snack foods, which were mainly prepared from millet, wheat, and cowpea flours. The most popular snack was *kosai*, fried cowpea balls prepared from cowpea paste. Further investigation into the preferred dishes prepared from the various milled fractions, i.e. flour, grits, and middlings, was considered to be warranted, and a potential

The milled products are packaged in 2-kilogram heat-sealed plastic bags.

for new products in the form of convenience and snack foods was indicated.

During the time of the mill's initial operation (April 1973) and the conclusion of Phase I (November 1974), a wide range of supportive research activities was undertaken. These activities involved cereal-grain and legume processing and utilization.

A test kitchen was established at the mill with a Nigerian home economist in charge. The work program of the test kitchen involved: milled-product quality control; traditional food-product recipes; development, testing, and consumer acceptance of recipes; and demonstration to home agents.

A low throughput of grain (45 to 90 kilograms per hour) in the milling operation was caused by the dehuller. This problem sparked the development, in November 1973, of a supportive two-year research project conducted at the Prairie Regional Laboratory of the National Research Council of Canada in Saskatoon. The existing dehuller was evaluated in terms of throughput, efficiency of husk removal, nutritional quality of

products, and yield of acceptable milled fractions. This attrition-type dehuller was compared with a new type that used abrasive action for dehusking. This new decorticating machine was clearly superior to the one in operation at the mill.

The new huller was further tested and modified to make a simple abrasive machine suitable for sorghum, millet, and cowpea processing. Comparative studies of flour colour and proximate analyses of mechanically and traditionally prepared flours indicated no significant differences in the milled products. The dehuller was able to remove the outer husk layer of the grain efficiently with a minimum of breakage and flour loss.

Since pigments in the millet gave the mechanically processed flour at the Maiduguri mill an undesirable gray-green colour, research was initiated on the preparation of light-coloured millet flour. These pigments were found to be pH sensitive and, subsequently, a simple acid treatment for use with mechanically prepared millet was developed. This enabled the preparation of a millet flour similar to the accepted, traditionally prepared flour.

An initial investigation into the preparation of high-protein fractions from Nigerian cowpeas using simple air-classification techniques was made at the Prairie Regional Laboratory. Mechanical protein-starch separation, using this method, has important applications for the development of protein-rich foods.

Closely linked to the Prairie Regional Laboratory project was the development of a cereal-grain and legume utilization research program at the College of Home Economics, University of Saskatchewan. This two-year project was conducted in conjunction with the Prairie Regional Laboratory project, allowing close coordination of the two projects. Studies were conducted on the physical, chemical, and functional properties of fractions, flours, middlings, and grits prepared by both mechanical and traditional processes in Nigeria and at the Prairie Regional Laboratory. No significant differences were found between the milled products processed by the two methods.

The development of new high-protein products containing sorghum, millet, and cowpea flours received attention. A technique for preparing fried snacks containing various blends of these flours was established. Nutritional evaluation of the product blends confirmed their high-protein composition (approximately 15 percent). Another important research area was the preparation of Nigerian-style homemade noodles *(taliya)* with a partial replacement (up to 50 percent) of wheat flour by various blends of sorghum, millet, and cowpea flours. These

noodles resembled regular all-wheat noodles with respect to cooking quality and texture, and contained between 12 and 16 percent protein (14 percent moisture basis). The techniques developed in this project were to be demonstrated through the test kitchen to small processors, including housewives.

During the latter part of Phase I, the new decorticator was set up in the pilot mill, and attention was given to the processing of sorghum. Although production was still low, the ultimate goal of establishing an efficient, smooth-running milling system was being more fully realized. A systematic means for keeping records of production, sales, and inventory, in addition to milling data, was introduced and subsequently adopted by mill management. Test kitchen activities were broadened and the transfer of the researchers' product development work was encouraged through a Canadian training program for the Nigerian home economist.

PHASE II

The Nigerian government requested an extension of the Maiduguri mill project for another two years. Phase II will concentrate on: further improvement in the efficiency of the mill operation; continued test-kitchen activities related to quality control and recipe development; and the building and operation of a bakery for the preparation of Nigerian-style bread from composite flours.

An earlier project, initiated in 1971 and conducted at the University of Manitoba, had developed a mechanical dough development process that could be adapted to the traditional, low-energy method used in the small bakeries throughout Nigeria. The preparation of bread from composite sorghum and millet flours was studied.

During 1975, the overall mill operation improved dramatically. As illustrated in Table 1, the amount of grain processed per milling day increased and sales rose significantly. In addition, the gross margin indicated an upward trend.

Table 1. Selected data from the mill management record system, January to September 1975.

Month	Extraction rate (%)	Grain processed (per milling day) (kg)	Milled products estimated sales (naira)[a]	Gross margin (naira)
January	76	606	478	34
February	79	334	824	63
March	75	529	1165	154
April	86	410	1876	536
May	91	616	1755	615
June	83	804	3204	760
July	80	995	4108	984
August	82	862	3793	1016
September	80	944	4871	834

[a]Based on the total value (naira) of production and inventories (beginning and ending).

The work program of the test kitchen involves development, testing, and consumer acceptance of recipes and demonstration to home agents.

Sorghum and maize are presently being milled into flour, grits, and middlings. The products are prepackaged into 2-kilogram heat-sealed plastic bags and 45-kilogram cloth sacks. Bran (dusa) is sold in 68-kilogram sacks. A profit of one to two naira ($1.60 to $3.20) is made for each 100 kilogram bag of raw grain that is processed.

The average composition of the milled grain is 26 percent flour, 30 percent grits, 24 percent middlings, and 15 percent bran. Grain throughput in the dehuller has reached approximately 180 kilograms per hour. An increasing demand has now prompted the mill to operate two labour shifts per day instead of one, and production is exceeding one tonne per day.

Initially, all processed grain was sold through farmer cooperatives. However, it was apparent that the products were reaching only a small segment of the population. Agents are now selling the mill products throughout the town and in the market, and the demand for flour, middlings, and grits is becoming more uniform.

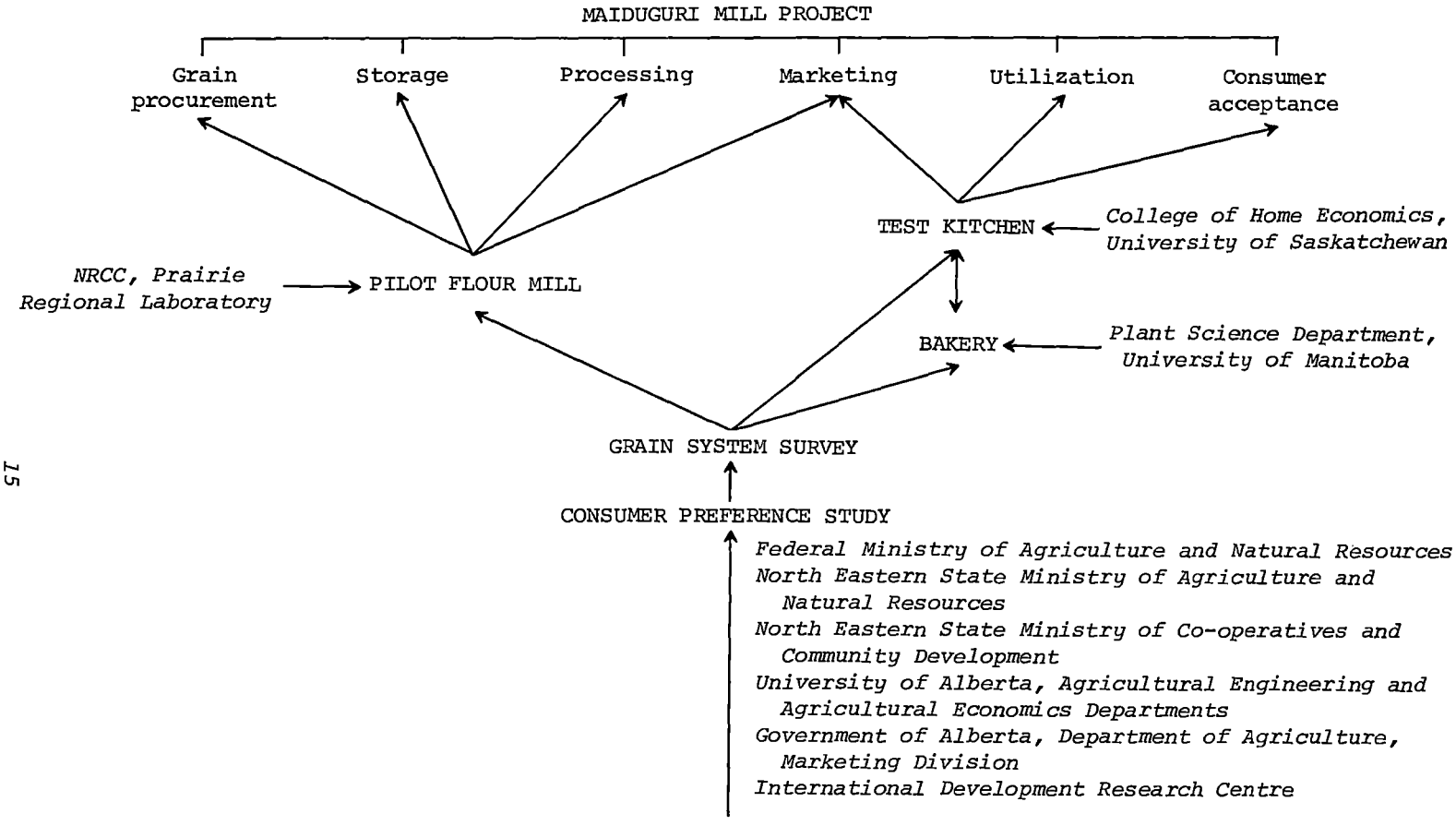

Fig. 2. A schematic diagram of the Maiduguri mill project.

A destoner, capable of removing clumps of dirt and foreign material such as sticks and stones, was added to the milling operation. The present CUSO volunteer who is assigned to the project as the resident mill advisor, will also provide assistance in the construction and operation of the bakery.

The bakery, now under construction, will consist of a small rotary oven, a mixer, a moulder, a doughbrake (sheeting roll), a divider, and a sealer. Bread will be prepared in both the traditional nonmechanical manner, and with the type of modern equipment that is being adopted by larger bakeries. The bakery is intended to serve as a training centre, and to introduce the technology for preparing composite flour bread. A Nigerian baker will be in charge of this operation, while the entire project will remain under the direction of the mill manager.

The activities associated with the Maiduguri mill project, as a major component of a postharvest grain system, are illustrated in Figure 2. Although the project may not cover every component of the postharvest system it serves to illustrate that such a system is made up of various activities that can be combined to form an integrated unit.