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Traveler Dr. Lloyd W. Rooney, Professor, Texas A&M University
Dr. Allan W. Kirleis, Asst. Professor, Purdue University

Date of Travel November 21 - December 7, 1979

Condensed Itinerary

Nov. 21-22 - Travel to Bamako, Mali

Nov. 23 - Sorghum Cooking Trials - Bamako, plus conferences with various officials including Mr. Myron Smith, USAID - Mali.

Nov. 24-27 - Travel from Bamako to Mopti, Bandiagari, Koporo Keniepe and return. Conferred with Experiment Station personnel, reviewed post harvest processes for sorghum and millets by viewing actual preparation in villages, markets, etc. Selected sorghums in the Cinzano nursery.

Nov. 28-30 - Conducted Milling and Cooking Trials, observed commercial milling establishments, conferred with officials and made selections in the nursery at Sotuba.

Dec. 1 - Airplane flight to U. Volta was canceled by airline. Traveled by vehicle to Bobo-Dioulasso in U. Volta. Stopped at markets along the roads.

Dec. 2 - Arrived Ouaguadougou, conferred with ICRISAT personnel.

Dec. 3-4 - Observed Sorghum Quality Trials at Kamboinse, local grain markets, breweries, commercial mills, and conferred with Voltaic nutritionists and Ms. Niec, USAID.

Dec. 5 - Traveled to Po near the Ghanian border to observe sorghum food preparation. Conferred with Dr. Pattanayak, ICRISAT.

Dec. 6 - Conferred with Ms. Niec, USAID. Departed to Paris.

Dec. 7 - Rooney returned to College Station, Texas. Kirleis went on personal business to Germany.

General Comments We accomplished our objectives of obtaining detailed information on the detailed procedures used in preparing foods from millet and sorghum. We were able to document the essential details to enable us to develop useful laboratory procedures for simulating actual traditional methods. This will let us devise procedures for selecting grain quality in the sorghum and millet improvement programs. Dr. John Scheuring, ICRISAT-Mali, made all the necessary arrangements, served as interpreter and was responsible for the accomplishments. Mr. Kabore and Dr. Pattanayak had an excellent program arranged in Upper Volta although it was shortened by our travel difficulties.

We consumed sorghum and millet Tô, Cous Cous, Dagadi and beer several times which helped to confirm observations regarding quality of the products.

Agencies and Individuals Contacted

Mali

Dr. John Scheuring, Sorghum and Millet Breeder, ICRISAT, Bamako-Sotuba

Mr. Phil G. Serafini, Agronomist, ICRISAT, Bamako-Sotuba

Mr. Jerry Johnson, Agronomist, SAFEGRAD, B.P. 34, Bamako

Mr. Myron Smith, USAID

Mr. Lassina Dembele, Acting Director of Agronomic Research and Head of Seed Production Control, Ministry of Agriculture, Bamako-Sotuba

Mr. Verhima Sidibe, Dirdctor of Entomology and Pathology, Ministry of Agriculture, Bamako-Sotuba

Mr. John Rowley (Mr. Geof Gilman), Office des Produits Agricole Malienne (OPAM)

Mr. Bill Carberry, U.S. Peace Corps, B.P. 128, Mopti

Ms. Debbie Hill, U.S. Peace Corps, Bamako

Upper Volta

ICRISAT, PNUD, Ouaguadougou, Upper Volta

Dr. C. M. Pattanayak, Team Leader, Sorghum Breeder

Dr. Peter Lawrence, Millet Breeder

Dr. Wesley R. Root, International Intern - Sorghum Breeding

Mr. Etienne Kabore, Technician

Dr. W. Stoop, Agronomist

Dr. A. Frowd, Pathologist

Mr. Georges Sempore, Chief; Mr. Alfred Sawadogo; Mr. Jean-Claude Ouedraogo, Service De Nutrition, Direction des Services Agricoles, Ministere du Developement Rural, B.P. 7028, Ouaguadougou

Ms. R. Niec, USAID-SAFEGRAD, Ouaguadougou

Post Harvest Technology of Sorghum and Millets in Mali and U. Volta

NARRATIVE:

General:

This report is a summary of our general observations relative to the use of sorghum and millets in Mali and U. Volta. We recognize the futility and folly of being instant experts in so short a time span. However, we feel that because of the previous work and observations of ICRISAT personnel that we were able to confirm their findings and develop more detailed observations of the variations in sorghum and millet use. We will divide the report into major sections on milling, Tô, Cous Cous and brewing. Other items will include observations on sorghum and millet varieties, miscellaneous foods, potential collaborators and recommendations.

Milling

Generally, sorghum and millets are dehulled and ground into flour in Mali and U. Volta. Sorghums and millets are dehulled (pearled) by pounding the grain in a wooden mortar with wooden pestle or by use of small commercial pearlers (dehullers) in some urban areas. The pearled grain is reduced to flour size by additional pounding in the mortar, by using a stone metate or by use of small commercial hammer and attrition mills. In general, sorghum is nearly completely dehulled while millet often has considerable pericarp remaining or it is ground without pericarp removal.

1. Use of the Mortar and Pestle (Kolon Kala). The grain is threshed, winnowed and the clean grain is covered with water in a calabash. Impurities are removed by flotation, the water is decanted and the moist grain is placed in the Kolon. Grain with glumes is pounded lightly in the Kolon and washed to remove the glumes. In some cases, market samples may be screened and hand picked to eliminate impurities prior to milling. In general, care is taken to completely remove glumes.

The pericarp (bran) is removed by vigorous pounding with wooden pestles by one, two or more women and young girls depending upon the size of the mill and the sample. The time required to mill one kg of sorghum in a mortar by one woman ranged from 8 to 15 minutes depending upon the variety. Sorghum varieties with a thick pericarp (chalky mesocarp) were preferred by the women because they were most easily milled. Sorghums with a thin, pearly pericarp required more effort to mill and usually additional water was added to them during milling. When pressed, the women acknowledged that the greatest yields of flour were obtained from the pearly sorghums but, they definitely preferred the chalky locals. These observations were consistently confirmed in U. Volta as well. Data on milling studies

conducted at Kamboinse illustrated and confirmed these observations that chalky (thick) pericarp sorghums were preferred for milling. Sorghum kernels with a soft, floury endosperm were not desirable either because they break down during milling too extensively. Thus, the pericarp is not removed as completely and milling losses are greater.

Mortar and Pestle Milling Studies
at Kamboinse Upper Volta. December 4, 1979
Table I

Sorghum	Initial Grain Moisture (%)[a]	Grain Weight (g)			Dehulling Time (min)
		Initial	After Dehulling[b]	Dried Dehulled[c]	
S-940 (chalky)	7.7	1000	--	--	11
local mixture of pearly & chalky	--	1000	1250	810	11
local (chalky)	10.7	1000	1250	820	8
E-35-1 (pearly)	9.8	1000	--	--	14

[a]Determined on Burrows Model 700 Digital Moisture Computor.

[b]Grain weight "after dehulling" equals inital grain weight plus the weight of temper water added to the grain during dehulling.

[c]"Dried dehulled" grain weight equals the weight of washed dehulled grain given an afternoon and overnight drying period.

Upon completion of pearling, the material is placed in a calabash and washed with water. The bran water is fed to livestock. The wet, pearled sorghum is allowed to dry for a short time prior to grinding into flour. Sometimes, bran is removed by drying the pearled grain in the sun and winnowing it to remove the bran. Both methods are effective.

The pearled sorghum is reduced into flour by additional pounding in the mortar. The ground material is sieved with hand sieves and the overs returned to the mill for additional grinding until it passes through the sieve. Another alternative for flour production is to grind the moist pearled sorghum with a stone metate. An increasingly popular option is to take the moist pearled grain to a diesel or electrically powered attrition grinder or hammer mill. The homemaker is charged 15-25 Fr. per unit (volume) of grain milled.

2. Commercial Mills & Milling Procedures. Four Malian and four Voltaic commercial milling operations were visited. These mills

included installations with a pearler (dehuller) and grinders, with only a pearler and with only grinders. The most prevalent milling operation consisted of grinding mortar and pestle hand pearled grains into flour. However, one mill in Mali specialized in pearling the grain.

Stone grinders and steel attrition mills were most common. A Hunt Premier grinding mill Model No. 1 A manufactured by R. Hunt & Co., Ltd., Atlas Works, Earls Colne, Colchester, England was common in both countries.

The following comments pertain to the commercial milling installations in Bamako, Mali:

Unit #1 Miller named Traore located in the Messina Medina Coura part of town. This operation had two No. 1 A Premier attrition type mills manufactured by Hunt Ltd. Observed corn, sorghum (dehulled) and millet (dehulled) being ground into flour on the Hunt mill. All these grains were quite moist as they entered the mill. The corn was estimated to contain at least 25% moisture. The feed rate of the mill was hand controlled and the gap between the grinding plates was adjusted by the operator according to the grain being ground. Samples collected from this milling unit were: 1) Corn flour (11287901), 2) Pearled sorghum flour (11287902), 3) Millet flour (11287903), 4) Millet flour (11287904). These samples were quite warm and probably have extensive starch damage. Flours did not feel gritty.

A stone grinder (attrition type) at this mill was no longer in use because the power consumption of the grinder was much higher than that for the Hunt mill for grinding an equal quantity of material. A third grinder (hammer mill) at this milling unit was used for grinding dry material. Dried okra was specifically mentioned as one of the products ground on this mill.

Major problems encounted by the miller were:

1) The grooved grinding plates wear smooth and must be refaced. Maintenance is a real significant problem.
2) When the mill is used continuously, heat build-up becomes a problem. We observed that the milled samples were hot and high levels of starch damage might be expected.
3) When corn is milled it normally required two passes through the mill if the grain is dry - a single pass produces a coarse grit. However, moist or wetted corn can be ground into flour on a single pass. Of course, if the corn is too wet it forms a paste and clogs the mill.
4) The miller had operated a dehuller but discontinued because of excessive maintenance, power and failure to find inexpensive repairs.

Unit #2 Located in Humdilia part of town: This mill was not operating because power was turned off because the electric bill was not paid. Equipment at the mill included:

1) An abrasive pearler (dehuller) which consisted of a 4-6 inch diameter stainless steel cylinder with equally spaced stainless steel impact bars (ca ½" x ½") mounted horizontally on the external surface of the cylinder in order to move the material toward the exit end of the dehuller. Surrounding the internal cylinder was another cylinder about 8-12 inches in diameter with elongated hole perforations (screen) on the lower quadrant of the unit. An adjustable steel bar was fitted to the full length of the outer cylinder to adjust the severity of dehulling. The grain is milled by abrasive action of grain on grain and grain on the surface of the cylinders. The mill is filled with grain to develop sufficient pressure to abrade the pericarp.

Dehuller problems were:

1) Wear on the internal cylinder and impact bars.
2) Impact bars come loose from the internal cylinder.
3) Difficult to obtain dehuller replacement parts.

This milling operation also had a Hunt, No. 2 A Premier attrition mill. Commercially pearled sorghum retained more pericarp than hand pearled sorghum. Sorghum was more completely pearled than pearl millet. The cost of pearling and grinding equal measures was 25 and 15 Francs ($1 = 400 Fr.) respectively.

Unit #3 Located in Youssonl Kesta part of town: Only a dehulling operation with an estimated capacity of 3-400 Kg grain/day. The owner of this operation once worked as a blacksmith. Therefore, he is able to repair and rebuild dehuller parts. He plans to add an attrition mill if he can obtain the capital. Type of dehulling equipment was the same as seen at Unit #2's operation. Owner said the dehuller is now being manufactured in the Ivory Coast.

The dehulling operation was as follows:

1) Housewives brought grain samples to the mill in various size calabashes. The samples were screened by hand to remove foreign material and the number of measures (volumetric) was determined. Measures varied in size from mill to mill so no comparison of cost was obtained.

2) The grain was tempered by addition of water; the grain and water was mixed and allowed to stand for up to 5.0 minutes before milling.. Usually it was milled within 2-3 minutes. Grain was probably tempered to about 12 to 15% moisture; but, the water was mostly in the pericarp so actual moisture added may not be 15%.

3) The exit gate on the dehuller was closed and grain was fed into the dehuller until it was filled. This was usually announced by a high pitched whine. Then, the exit gate is opened and material flows continously through the mill. The pressure on the exit gate can be adjusted to control the extent of dehulling, if desired. The feed gate is also adjustable.

4) Millet, sorghum and corn require different levels of moisture for tempering with millet requiring the most and corn the least. Kende, a thin, pearly corneous sorghum, requires a greater moisture level and more temper time than Keninke, a local sorghum with a thick, chalky pericarp. The miller preferred Keninke locals. They were also preferred for mortar and pestle milling. Breakage can be a problem with some softer sorghums.

5) The milling by-product, bran, is sold for animal feed at 1,000 Fr. per flour sack.

6) The mill was extremely busy with numerous grain samples awaiting dehulling. The miller was extremely progressive and could be an excellent cooperator for milling studies although he might be too busy.

Commercial Mills in Ouaguadouga, Upper Volta:

Unit #1 This operation had an attrition mill (Hunt, No. 1 A Premier) and a stone grinder (vertical). These mills were identical to the mills seen in Bamako, Mali.

The owner reiterated what was said in Mali - that the stone grinder is more costly to operate than the attrition mill.

Unit #2 This operation had two Hunt Mills (No. 1 A Premier and No. 2 A Premier). We observed that whole grain millet was given two passes through the mill to produce the desired flour partical size. This miller said his major problem is attrition plate wear. Turning parts wearing out (bearing, etc.) was identified as a secondary problem. He indicated that when the mill is properly maintained (grease bearings) the bearings have a life of one to two years.

Unit #3 This operation had a dehuller and stone grinder (vertical). The dehuller (model no. 680113) was manufactured by Körber & Naumann, Masch. Fbr. Mühlenbauanstalt, 74 Berzeliusstr 7, Hamberg 74 Germany. The owner indicated that he is able to purchase a new dehuller but is unable to obtain replacement parts (especially the center shaft).

Unit #4 Equipment at this operation:

1) Hunt, model No. 1 A Premier Attrition Mill.
2) Dehuller
3) Stone grinder (vertical), New Super, EXT 1, Erling-Foss-Export, DK 2200 Copenhagen, Denmark.

The owner indicated he is using the stone grinder because he was able to buy it at a low price.

Future Trends in Milling

In both countries the trend is toward increasing use of small mills to pearl (dehull) and to grind the dehulled (pearled) grains. Mr. Ismael Soumailia of S.C.A.E.R. in Bamako is involved in government importation of agricultural equipment into Mali. He indicated that 30 dehullers have been imported from China within the last year.

Most of them stay in the Bamako area, but demand in other towns exists also. Cost of the mill powered with a 24 hsp. engine is $2000.00 (U.S.) in Bamako. Electrically powered mills are $1200.00 (U.S.). The mills are: Rice Milling Machine, Model LN 632 F, sold by China National Machinery Import and Export Corporation, Shantung Branch, 82, Chung Shan Road, Tsingtao, China. The Hong Kong address is: China Resources Co., Bank of China Building, Hong Kong.

Commercial milling of sorghum is increasing in the urban centers rapidly and even in large villages. The increase is likely to continue. The Chinese made mills can be maintained with locally made parts. Chinese grinders are available; but, have not enjoyed the success of the dehullers.

Mechanical Dehulling and Grinding Equipment at Kamboinse

ICRISAT/Upper Volta is studying the use of a CeCoCo rice mill for dehulling sorghum mechanically. They are also using a gasoline powered hammer mill (Monta, Campsas 82370 Labstide St. Pirre) to produce sorghum and millet flour. This mill has interchangeable screens for making coarse and fine flour. The hammer mill (fitted with the fine screen) was demonstrated with E-35-1 dehulled sorghum. The flour from this mill had a very sandy texture and was coarser than stone ground E-35-1 flour. Proper tempering of the dehulled grain might reduce the gritty characteristics; but, use of hammer mills may produce gritty flour compared to attrition mills. It is something that must be considered in view of other observations of sandiness (grittiness) in composite flours made of sorghum and wheat flour.

The experimental milling system at Kamboinse has not been developed and evaluated yet. Limitations of time and personnel has not permitted its correlation with traditional methods. Rooney has collaborative work on Tô quality testing underway with U. Volta/ ICRISAT. Mr. San San Da, a graduate student at Texas A&M on leave from ICRISAT/U. Volta, is working on breeding and selection schemes, for Tô quality. He has made progress on methods that use small quantities of grain for To evaluation as part of his thesis research.

Grain Marketing and Government Policy

OPAM (Office des Produits Agricole Malienne) is the Government Marketing Board for grains in Mali. The agency has the responsibility for grain procurement, storage and distribution to the urban sectors of Mali. About 80% of the total grain produced in Mali remains on the farm where it is produced. OPAM handles about 20-30% of the grain that is not used on the farm (≅5-7% of total grain production). The objective is to control prices, supply deficit areas and supply the sectors. The government sets a fixed price that they will pay the farmers (50 Fr./kg) and sells the grain to consumers at 70 Fr./kg. Sorghum was selling for 100 Fr./kg in the wholesale grain markets in Bamako. In addition, grain in U. Volta brings significantly

more than in Mali which encourages Malian grain movement to U. Volta. Thus, a parallel market exists and grain finds its way to U. Volta for sale in spite of government efforts to control it.

OPAM procures grain supplies by assigning quotas of grain for each Avvondissement within each circle of the region. The quota must be sold to OPAM at the official government price, usually through an intermediary such as Operation Mils Mopti for the 5th region which is a major grain production area. Operation Mils Mopti serves as a device to disseminate improved farming methods such as fertilizers and insecticides, farm equipment and development assistance. In a sense, the forced sale of grain to the government is a tax which may be an efficient way to take care of needs in the urban sector. But, low grain prices discourage increased production of grain.

Quality of the grain OPAM received and stores has been surveyed by Mr. W. Settle, a Peace Corps entomologist, by screening sacks of millet and sorghum obtained from four different circles. A total of 126 100-kilo sacks of sorghum and millet were screened. Deliberate adulteration of grain sacks was suspected in only a few cases. Most of the impurities were fine sand, seeds, dirt, stalks and rocks which are natural contaminants of grain threshing and handling. Usually, the level of impurities is quite low (3 to 4%). Insect damage varied and was thought to be related to the age of the grain as some grain is reportedly stored in the Dogan Country up to 10 years. The oldest grain is sold to meet the government quota. Moisture content is extremely low, from 7.7 to 9.7%, which probably permits extended storage without serious insect problems.

Other methods may control insects. For example, a fumigation procedure in the Dogan Country is to place bundles of branches and leaves from a local tree and/or shrub in the empty grain bin. Then, dried millet stalks are placed inside and burned. The shrub has not been identified. Sorghum is sometimes mixed with ashes for bulk storage of threshed grain while millet is usually stored on the spikes. We observed millet that had been in storage for four years which looked relatively free of damage.

The grain procured by OPAM was bought at a fixed price without apparent regard to quality. Therefore, the freedom from gross contamination is a compliment to the Malian farmer's integrity. Only one sack of 125 contained excessive foreign material, i.e. 30 kg of soil, which suggested intended adulteration.

Harvesting and Threshing

Sorghum and millet heads are cut from the stalk, carried into piles at the edge of the fields and then transported to the village for storage and possibly threshing. For millet, the heads are stored and grain is threshed with a mortar and pestle by the housewife as needed. When larger quantities are threshed, the millet or sorghum is placed on cleared ground and beaten with flails (sticks). The

grain is collected and winnowed to remove trash. Sorghum is more likely to be stored in threshed form although we observed sorghum heads stored in granaries also.

Granaries

Grain storage structures varied significantly in construction in areas of Mali and U. Volta. Granary construction in the Dogan Country of Mali is of mud reinforced with Fonio Straw. The granary is supported above the ground, has a mud top covered by thatch to shed water with a wooden granary door that has an intricate wooden lock. Numerous granaries exist and are an index of wealth and status. The Chief is responsible for securing adequate grain supplies for "Le Grande familia". Thus, he has the keys to the granaries and provides portions of grain to the women for food preparation for the family. Failure to provide sufficient grain for family needs is a severe short coming.

The granaries in U. Volta are constructed of grass that is woven together with a thatched roof. They are above the ground; but, are not nearly as sturdy nor as good as those in Mali appear to be. In some villages, up to 20 granaries per compound appeared common. The severe nature of the area produces variable crops so grain to meet the needs for several years is stored by these hardy people.

Sorghum types

In Mali, 900 local sorghums were collected recently. Dr. Scheuring grew this collection this past year and we were able to observe it at two locations, Sotuba-Bamako and Cinzana. Considerable grain weathering and molds had attacked the Sotuba-Bamako nursery; but, the grain at Cinzana was not weathered. The Cinzana nursery had suffered severe drought stress. Even so, considerable grain was on many of the locals. Interestingly, TAM623 (tropical adapted from Texas A&M) had a good yield of grain.

The local grain types, called "Kende" types have small, hard, corneous kernels with a thin, white or red pericarp. The 1,000 kernel weight varied from 15 to 20 g. Kende types are milled by pearling and are preferred as rice substitutes. They are used for Tô, Cous Cous and Bouille also. They are Margarita Ferum according to Snowden's Classification. Some brown Kendes were present in the locals, according to Dr. Scheuring. This should be confirmed since the corneous endosperm might permit milling of brown kernels to remove condensed tannins.

"Keninke" is the local name given to a type of sorghum with rounded, elliptical seed similar to conspicum but smaller. 90% of the Keninke types have a thick, chalky pericarp and many have purple splotches on the pericarp. The apparent grain characteristics of TAM623 is very similar to that of many Keninke types. Some have a thin, pearly pericarp. Red pericarp was observed although it is not

common. The French called Keninke "sorghum gambicum". Guinensia is Snowden's Classification. The head and glumes resembles that of conspicums. Keninke is used primarily for Tô, Bouille and Cous Cous. Keninke is the most important sorghum in the areas of Mali we visited as judged by markets, although Kendes were observed in villages' stored grains.

Durras "Gadiabia" sorghums in the Malian collection originated mainly from the northern parts of Mali where they are grown. They have typical durra characteristics with considerable variation in kernel size and color. Many of them have pigmented undercoats (testa). Dr. Scheuring has observed some lines that appear to have a modified testa which is extremely thin; but causes severe off color under certain environmental conditions. The durras appear to be an excellent source of drought resistance.

Tan plant color was the exception rather than the rule. Apparently, as is true in other areas of Africa, plant color is not a major hang-up.

Special Use Sorghums

A sorghum head with large dark brownish purple glumes and white kernels is steeped in hot water to produce "coffee". Other sorghums are grown to produce dyes for staining cloth. Some special sorghums are reportedly grown in some parts of Mali and U. Volta around the villages. They are harvested in the dough stage, steamed and eaten. Pop sorghums apparently are not known. Parching or puffing (expansion) of sorghum and millets is not done. Yellow endosperm sorghums were not present to any extent in the Malian sorghum collection.

In grain markets in Bamako and numerous villages and local markets we observed mainly white chalky "Kinenke" grain types. Kende types were present; but composed considerably less volume. Some Gadiabia (Durra) types were present in the Bamako wholesale grain markets probably coming from N. Mali via OPAM since it was heavily damaged by insects.

Upper Volta

The predominant type of local sorghum was a conspicum with a thick, chalky pericarp. Some had purple splotches on the pericarp and undercoats exist. We examined grains in the markets as we drove from Mali to Ouaguadougou. This circumstantial observation suggested a gradual transition in grain kernel characteristics. Brown sorghums with an undercoat ($B_1B_1B_2B_2$) and dominant spreader (SS) were used for beer production and special "health foods". Red sorghums grown in Eastern U. Volta were present in the Ouaguadougou grain market. Brown and red sorghums were cheaper than the white locals. Sometimes, red grains were blended with white grain. Some pearly, white sorghums were in the market; but the predominant type had a thick pericarp. A grain trader confirmed that the pearly sorghums were generally con-

sidered hard to mill although they gave greater yields of flour than chalky types.

Millet

Millets in Mali consisted of two distinctly different types, the Souna and Sanio. The Souna is an early maturing millet that cannot be stored for more than two years without developing an off flavor. Sanio (Sanyo) is late maturing, tillers profusely if moisture is good and can be stored for four years or longer. Apparent differences in kernel size and shape, and probably the germ to endosperm ratio were observed. Malian millets that we saw in the markets were slate gray and of the Sanio type. Yellow endosperm millets were not observed.

In Upper Volta, considerable quantities of yellow endosperm millet were observed along with the Sanio slate gray millets observed in Mali. Dr. Scheuring had 400 local Malian millets growing; but time did not permit travel to the nursery to observe them. Dr. Scheuring's observations were that the local Malian millets were far superior to any of the exotic millets in the ICRISAT millet nurseries. In general, people seemed to prefer the strong flavor of millet for Cous Cous production although it is almost impossible to completely remove the pericarp by milling.

Other Crops

Fonio, Digitaria exilis, is grown in Mali. It has small seeds which are pearled and used similarly to sorghum and millets. Yields of grain are 300-400 kg per hectare; but it grows under extremely poor conditions. Fonio straw is prized for reinforcing adobe for building construction, especially granaries. Eleusine coracana (finger millet, ragi) produced high grain yields in some ICRISAT trials in Mali and may have a niche in cropping systems particularly in low spots where it can be planted as the water recedes. Pigeon peas looked extremely promising. Preliminary efforts to mill ragi and pigeon peas are described elsewhere.

Ground nuts, cow peas and Bambara nuts are major crops. Rice is grown along the Niger river. Some African red rice was observed in the markets. Dry roasted Bambara nuts tasted like hard, dry roasted groundnuts. Cow peas varied considerably in color with insects causing major damage during storage. OPAM has major problems with insect damage in stored cowpeas.

Tô Production Methods

Tô is the name in Mali and Upper Volta which is generally used to refer to a stiff porridge made from sorghum, millet, maize or Fonio flour and eaten with a sauce. Tô is known by numerous names in Africa where it is consumed in some form. For example, it is known as aceda or asidah in the Sudan, bogobe jwa ting in Botswana, tuo, tuwo, akfa, eko tutu etc., in Nigeria, tuo jaafi in Ghana, ugali in

Kenya, atab in Uganda and sangati in India. Nearly 80-90% of the sorghum grown in Mali is consumed as Tô. It is the major food in Upper Volta although several sources estimated that at least 30% of the sorghum in U. Volta is consumed in beer production.

The procedure for making Tô in Mali and Upper Volta differs significantly. Generally, dehulled sorghum is used in both countries. Completeness of dehulling varies among tribal groups; but our observations suggest that dehulling is rather complete for most sorghums. Certain soft, brown sorghums are used without dehulling. Sorghum flour is sifted through a fine sieve. The major difference is that alkali is used in Mali while acid is used in U. Volta. In Mali, the Tô during cooking is beaten vigorously on the side of the cooking pot. In U. Volta, the mixture is stirred during cooking but it is not nearly as vigorous. The combination of alkali and vigorous stirring makes Malian Tô considerably different from that made in U. Volta. The taste, texture, keeping quality, color and probably the nutritional value is affected by these critical changes. Thus, the properties of sorghum for good Tô quality in U. Volta differs from that of Mali. Observations by Scheuring and Pattanayak on E-35-1 grain already document differences. Thus, procedures to make Tô with alkali and acid are needed.

Tô Preparation

All cooking was done on an open fire using a metal pot. Heat was carefully controlled. The following is a general step by step procedure, without proportions, used for making Tô. The relative proportions of flour to water were not documented; but Dr. Scheuring has agreed to obtain data on this in future cooking trials.

1) Bring water to boil.
2) Add small piece of alkali (wood sorghum, or millet stalk ash concentrate) solution pH 8.9. The alkali is obtained by leaching the ashes of millet (preferred), sorghum or wood with water. The water is allowed to evaporate. Or the leachate (liquid) is used.
3) Add a small portion of flour to the boiling alkali solution while stirring thoroughly to avoid lumps after each addition. Sometimes a small amount of sorghum flour is thoroughly dispersed in cold water which is added to the boiling water.
4) Continue cooking until smooth and thick. This is referred to as Bouille. Sometimes it is consumed after cooling as a thin porridge. Special bouilles are given to young children.
5) A portion of the bouille is placed in a calabash. Then the remaining flour is mixed in small proportions into the bouille in the cooking pan. The bouille from the calabash is added after nearly all the flour has been stirred into the cooking pot.
6) The mixture is heated with vigorous stirring - which involves beating the thick porridge against the side of the cooking pot. A wood paddle is used for stirring and beating. The vigorous beating avoids lumps, probably incorporates some air into the porridge and

undoubtedly produces more complete gelatinization and eliminates gritty particles that would affect texture.

7) The heating and stirring is continued at low heat until the porridge changes color (slight darkening). We were never able to clearly distinguish the color change.

8) Porridge was placed in a shallow pan to cool. It was served after one or more hours of cooling with a sauce. It is consumed by taking a handful, dipping it in the sauce and chewing.

9) Uneaten portions of the Tô are held overnight and consumed the following day. The cold Tô is placed in a pot with a small amount of water and warmed. Alternatively, the cold Tô is consumed with a hot tea and/or sauce. Texture changes during storing are especially important.

10) In Mali, we observed Tô production in several villages and ate Tô from a common pot with our fingers several times. Adherence (stickiness) of the Tô to the fingers and teeth are major quality defects. Differences among varieties were apparent. Color differences exist; but, are not major quality factors unless the color is intensely dark. A light yellowish color (E-35-1) is preferred. In fact, Tô made from yellow maize grits (U.S. Soy Fortified Corn Grits) is well liked. A yellow endosperm sorghum might be useful. The alkali reacts with the phenols to intensify color.

Tô Preparation - U. Volta

Tô preparation in U. Volta at Kamboinse by Mossi women was as follows:

Preparation of Tamarind Solution. Dried tamarind (*Tamarindus indica*) pods (360 g) were soaked in water (1610 ml) for about three hours and then boiled in a covered container for 10-12 min. The boiled mixture was cooled and the liquid was separated from the solid tamarind. The tamarind solution was between 4-5 in pH.

Tô Preparation. (see proportions used in Table)

1) Approximately, a 50-50 (v/v) mixture of tamarind solution and water was placed in a metal pot and brought to a boil.

2) A small volume of the boiling solution (step 1) was removed and mixed with about 1/5 of the total flour which was stirred until it was smooth.

3) The flour mixture was added (step 2) to the remaining boiling solution (step 1) and stirred until it was smooth. The combined mixture was heated without stirring for 5 to 7 minutes (heating time may vary when proportions change). The pH of this mixture was 4 to 5.

4) Two calabashes (cup size) of the thin paste were removed from the hot mass and set aside.

5) The remaining flour was added to the thin paste (which was heating) with stirring until the mixture was again smooth.

6) The thick paste was heated with stirring (step 5) for about one minute and the thin paste set aside (step 4) was added.

7) The mass was stirred with heat until stiff. This took about 6 min. depending on the quantity of Tô prepared. The pH of the finished product was between pH 4-5.

8) The cooked Tô was placed into a calabash, allowed to cool and was consumed with a sauce. Definite differences existed for the sorghums. Observations of proportions, cooking times and temperatures are as follows:

Proportions of flour, tamarind solution and water used at Kamboinse for Voltaic Tô:

Proportions Used

Grain	Flour	Tamarind Soln. (ml)	Water (ml)	Total Liquid (ml)	Liquid/Flour
S-940 sorghum	250	~600	480	1080	4.3
local sorghum	250	~600	590	1190	4.8
local millet	250	280[a]	720[a]	1000	4.0
E-35-1 sorghum	250	220[a]	880[a]	1100	4.4

[a]normally more tamarind solution is used - began to run short, therefore the amount was reduced and made up with water.

Cooking time, temperature and Tô pH taken at Kamboinse:

Grain	Thin Paste			Thick Paste		
	Total Time (min)	Final Temp (°C)	pH	Total Time (min)	Final Temp (°C)	pH
S-940 sorghum	-	~90°	4-5	-	>90°	4-
local sorghum	7	~90°	4-5	6	>90°	4-
local millet	6	~90°	4-5	6	>90°	4-
E-35-1 sorghum	5	~90°	4-5	6	>90°	4-

At Kamboinse we were shown an alkaline solution (pH 10-11) prepared by leaching sorghum and millet stalk ashes with water. Opinions varied on the percentage of Voltaics who use alkali. In general, alkali is used to produce Tô for people who are sick. However, it is used by some tribes routinely. For example, the Lobi in South-western U. Volta use alkali routinely in Tô production. However, the majority of Voltaic Tô is made with acid, i.e. tamarind, lemon, etc. The taste of Voltaic Tô differed significantly from that of Mali as would be expected.

Cous Cous Preparation

Sorghum and millet Cous Cous preparation was observed in several

villages in Mali and by two different tribes in U. Volta. The procedures were essentially the same. Cous Cous is considered a fine food especially that of millet which is valued for its fine flavor. Dried Cous Cous is used as a convenience food for unexpected guests, etc., because of its keeping properties. We consumed sorghum, millet and dried millet Cous Cous several times with great relish. Dried Cous Cous reconstituted with milk and sugar had the texture of "Cream of Wheat" cereal only the flavor was better. Moist Cous Cous was consumed with a sauce which in some cases was highly seasoned. Again we consumed Cous Cous willingly with great gusto. The only defect observed was grittiness probably caused by a little fine sand remaining in the products.

A typical procedure for Cous Cous is:

Sorghum or millet flour prepared from pearled grain in "Kolon Kala" mill was screened through a fine sieve. The ground material on top of the sieve was pounded until it passed through the sieve. In some cases, ground whole millet grain is utilized.

1) Several increments of water were added to flour with hand mixing to distribute the water uniformly. The operation was accomplished in a large calabash. The mixture was worked to eliminate large lumps and to obtain uniform water distribution.

2) The last step in the agglomeration process was to knock the calabash containing the agglomerated sorghum flour against one's leg several times. This tends to distribute the product from the bottom to top and vice versa.

3) The agglomerated flour was screened on a sieve with larger openings than those for the flour. The overs were put back into the calabash and broken down by rubbing against the side of the bowl. This operation was repeated until all of the agglomerated flour passed through the coarse screen. This produced agglomerates with uniform size.

4) The screened, agglomerated flour was placed in a Cous Cous cooker which is a pot with many round openings in the bottom. The Cous Cous pot was placed above a pot of boiling water. The two pots were sealed together with cloth soaked in wet okra powder or oil to prevent loss of steam. The upper pot containing the agglomerated flour was covered.

5) The agglomerated flour was steamed for about 30 min. As the steaming process continued the Cous Cous became darker in color. Several times (3) the partially cooked material was removed from the pot and stirred or broken apart by hand.

6) Finally, near completion of cooking, the steamed Cous Cous was mixed with some dry, powdered baobob (Adamsonia digitata) tree leaves (bright green color). After additional cooking it was served with a sauce. Sometimes, peanut butter or gumbo (okra) was added to the Cous Cous instead of the baobob leaves. The cooked Cous Cous is sifted or stirred to reduce any clumps that might have developed

during cooking.

7) For dried Cous Cous, the ground baobob leaves were not added. The Cous Cous was not completely cooked before it was spread in the sun to dry. Cooking inactivates the enzymes and dried Cous Cous apparently stores nicely although no estimate of storage time was indicated. The sun dried Cous Cous is broken into individual particles with a mortar and pestle followed by sieving (coarse screen) to achieve uniform size.

8) The proportions for Cous Cous made from whole millet flour at Kamboinse were: 550g of whole grain millet flour (through a fine Tô flour sieve) and 310 ml of water. The moisture content of agglomerated flour varies from 40 to 50% (estimated).

Cous Cous quality is judged by taste. A bland taste is undesirable which probably explains why millet is often used. Color is not important. For Cous Cous preparation, sorghums with dark color are okay. Cous Cous accounts for only a small portion of total millet and sorghum consumption. It is considered a super food reserved for special occasions because its preparation is more complex, time consuming and requires special sauces (more complex). The daily activities of women do not allow time to prepare it routinely. Cost of energy (wood) for cooking is undoubtedly a serious consideration. Some sorghums apparently make better Cous Cous than others. Adverse quality is related to excessive "clumping" of the agglomerated particles together during steaming. It might relate to stickiness. Turning the Cous Cous during steaming permits uniform cooking and product color and prevents clumping and overcooking. The ground baobob leaves or okra may help prevent clumping, adds flavor and improves acceptability.

Sauce Production

Sauces for Tô and Cous Cous differ in complexity with Cous Cous the most elaborate. In general, Tô sauce contains whatever is edible and available. Gumbo, tomatoes, onions and garlic, fermented Da, Neme seed, salt, peppers or chilies, peanuts, cow peas, cooking oil, baobob powder, various dried leaves, meat and fish are ingredients used in the sauces. At times, Lung fish are dug from mud of dried lake beds and incorporated into the sauce. The dry ingredients are usually ground by pounding them in a small mortar with a pestle. The sauce is boiled vigorously followed by simmering. We generally had sauces that included meat, and even a boullion cube (once). The general availability of meat in the sauces was not determined. The Cous Cous sauces we consumed were spicy, aromatic, and reminded Rooney of good Mexican style foods of Texas.

The sauce composition probably plays a major role in nutritional supplementation of the cereals. A thorough study of the actual kind and quantity of sauce ingredients would be extremely useful. This might be accomplished by a Peace Corps volunteer in Mali or by the

Voltaic Nutrition Service (see section on recommendations) group. Mr. Sempore's group has some interesting data on village surveys in U. Volta and will be doing more.

We encouraged Ms. Debbie Hill, a Peace Corps volunteer in rural health in Mali, to incorporate a study of food consumption in her work on village nutrition and health care. More reliable observations of actual food consumption patterns in a village could be useful. Also more specific, reliable information on food preparation could be obtained. The extra work involved would not necessarily be great; but, key observations could be made that would be very useful.

Brewing of Sorghum and Millet

Sorghum and millet beers were tasted, drunk and observed in markets and a beer hall in Mali and in U. Volta. Several different Voltaics consistently estimated that Chapalo (beer) from sorghum required 30% of Voltaic sorghum production. In Mali, beer production was limited, but, it was available. Brewing operations were similar in Mali and U. Volta but done on a larger scale in U. Volta. In some cases, the wort (unfermented liquid) is consumed by children. It has a pleasant sweet taste.

In general, brewing procedures are:

1) The threshed sorghum or millet kernels are steeped in excess water in a calabash until they are imbibed. The kernels are stirred or poured from one container to the other to aerate. Then, excess water is removed.

2) The steeped grain is stored in a large clay pot for 3 to 5 days for germination and growth of the sprouts. The grains are aerated (stirred) and kept moist throughout this period. Time depends on temperature and on the kind of grains. For example, one brewer preferred white sorghum because it sprouted faster than brown sorghum. However, brown or red sorghum is generally used.

3) The germinated grain is placed in a layer in the court yard to sun dry.

4) The dried malt is crushed in a mortar or with a mill to a coarse meal. In our observations, the dried plummules and roots remained with the malt.

5)The ground malt is mixed in a large clay pot with water and ground fiber from the bark of a tree or shrub. The bark fiber probably serves as a filter aid and for clarification.

6) The mixture is stirred and allowed to set for 1 hour. The clear liquid on the top is decanted into another pot and retained. This liquid contains enzymes extracted from the malt and will be used to saccharify the starch.

7) The bottom portion (solids) is put into a second clay pot, water is added and the mixture is boiled, which gelatinizes the starch, coagulates proteins and controls off fermentation.

8) Then, the enzyme extract (step 6) is added to the boiling solution and the solution is brought back to boiling. This is done in the afternoon or evening. The next morning, the mixture is filtered. A coarse woven grass sieve (basket) is used. The bark fiber, sprouts and pericarp of the sorghum forms a filter cake. The boiling has coagulated much of the proteins.

9) The filterate is boiled (sterilization) until about 2:00 p.m. until the volume reaches a specified level. The fire is removed; the wort is cooled until about 11:00 p.m. Some concentrating of the wort is apparently achieved during this step.

10) The cool wort is poured into a large clay pot. The pot usually has yeast inocculum from the previous batch of beer in it. Additional inocculum that is scraped from the bottom of a previous batch of beer is added to the "sterilized" wort also. The pot was covered and fermentation commenced at about 11:00 p.m.

11) Active fermentation occurs with bubbling, froth on top of the fermentation pot. The beer can be drunk the next morning. By late afternoon, the beer if it has not been sold contains a high content of alcohol and usually begins to sour, probably by acetobacter or Lactobacilli.

Beer Consumption

The beer is sold by the calabash in the market or in the beer hall located in the compound of the brewer. The clay pots are carried by the women on their heads to the market where it is sold. In the morning, the beer has a slightly sweet, pleasant taste with a slight hint of fresh apple cider flavor. Sorghum beer is an attractive red, translucent liquid. It does not have a great amount of solids. However, yeast cells are in the bottom of the calabash. It is different from the soured, fermented, high solids sorghum beer common in Southern Africa. Chapalo is a fine refreshing drink which we highly recommend.

The people of Mali and U. Volta use resources wisely. Wood is used in cooking operations, brewing, etc. The fire is carefully controlled and wood is used extremely efficiently while maintaining an even temperature.

Grain Quality Trials - Kamboinse and Bamako-Sotuba

Quality trials of sorghum lines have been conducted at ICRISAT - U. Volta for three crop seasons. Dr. Pattanayak's group recognized early that grains without at least minimum acceptability for Tô would not be widely accepted by Voltaics. He has used native women to test sorghum grain quality for Tô production. In the initial tests, he found that S-940, an elite line with good yield and agronomic properties, had totally unacceptable Tô taste, texture and keeping properties.

In 1979, grain from 15 elite lines grown in regional adaptation trials had Tô acceptability ranging from 45 to 96%. Grain of S-940

was poorest; but, another line, A1567, was only 56% acceptable while the locals were at least 80% acceptable. In addition, Tô quality was evaluated for grain from an additional 103 preliminary lines and introductions from Sudan with a range of 35 to 100% acceptability. S-940 has consistently had a poor rating although the level of acceptability varies. A selection of S-940 (S-940-S) had high acceptance so progress can be made in selecting for quality.

The grain quality trials require large samples of grain, considerable time and are variable. It is almost impossible to standardize these trials. Test(s) to predict Tô quality based on 25g of grain would be extremely useful according to Dr. Pattanayak. They would permit early selection for quality while retaining the large scale cooking trials for final evaluation of a limited number of elite lines being considered for release.

Trials in Mali by Dr. Scheuring using village women have shown that sorghum lines differ in Tô quality. The effect of alkali causes major differences in grain quality compared to the Tô of U. Volta (acid). For instance, E-35-1 grain is acceptable in U. Volta; but, its keeping quality is unacceptable under Malian procedures. A major need of ICRISAT - Mali is to have methods of Tô evaluation that will be effective and practical for use in a breeding program and to have large scale cooking trials conducted with village women for advanced lines being considered for release.

We believe that we can aid Drs. Pattanayak and Scheuring by developing acceptable procedures for evaluating Tô quality for both acid and alkali preparation techniques. They do not have the time, equipment or the desire to evaluate testing procedures. In addition, they have limited capabilities of conducting practical cooking tests on large numbers of samples. Therefore, we believe that continuation and expansion of work to define Tô quality under alkali and acid conditions and to develop tests to predict it are first order priorities to be pursued collaboratively.

We believe that laboratory milling and quality tests can be devised for both acidic and alkaline Tô quality. Mr. San San Da, U.S.AID - SAFEGRAD trainee at Texas A&M (working on a PhD. in breeding and quality) has a Tô test almost standardized. He has identified a practical milling test that can be used on small samples of grain. The pearled, ground grain is cooked under standard conditions; measureable differences exist in texture between S-940 (poor quality) and S-29 (good quality). In related studies, grain from sorghum lines grown in Texas was shipped to Dr. Pattanayak for Tô evaluation. Thus, we will be able to insure that our tests in Texas relate to actual tests of Tô quality on the same grains. We will initiate experiments with alkali based on findings of this trip.

Other Products from Sorghum and Millet

Dagadi, a round dough ball of steamed millet flour is consumed with milk and sugar. It can be kept several days. Some millet flour is cooked in water, a dough is formed by mixing additional flour into the paste and the dough ball is steamed in a Cous Cous cooker. Then, it is rolled in flour. Flat millet cakes were sold in the markets. Pearled sorghum and millets, sorghum and millet flours of various particle sizes and dried Cous Cous were observed. Creme, a dried food consisting of acidic sorghum or millet paste pressed into a bar and dried was another food observed.

Bouille, a thin porridge produced in the initial procedures for Tô production, is consumed. Special bouilles are made for weaning foods. Pongonya, a health food composed of cooked fonio and cowpeas, was described. Sometimes millet and cowpea mixtures are considered "better" than rice.

Sorghum and millet flours are being blended with wheat flour in yeast leavened bread production. We consumed bread in Mopti, Mali that had millet flour (probably) mixed with the wheat flour although it was not acknowledged. A number of organizations are working to produce composite flours from sorghum and millet for use in bread production. Treatment of the sorghum to prevent grittiness is a major concern.

Tô Quality of Finger Millet

The finger millet Tô was a very dark color (reddish-brown), had a weak, sticky gel and underwent rapid syneresis (weeping). The taste was not acceptable. Part of the problem is milling. Pounding in the mortar did not remove the testa (hull) to any extent. So, the flour was ground through an attrition mill (same procedure used for sorghum) and the coarse particles were removed by sieving. An estimate of flour yield is about 80% of initial weight. Our preliminary experiments were not promising. Further experiments are needed to determine proper dehulling procedures although finger millet is not dehulled in many Indian food preparations.

Pigeon Pea Dehulling Experiments

Agronomic trials of pigeon peas conducted in Mali look extremely promising. We tried heating the pigeon peas followed by mortar and pestle milling to dehull them. The experiments looked promising; but, a village method to completely dehull pigeon peas is needed if they prove to be adapted to Mali conditions. They would be a natural for inclusion in the Tô and Cous Cous sauces. Dr. Sefah Dedah of Ghana would be helpful in working with ICRISAT/Mali to develop dehulling techniques.

Nutrition Service (U. Volta) Nutrition Studies

Mr. George Sempore, Chief, Nutrition Service, and two colleagues spent one day with us at Kamboinse observing the cooking trials. Then,

They helped us to find and visit four commercial milling installations. Apparently, it was the first time they had visited local milling establishments so we learned together.

Mr. Sempore and colleagues have a two year IDRC funded project to work on sorghum, millet and cowpea quality. They will have a combined approach of surveying villages to determine the variation in types of millet and sorghum cultivars, how they are consumed and any apparent differences in quality. Then, they will determine physical and chemical properties of the grain samples collected in their laboratory. We discussed in detail our observations of kernel characteristics of sorghum and variation that we have observed. These discussions indicated a clear need for a publication that summarizes current knowledge of the structure and genetic variation in kernel characteristics of sorghum and millet. Rooney has photos and other information on sorghum that would answer many questions and provide guidelines of use in Mr. Sempore's studies. Close coordination with the Voltaic Nutrition Service projects is desirable. Rooney has already sent samples of grain to Dr. Reichert at the Canadian National Research Center in Saskatoon. Dr. Reichert's group is working on milling and quality of sorghum and millet samples on an IDRC funded project. Close informal coordination and cooperation now exists and hopefully can become even more effective as the work progresses. There is much to do and few to do it in sorghum and millet quality research.

Publications of Interest

Vogel, S. and M. Graham, editors, Sorghum and Millet Food Production and Use; IDRC-123e, Box 8500, Ottawa, Canada K1G3H9.

Leung, W.W.T., F. Bussous and C. Jardin, Food Composition Table For Use in Africa; U.S. Dept. Health, Education and Welfare; Public Health Service and F.A.O. 1968. This publication was translated into French in 1970.

Two thesis reports were recently completed by students in Mali. If anyone is interested, Dr. John Scheuring should be contacted. The titles are:

Etude Preleminaire Sur Quelques Nouvelles Especies de Millets Introduites au Mali, Thesis; Institut Polytechnique Rural de Katibougon, Dec. 1979.

Etude de la Prospection 1978-1979 des Sorghos Cultives au Mali. Observations sur Quelques Caracteres Genetiques et Leur Variability.

Summary and Recommendations

Procedures for preparation of Tô, Cous Cous and beer are presented in as much detail as possible. Color slides are available to document the essential steps. Malian Tô is made with alkali and vigorous beating while Voltaic Tô is made with acid and only moderate stirring. Additional information on proportions is required. Variation in procedures among tribal groups is needed.

Tô is the major food made from sorghum and millet and is made daily. Texture, taste and good keeping characteristics are required quality attributes. Some exotic sorghum introductions have poor Tô quality. Grain with acceptable quality for production of Voltaic Tô may be totally unacceptable for production of Malian Tô. Laboratory tests using alkali and acid are needed.

The use of village women to evaluate the cooking quality of sorghum has effectively identified poor quality sorghums in U. Volta and Mali. The knowledge gained in these trials provides essential information required to permit development of simple laboratory tests for use in selecting and screening sorghums for Tô quality. However, there will always be a need for cooking trials on advanced, elite lines to make sure that Tô quality is acceptable. In the final analysis, the only sure way to test sorghum Tô quality is to let village women evaluate it. Hopefully, the combination of laboratory tests and screening will greatly reduce the number of lines being tested in early generations, which will expedite the breeding program.

Specific information on the physical and structural characteristics of sorghum and millet should be summarized and published in English and French (and possibly Spanish) for distribution to sorghum and millet workers. Slides illustrating structure and genetic variation would be helpful. Rooney has information on sorghum and will attempt to develop a set of slides. Millet slides will be needed.

Specific, practical test for texture, stickiness, milling characteristics and hardness of the grain are needed.

Information on why S-940 has unacceptable Tô quality is needed to provide a sound basis for developing screening tests. For example, the relation of amylose content to Tô texture and keeping quality would be useful.

The effect of alkali and acid on the nutritional quality of Tô should be determined. It is possible that alkali enhances the nutritional value of sorghums.

A standard method for preparation of Cous Cous is needed to determine variations in quality of sorghum and millets. The pro-

duction of Cous Cous is small, but release of varieties with terrible Cous Cous quality should be avoided. It is possible that some exotics might have pour Cous Cous quality.

Sorghums with a thick chalky pericarp are preferred because they are more easily milled than pearly sorghums. Milling studies to compare pearly and chalky kernels are needed. Brown "Kende" sorghums might be pearled by abrasive milling techniques to remove most of the condensed tannins because the kernel is hard and corneous. This might be a way of utilizing bird resistant sorghums. The "rice like" properties of Kende sorghums should be investigated. Collaborative studies with Dr. Scheuring and his coworkers are underway.

Dehulling of sorghum and millets with rice milling equipment should be evaluated. The effect of tempering time and level on milling energy requirements, product yields and quality should be evaluated for various mills. It is possible that proper conditioning could be practical and helpful to small millers.

Sorghum utilization in "new" food products made with local technology might be fruitful. For instance, Mr. Sempore indicated Voltaics are consuming more popcorn which is imported. Pop sorghum varieties might be introduced. Simple methods using local technology to parch or puff grains might be fruitful. To be effective this would have to be done by locals. Mr. Sempore, Chief of the Upper Volta Nutrition Service, was interested in pop sorghum and other special kinds of sorghum.

Pigeon pea dehulling efforts were only partially successful. Proper heating of pigeon peas with pounding may be satisfactory. Dr. Sefah Dedah has experience with dehulling of grain legumes and would be a logical resource for pigeon pea dehulling procedures to fit Malian conditions.

Finger millet produced poor quality Tô. The alkali intensifies the color and stickiness. It might be more suited to Cous Cous production.

Two types of millet exist (Sanio and Sauna) which differ in storage properties. Studies to evaluate their storage properties and quality attributes should be fruitful. The Malian millet collection would be a good place to look for variation in pearl millet grain characteristics and quality.

More information on foods consumed throughout the year with special emphasis on Tô and Cous Cous sauce ingredients would be useful. Local nutrition and health care personnel could be extremely helpful in obtaining more reliable information.

The success of this mission was possible only because of the interest and high priority it was given by ICRISAT personnel. We hope to expand existing collaborative efforts between ICRISAT - Mali and Upper Volta and our sorghum and millet programs in the USA. We hope the information in this report illustrates a few of the ideas developed during our short visit. We thank all of the officials, especially the ICRISAT personnel, for their hospitality and assistance. We invite constructive criticism of the procedures described in this report, because we recognize that they are probably inadequate. However, we believe they are the best currently available. Constructive comments and future observations will help to refine them.