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Trip report for Dr. E. Varriano-Marston and Dr. R. Carl Hoseney

July 5 through July 26, 1980

On July 7, we visited Dr. D. A. V. Dendy of the Tropical Products Institute in Culham, United Kingdom. Dr. Dendy is collaborating with us on a chapter on sorghum and millets; thus a good share of our time was spent discussing the content and organization of the chapter. Dendy explained that TPI is funded partly by the government with increasingly larger amounts of support coming from grants of various types. Their cereal staff consists of 8 people, and much of their time is spent in developing countries on short (several weeks) to medium (several months) length assignments. Thus, the institute does relatively little research work at Culham.

Dr. Dendy showed us a large number of machines developed at TPI. In general, most of them were very simple, hand or foot operated machines used to shell, dehull, or grind various grains. The technology was simple but practical and could readily be used at the village level in developing countries. TPI has developed a decorticator for grain sorghum which employs a wire brush. The decorticator appeared effective although it was impossible to evaluate it during the brief demonstration. A large scale model has been designed and will be built and sent to Sudan to be evaluated along with other machines under a FAO project. However, TPI is about 1 year behind schedule in supplying the machine.

On July 8, 1980 we visited the Flour Milling and Baking Research Association in Chorleywood, United Kingdom. Norman Chamberlain served as our host and gave us an overview of their organization. Their financial support comes from member firm dues (50%), from the government (40%), and from contract research (10%).

During our visit we had discussion with Dr. E.E. McDermitt on the role of α-amylase in bread. Of particular interest was the method they have developed to measure stickiness. We have used their basic method to measure stickiness in cakes and various millet products (tuwo), but have had limited success. We understand that Rooney's group at Texas A & M have also been using the procedure for sorghum tuwo.

A productive discussion was held with Dr. P. L. Russell who is working on staling. Dr. Russell is using a DSC of the same model that we have just received. The discussion was mainly on problems in settng up the hardware and how to handle the data. We felt that several points that were covered would save us time in setting up our instrument, and that Dr. Russell would be an excellent contact for future reference on the use of the instrument.

We visited with T. H. Collins and Norman Chamberlain on air incorporation in doughs and had lunch with Dr. D. W. E. Axford, Director of Research for the institute. In the late afternoon Dr. Chamberlain provided transportation to the airport for our flight to Khartoum.

On July 9, we visited Dr. Sitt Badi of the Food Research Center, Khartoum North and discussed their research program on sorghum and millet. They are involved in an FAO sponsored project to evaluate a number of different types of decortication equipment. Study is in progress even though some equipment (see TPI) is not yet there. Preliminary work shows rather large differences in the efficiency of decortication and on the percentage of broken kernels.

We also visited Dr. Abdoul Hafiz Abdoula, Head, Department of Agricultural Engineering, Khartoum University. They have a FAO project on grain storage. The project has two major emphasis: first, to determine storage losses, both type of losses and extent of loss; and second, to study types of storage facilities used in Sudan such as ground huts, buildings, or metal bins. We discussed K.S.U. work in the grain storage area and suggested that he contact

Dr. Pederson or Mills or AID for further details.

We also met, very briefly, with Prof. Kambal, a Sudanase trained at Nebraska but now working as a plant breeder in Yemen.

Working with Dr. Badi is Mrs. Laila Yahia Monawar, a PhD student who is doing a nutrition project. She plans to feed chicks and rats to determine the nutritional value of certain sorghum dishes.

We also met with Dr. Paul Ladu Bureng, a Sudanase who recently completed his PhD at Reading, United Kingdom and returned to the FRC. His thesis which is extremely long (500 pages) was on the malting characteristics of sorghum, particularly the production of dried flakes. The title is "A Study of the Malting Characteristics of Sorghum Grain and the Preparation of the Fermented Food Huller-Murr." He used a feterita as the only sorghum variety. We are planning to obtain a copy of his thesis through the interlibrary loan system.

From July 9th through July 11th, we attempted to reconfirm our scheduled flight from Khartoum to Jeddah via Mid-East Air and then to from Jeddah to Bombay via Saudi Air. However, Mid-East Air stated they would not carry us unless we had a Saudi Arabian in-transit visa. We were not familiar with an in-transit visa and only had a 3 hour lay over in Jeddah. Personnel at Saudi Air told us that we did not need a visa, and a note to that effect was sent to Mid-East Air. However, the note did not appease Mid-East so we had to make new travel plans from Khartoum to Bombay.

To make a long story short, the next few days a great deal of time was spent attempting to arrange travel from Khartoum to Bombay. We tried to obtain routes through Ethiopia, Eygpt, Kenya, and Kuwait but all were unsuccessful. The fact that telex machine was not working was not helpful. Also our tickets were billed on the basis of mileage and no one, including us, understood how they were computed. Thus others would not accept them or endorse them for TWA. Finally with the help of a highly placed Sudanase Government

Official, who was a friend of Dr. Badi, we were able to obtain confimed reservations from Khartoum to Athens. There was a flight from Athens to Bombay after a 9 hr lay over, but it could not be confirmed. We felt our chances in Athens was much better than Khartoum and thus took the flight. We did however have to purchase new tickets from Khartoum to Bombay. To date, TWA has refused to refund the Khartoum to Bombay part of our original ticket. We are still discussing the matter with TWA.

With the additional time in Khartoum, we finally left on the 13th, in addition to sitting in various airline offices we did make a number of visits. We met with Mr. Wendal Morris of USAID in Khartoum and explained our work. He sent cable to India for us to let the Indians know our schedule was revised. However, the cables had not arrived by the time we left India.

We met with Mr. Abdoul Fahab Musa of Khartoum who has invented a machine to make kisra and has a kisra factory on the outskirts of Khartoum. The factory was not working at the time we were there but he planned to start production again soon. He was very proud of his equipment and quite willing to show it and discuss the process.

The following are notes on kisra production according to Mr. Musa. The amount of water varies but in general the formula consists of 1 part water to 2 parts meal. The milling of the meal was not thought to be critical. The mixture is allowed to ferment 10-16 hours, longer times are necessary in the winter due to lower temperatures. In general, the pH will drop to about 3.8. Different varieties of grain sorghum will definitely give different products. Color is viewed as a very important factor in consumer acceptance. There is a bleaching effect with fermentation. This is particularly true with pearl millet which is used to make kisra in the western part of the country. The strength of the sheet is another important characteristic; it must be strong to peel as a sheet from the cooking surface. The product should not taste pasty.

Another important factor is staling. The product becomes more brittle with time. The products will develop mold in 2-3 days which is the maximum storage time. Some varieties of sorghum will give a thicker kisra even though you dilute the batter with water. This appears to be a quality difference. Other varieties will give a pasty product. Mr. Musa feels that the most difficult part of the process is fermentation which manifests itself as differences in thickness and flavor.

His kirsa machine was basically a cast iron wheel about 30 inches in diameter. The wheel was heated to 200^{0}C by a propane flame positioned inside the wheel. The batter was spread on the outside surface in a thin sheet and peeled from that surface at the bottom. The speed of the wheel could be varied to give a moist kirsa or a dried, and therefore, stable product.

After visiting the factory, we felt that the machine would undoubtedly work, but a major problem would be handling, shipping and selling the limited shelf life product.

That same day (July 9th) we also were taken to a poorer section of Khartoum to visit a house where Marisa (a fermented beer from grain sorghum) was produced, consumed, and sold. Alcohol consumption in Moslem countries is not widespread but occurs to a reasonable extent particularily among the poorer people. It took a guide to find the house, and there was considerable discussion before we were allowed into the compound. Once inside they were quite willing to show us the Marisa process and to be photographed. The process was explained as follows. The sorghum meal is pasted (cooked to gelatinize the starch), cooled and mixed with flour (uncooked) made from germinated sorghum. They are mixed together along with a starter from a previous batch and allowed to ferment for about 2 days. The mixture is then strained through a cheese cloth to remove the pericarp and other larger

pieces; the overs are fed to chickens. The material passing the cheese cloth was a thick, grey mixture resembling a hog slop and having a pH of about 3.4. Dr. Badi and associates stated that many of the people's diets consisted almost entirely of Marisa, including some apparently healthy children that we observed. The alcohol content of Marisa is not known; however, an elderly gentleman that allowed me to take his picture was feeling no pain. Thus the alcohol content was presumed to be in the area of 3-6%. The temptation to taste the product was easily resisted.

Arrangements were made with Dr. Badi to send us a number of samples of grain sorghum and pearl millet. We need to renew our import license before we can receive the samples.

On July 10th, we visited Mrs. Shahwa El Guzuli, head of the nutrition department, of Sudan Ministry of Education. She gave us a tour of the department and explained that they provide a nutrition educational service for teachers, cooks, and housewives. They teach the students how to plan balanced meals and the importance of nutrition in the health of children and adults. Their program is sponsored by FAO, UNICEF, and the Sudan Department of Agriculture. Mrs. Guzuli indicated that malnutrition was a problem in Sudan but was related more to ignorance concerning good nutrition than to socio-economic status. The problem is particularly prevalent among children 1 to 5 yrs. of age.

We left Khartoum on July 13, at 10:00 a.m. via Athens to Bombay arriving July 14 at 9:00 a.m. The next plane to Bangalore was not until July 15 at 8:50 a.m. While in Bombay we contacted Dr. and Mrs. V. S. Rao. The Rao's are KSU graduates and Sudha works as a Cereal Chemist at the Bhabha Atomic Research Center in Bombay. We wanted to follow up our 1978 visit to the center and see if atomic energy is being used to any extent to preserve grain. The report was that it is not being used.

On July 15, we went to Bangalore by plane and on to Mysore by a 3 hour taxi

ride. At the Central Food Technological Research Institute (CFTRI) we met with Dr. C. P. Natarajan, Director of CFTRI, Dr. S. R. Shurpalekar, Head of the Milling and Baking Division of CFTRI. In Dr. Shurpalekar's laboratory we were given a demonstration of chapatti making by Mr. H P. Rao. Mr. Rao had worked in Dr. Hoseney's lab at KSU for 2 months in 1979. In general, Mr. Rao reported that for wheat chapatti the farinograph water absorption minus 14% gave the correct water for chapatti. He had also found that the Research Water Meter was useful in measuring the water for chapattis. A flow time of 62-65 sec. was thought to be optimum. He stated that housewives allow the dough to rest overnight before baking. He rolled his chapatti dough to a 2mm thickness and baked them in a gas tandoor cooker. The cooker consists of a rack with a indirect gas heater in the bottom and a dome above the rack. It appeared to be capable of supplying intense heat and did a nice job of puffing the chapatti. Chapattis brushed with oil during cooking are called pareatta. He used a tear test to evaluate the strength of his chapattis. The machine used was a paper tester (Elmendorf Paper Tearing Tester, H. T. Messmer Ltd., London, No. 16500). He felt this gave him reproducable results.

Another project in the group was the baking of Nan (a leavened Indian bread). Mr. Rahim headed this project. From our discussion Nan appears to be more similar to our U.S. bread than is the unleavened chapatti. Other projects they are working on include: the effect of grain storage on baking quality, the effect of extraction rate on quality, and replacement of wheat flour with legume or cassava flours.

On July 16, we visited with the cereals section (all cereals other than wheat) which is headed by Dr. H. S. R. Desikachar. Unfortunately, he was out of the country during our visit. We met with Dr. K. R. Bhattacharva and S. N. Raghavendra Rao. Much of their work is with rice but since the mid 1960's they have worked with sorghum, millets, and legumes, and have published a

number of studies on pearling of sorghum and millet. Much of the millet work was with ragi (finger millet). Traditionally the grain is pounded and made into dumplings. They have developed weanling foods containing 70% malted ragi and 30% green gram. Ragi has a very high calcium content. They are doing considerable work on developing new foods, mainly snacks, from sorghum. They are also working with Kodo millet (also called Varagu millet), Paspalum scorbiculatum, a dark brown small seed. The process for ragi milling is as follows: the seeds are soaked overnight, allowed to germinate for 48 hours, sun dried, pearled or dehulled and toasted at 70°C. After toasting 10%, water is added and it is ground in a hammer and or plate mill and screened to remove the pericarp. With the small seed size the 65% extraction that is obtained is a high yield and probably contains a part of the pericarp.

On July 17, we arrived in Hyderabad and visited the National Nutrition Institute (NNI) that afternoon. Dr. Tulpule, the director, told us of the problem of pellagra with sorghum eaters. Work with dogs and humans has shown that adding isoleucine will alleviate the symptoms and adding leucine will make the diet more pellagragenic. There appears to be little question that the isoleucine/leucine ratio is an important factor in the nutritional quality of sorghum.

Dr. Tulpule feels that, in general, except for 1-2 year old children, there is little problem in obtaining adequate protein in the diet if sufficient calories are eaten. He made the point that at weanling the child often has diarrhea because he is now consuming much more water of doubtful purity. The diarrhea causes losses of injested nutrients which means that the child must eat more to make up for losses. He also stated that their studies have shown that poor women on insufficient diets give the same quantity and quality of milk as a woman consuming diets high in nutrients.

In a discussion with B. S. Narasinga Rao (NNI) we learned that 40 to 60%

of the people in India are anemic. People comsume 20 to 30 mg of iron per day from the diet but the absorption is very low, 0.5% from millet and about 2% from wheat. Fortification of cereals is impractical as most are processed and consumed within the home. They are looking at salt as a possible carrier of iron. It is consumed by almost everyone and is already fortified with iodine. Ferrous sulfate does not work well because of water uptake etc. However, they have identified other iron salts which are stable and readily absorbed by humans. He did not identify which salts they were testing.

They have a simple method of estimating iron absorption. The sample is digested at pH 1.35 with pepsin, the pH is adjusted pH to 7.5, and the iron is determined in the supernatant. The method apparently gives good estimations of iron bioavailability.

According to Dr. Deosthale studies on iron adsorption indicate that there is improved absorption with pearled grain and a good correlation with degree of pearling. They used the method given above to estimate absorption. Low iron absorption was thought to be related to tannins and phytic acid. However to date, is not very clear on which, if either are involved. They are continuing work in this area.

For preschool children the staff at the institute estimate protein requirements at 1.75 mg/Kg body weight. In India 2.00 mg/Kg is commonly consumed. Energy requirement is 100 KCal/Kg body weight. Below 80 KCal/Kg or 1.75 mg protein/Kg body weight, nutritional problems are encountered.

We had further discussions with Dr. Pant on the importance of the isoleucine/leucine ratio in sorghum. He could not produce black tongue in dogs with opaque-2 maize. In a study of 350 varieties of grain sorghum they found little variation in isoleucine/leucine ratio.

Dr. Pant and associates are also working on storage stability of grains. In a 10 month storage study in Indian households, they found one variety that

was resistant to storage insects (J. Sci. Food Agric. 28:963, 1977).

They are also working on oligosaccharides in grams and have found that germination lowers the level and cooking increases the level of oligosaccharides detected. The increase was thought to be due to improved recovery resulting from cooking.

On July 18, we visited ICRISAT. The goal of Dr. A. Patanothai and Dr. Kumar, millet breeders, is to select for increased protein and lysine without reduction in yield. In general, they thought they could increase protein with no loss in yield. They have found a strong negative correlation between protein and lysine. Resistance to downy mildew have been found in pearl millets. They also are finding millets that are resistance to ergot.

Discussion with D. S. Murthy, dealt with the differences between field and storage molds in sorghum. He stated they are screening their sorghum breeding material for product quality; using a roti (chapatti) as a test product. Some varieties make good rotis, others do not. The factor responsible for the difference is unknown. With their trainees from West Africa, they are working to produce typical products (tuwo etc.). He has found that the particle size index (developed by L. Rooney, Texas A & M) is useful. They are looking at traditional pounding as an index of millability which is thought to be an important factor in acceptability. He also showed us a sample of a scented sorghum. The sorghum has been described in a recent publication (Current Sci. 48:823, 1979).

In our discussions with Lee House, sorghum breeder, he emphasized that we should look at quality differences within visually acceptable grain types. He and Dr.Murthy expressed a willingness to select and grow grain for us. He also suggested that we contact J. Schrewring in Mali for seed samples and food preparation methods.

Drs. R. Jambanathan and Subramanian showed us slides on food products made

from sorghum and millet in India. Their work will be described in the Vienna paper that will be published by TPI. They also demonstrated the making of millet rotis. Basically they use a method similar to ours. They do not use high heat but agree that villagers generally do. Their procedure for millet roti was as follows: to 50 g meal add 50 ml water, knead for 5 min, roll to 3 mm thickness for millet and 1.5 mm for sorghum. Bake on a hot plate (240°C) 1.5 min on first side then wet top surface with water and bake second side. There was very little puffing although they suggest that a good millet would give some puffing.

They have also completed some work on sugars in millet and sorghum using Bio-gel P-2. The sorghum paper has been submitted for publication, and the millet data is being verified. They will send us copies of both papers.

On July 19, we visited the Home Science College in Hyderabad and had discussions with Dr. Pushpumma and Dr. Geervani. They felt that there were pressures on villagers to switch to rice and wheat from sorghum and millet because sorghum and millet must be processed each day.

Dr. Pushpumma is writing a monograph on traditional processing and consumption of sorghum, millets, and legumes in India. It will be published by IDRC.

Drs. Pushpumma and Greevani felt that color is an important quality factor; with sorghum, white or yellow is preferred. Villagers generally believe that new varieties are not as good for their health. In addition, they have found that sorghum stores with more difficulty than does millet.

Their feeding studies with children ages 1 to 5 on diets of sorghum and rice in combination with legumes showed that growth rates were good by Indian standards when sorghum was included in the diet and was often better than diets with rice alone. She (Dr. Pushpumma) feels that although protein is not a problem if calorie requirements are met using a typical Indian diet, it is

impossible for the child to consume sufficient calories (insufficient capacity in stomach - even 6 meals/day failed to provide the necessary calories).

She feels strongly that niacin deficiency in sorghum eaters has been overemphasized. Although sorghum may be deficient in niacin, most people eating sorghum also consume sufficient pulses so niacin deficiency is not a real problem. She also feels that diet surveys are worthless and that you can only learn by living with the people.

The afternoon of July 19, we flew to Delhi. On July 20, we flew to Amristar. Dr. J. S. Sidhu met us for the 3 hr car trip to Ludhiana. On July 21, Dr. Sidhu and Mr. G. S. Baines gave us a tour of the new Food Science and Technology building at Punjab Agriculture University. A new building is being constructed (construction is slow because all concrete in the country is being sold to the Middle East for hard currency) to house the cereal section. At present they are working on the following problems: the milling of cereals; the use of durum wheat for breadmaking (durum allows them to avoid certain diseases); and α-amylase activity in both wheat and rice.

We met briefly with Dr. Kirpal Singh, Director of Food Processing and Technology and with Dr. A. S. Cheema, Vice Chancellor of Agriculture. A major problem now in India is over production. This presents large problems with grain storage and transportation. They are currently suggesting that cereal production be limited. It seemed incongruous that food production in India be restricted. During our car trips from Amristar to Ludhiana, we saw many tons of grain stored on the ground in gunny bags under black plastic. The temperature was near 40°C and the humidity near 90%, thus this grain is going bad very rapidly. Over production of both wheat and rice in the Punjab is indeed a problem. Also during our drive we saw many fields of pearl millet growing. However, the people we talked with did not want to discuss millet, but would talk about wheat and rice whenever we asked about millet. It

obviously is a important crop in the area, but the very proud Punjab's would not discuss the crop.

On July 22, we visited Punjab Breweries, a very modern brewery producing 40,000 liter bottles per day. They were using 10% sugar and 10% rice with the remainder being barley malt to produce the beer. The hops used were half imported and the other half domestic. On July 23, we visited a typical Indian "chucky" mill. This mill, as do many of the modern ones, had a pearling device and the wheat was lightly pearled before it was ground. The pearling removed about 6% of the kernel. The flour produced was rather white and more refined than what had been produced in the past. This is a new trend in India and is a concern to some nutritionists. The flour we examined was very gritty indicating that the white wheat they were grinding was extremely hard.

The afternoon of July 23, we drove to Amristar for a flight to Delhi and from there to Bombay. We spent the 23rd in Bombay visiting the Drs. Rao. The flight from Bombay to Niarobi was delayed due to engine trouble and we arrived at 6:00 a.m. on July 24. We left Kenya that afternoon for Dakar and arrived in Dakar at 1:30 a.m. on July 25.

Dr. Ken Steinke of USAID-Dakar met us at 8:30 a.m. and took us to ITA where we visited with Dr. Thiam and Mme N'Deye Niang of their cereal section. We discussed the basic composition of sorghum and millet and the traditional processing of millet. The grain is cleaned, placed in a large mortar and pestle, wet with a small amount of water, pounded, dried and winnowed to separate the light pericarp. Water may be added 2 to 3X during the process. The decorticated grain is then washed and dried before being pounded into a flour. The flour must be produced each day because it deteriorates in storage. During the milling process the grain may attain a moisture content of 25%. They feel the high moisture leads to lipase activity and thus hydrolytic rancidity. They feel lipoxygenase activity is low in millet and thus not much

oxidative rancidity occurs during storage. They think that with dry decorticating and milling a flour with 6 months storage stability can be produced, even though the germ is still in the flour. He feels the problem is moisture not fat. We were not convinced that both oxidative and hydrolytic would not occur in the dry milled grain.

They also stated that in Senegal millet is preferred to sorghum for cous cous. They expressed concern that nutrients were lost in the traditional processing because water was used. It was not clear to us where the nutrients were going.

They described the preparation of a number of traditional foods. Cous cous is made from a coarse ground meal, water is added, and the meal is agglomerated and then steamed. By law, bread is Senegal contains 15% millet flour, but it was not clear how well the law was being enforced. Cakes containing 50% millet flour can be produced. They were prepared for us to sample, and we found the cakes to be very heavy but with a reasonable taste. Biscuits are made with 20% millet and cous cous with 100% millet. Traditional milling gives about 65% yield of flour.

They have developed weanling food based on millet with mixtures of groundnut and soy flours. Some traditional millet foods include:

Lakh: There are at least two types: one is prepared with semolina, vegetables and fish; the another with millet flour.

Millet: Millet is mixed with H_2O to make small dough balls which are cooked in boiling water. The product is eaten with curds and sugar.

Fonde: a more fluid paste, taken with sugar, curds, or tammerand pods.

Rouye: millet flour cooked in water - very thin gruel - often given to babies.

Mr. Thiam also discussed fermented foods. He thought lipase would cause sour taste due to free fatty acids. We had a problem with that explanation.

We were given a tour of ITA and shown a millet, (souna variety), supposedly the most popular variety in Senegal. It was very small seeded and yellow in color.

Next we visited Mr. Gupta, the ICRISAT millet breeder, in Senegal. He said that a common practice in Senegal was to plant millet in one hill per square meter and maybe 30 seeds per hill. He wants to reduce the height of souna millet from 3 to 2 meters. We asked about the small seed size we had seen at ITA but he tells us that souna is large green-gray and what we were shown was not souna.

In the afternoon we visited with Paul Rusby of AID Senegal to try and clear up the confusion on the pearl millet grown in Senegal. He stated that souna was the most preferred with a second variety sanio as less preferred. He had a young Senegalese lady help explain the difference. She stated that souna is green-grey and smaller in seed size and sanio is reddish and larger in seed size. This left us confused about what the yellow variety was that we was at ITA. We arranged for the lady to accompany us to a local market to see the varieties. In the market the only variety available was souna, it was quite yellow, just as we had seen at ITA but much larger seeds. We were told that sanio was not available because of the time of the year. We are still not sure about the millets in Senegal.

During our visit with Paul Rusby, we made several suggestions concerning his millet proposal. We suggested that the first step of the project should be to determine which millet flour is shelf stable. Can it contain the germ or not. Once this is known a milling system to make the proper separation could be developed. We also discussed what should be done with the material removed during processing, i.e. the pericarp and perhaps the germ. We suggested that it could be defatted, the oil recovered as a cooking oil and the defatted germ and perhaps part of the pericarp could be added back to the flour to improve the yield. We also questioned whether a simple cooking or even

extrusion cooking could stabilize the product against rancidity as he assumes in his proposal.

The Senegalese lady that accompanied us to the market stated that it millet was dried after decorticating, the flour would last 15 days (she didn't appear very certain) however, we saw millet in the market that had been decorticated. She stated that there was normally a price differential between souna and sanio.

Having accomplished most of our goals for Senegal that day we checked on flights leaving earlier than our scheduled flight on July 29. We found a flight leaving Dakar at 2:00 a.m. July 26, and arrived in Manhattan at 3:00 p.m., July 26.