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Traveler L.W. Rooney, Professor, Cereal Quality Lab, Texas A&M University

Date of travel July 30 - August 17, 1980

Condensed Itinerary and Activities

7/30 - Departed College Station, arrived Washington, D.C.

7/31 - Participated in a conference with Drs. Graham, Jansen, MacLean Crowley, Hornstein and Leng to review information on the nutritional value of sorghum for use as human food.

7/31 - 8/3 - Travel to Hyderabad, India. Met by Drs. L. House and D.S. Murty of ICRISAT.

8/4 - 8/5 - Participated in traditional sorghum milling trials conducted by Dr. Murty in the ICRISAT Lab, observed procedures for production of ugali, ugi and roti. Conferred with Drs. House, Murty and Konwar regarding sorghum quality research and the possibility of developing a symposium on grain quality.

8/6 - Reviewed and evaluated data obtained for the International Food Quality Trials, developed specifications for analyzing the data. Worked on details of the quality symposium with Drs. House, Murty and others. Conferred with Drs. Jambunathan and Subramanian of the biochemistry lab, reviewed their research and several manuscripts they have in preparation on sorghum and millet research.

8/7 - Dr. Subramanian presented slides on his surveys in India to determine how sorghum and millets were used. Conferred with Dr. House regarding detailed Sorghum Quality Symposium program.

8/8 - Presented preliminary program on Sorghum Quality Symposium to Dr. J.C. Davies, Associate Director, ICRISAT, which he agreed to support in principle.

8/9 - Departed ICRISAT with Dr. D.S. Murty to travel by auto to Dharwad in Karnataka S. India. Stopped en route to observe sorghum and millet fields, markets and foods.

8/10 - Observed commercial mills, roti baking facilities, grain markets and consumed sorghum foods. Conferred with two sorghum breeders from Agricultural College (Dharwad) and observed ICRISAT and All India Coordinated sorghum nurseries on the Agricultural Sciences Experiment Station.

8/11 - Travel from Dharwad to Mysore in Karnataka. Observed crops and a few markets.

8/12 - Conferred with Dr. Desikachar and associates, Central Food Technological Research Institute, on sorghum and millet quality research. Dr. Desikachar's group has worked on weaning foods from millet and sorghums. Conferred briefly with Dr. Natajaran, Director, C.F.T.R.I.

8/13 - Returned to ICRISAT, Hyderabad.

8/14 - Reviewed statistical analyses of international food quality data,
8/15 revised plans for the Sorghum Quality Symposium. Conferred with Dr. N.G.P. Rao on high lysine sorghum.

8/16 - Returned to U.S.

8/17 - Arrived College Station, 10:30 p.m.

Agencies and Individuals Contacted

ICRISAT - Dr. L. House, Sorghum Breeder

Dr. D.S. Murty, Sorghum Breeder

Dr. R. Jambunathan, Biochemistry

Dr. V. Subramanian, Biochemistry

Dr. N.G.P. Rao, Sorghum Breeder, Haute Volta

Dr. E. VonOppen, Economist

Dr. L. Mughugho, Sorghum Pathology

Dr. R.J. Williams, Millet Pathology

Dr. J.C. Davies, Associate Director

Dr. Konwar, Associate Director

Agriculture College, Dharwad 580005, Karnataka

Dr. B.T. Shaukare Gowda, Sorghum Breeder - rabi season

Dr. R. Parameswarappa, Plant Scientist (sorghum breeder - Kharif season)

Central Food Technological Research Institute (C.F.T.R.I.), Mysore, India

Dr. R. Desikachar

Mr. N.G. Malleshi

Mr. A. Chandrasheker

Mr. S.N. Ragharendra Rao

General Comments

This consultation's major goal was to review, collate and summarize data from the International Sorghum Food Quality Trials. These trials were initiated by ICRISAT in 1978 to attempt to develop information on the attributes of sorghum grain that affect its quality for use in major food products, i.e. injera (Ethiopia), kisra (Sudan), Tô-alkali (Mali), Tô-acid (Haute Volta), ugali (Tanzania), tortillas (Mexico and U.S.) and roti or chapatis (India). In addition, basic information on physical, chemical and structural properties could be determined by the various laboratories. Milling studies have been done in several labs in the U.S. and Canada. Plans for a symposium for October 1981 based in part on these data have been developed. (See Attachment).

An opportunity to travel with Dr. Murty of ICRISAT to Dharwad and Mysore in South India to study grain markets, commercial production of roti and confer with scientists at C.F.T.R.I. occurred. The comments that follow attempt to summarize our observations.

Weaning Foods

Information on the type of weaning foods used in sorghum and millet consuming areas of India was specifically solicited. This information was deemed important because of allegations by MacLean and Graham that sorghum is poorly digestible and virtually unfit for human food. Ground, whole sorghum is hardly ever fed to weanling children. Weanling children are almost always fed a special food consisting of milled sorghum, cooked, mixed with milk and fed as a thin gruel. In some cases, the sorghum is germinated, dried, (sorghum malt) and cooked for use in infant foods. Extended soaking, sprouting and mixing of the processed sorghums with other commodities obviously occurs. When we asked if whole ground sorghum was fed to infants, knowledgeable sorghum consumers were incredulous. They felt that everyone should know that sorghum alone wasn't good for children.

Dr. Desikachar's group at C.F.T.R.I. has developed commercial processes for producing an infant food from malted ragi (Eluesine coracana) and sprouted green grams (Mung beans) (P. mungos). They feel the method can be used at the village level and will cost about 5-6 R/kg. Sorghum was selling in the market for 1.5 to 2.0 R/kg.

Repeated comments from people who were sorghum consumers indicated that sorghum is always specially prepared for weanling children. They also maintained that in the villages almost everyone had milk to mix with the processed sorghum and other commodities. All agreed that sorghum without special preparation was not given to weanling children.

Many comments relative to the heaviness of sorghum were repeated. Sorghum is said to stay with an individual who is working hard. Undoubtedly this is related to the poorer digestibility of sorghum compared to rice and wheat.

Sorghum Digestibility Studies

The reports of Graham and MacLean in which the nutritional value of whole grain sorghum fed to pre-school children was found to be extremely poor were of some concern to ICRISAT personnel. Questions were raised concerning the need for human nutritional studies to determine nutritional value of sorghum

relative to other cereals. Because these studies are usually extremely costly, confounded with other variables (in spite of the investigators best efforts) and never seem to provide definitive answers. I believe that diversion of scarce resources from sorghum improvement into extensive nutritional trials with humans would not be wise. Nutritional value of sorghum is important, but sufficient data exists with controlled animal experiments (including growing and finishing swine trials) to suggest that sorghum is more difficult to digest. However, sorghum consuming populations have learned to process the sorghum to improve the digestibility sufficiently to permit productive lives. Thus, I am not in favor of spending resources on defensive activities. Rather, I think we need to determine what factors affect digestibility and determine whether it can be improved through breeding or modified processing methods. In addition, the use of swine as a test animal will greatly reduce the cost and probably lead to more rigorously controlled experiments than human feeding trials. Along these lines, work at several universities in the U.S. may be helpful. For example, Dr. Tanksley has completed several elaborate digestibility trials on sorghum in comparison to corn in which he shows that sorghum protein is slightly (5% points) less digestible than corn protein. His work has been mainly with ground whole sorghum, but could be readily done on sorghum flours. Human nutritionists could benefit by evaluating the various animal nutrition studies on sorghum. (Tanksley's manuscript is attached).

Sorghum Roti Production

Sorghum and wheat rotis were being made in a large hotel in Dharwad, Karnataka. Sorghum is consumed and preferred by many people in this area. We were able to observe the production of both sorghum and wheat rotis. Surprisingly, the sorghum and wheat rotis looked and tasted similar. However, procedures for production of the doughs were different.

The hotel served sorghum roti at three meals daily which meant that from several hundred to 1,000 sorghum rotis were made daily. The basic procedure is as follows:

1. The maldandi grain was cleaned, the whole grain was milled directly (without tempering) on a commercial plate mill (attrition type) which produced a fine, smooth feeling flour. Milling was done in a small commercial mill at a cost of 0.15 R/kg. The flour was sifted through wire mesh by hand which removed large glumes and pieces of trash. Very little pericarp was removed.
2. Some of the sifted flour was stirred into boiling water and a dough or thoroughly gelatinized sorghum flour was obtained. This "starter dough" was moist, sticky and cohesive.
3. Then, the dough for roti preparation was made by mixing dry sorghum flour into the "starter dough." The whole mass was kneaded thoroughly until it resembled the consistency of masa. About 25-35% by weight of "starter dough" was mixed with 65-75% by weight of flour. No exact measurements were taken, however. The starter dough provided sufficient adhesiveness to permit pliable dough to be formed which also helped to insure complete puffing of the roti during final stages of baking.
4. Then, a portion of the dough was firmly pressed and shaped by hand into a 10-12" diameter thin dough piece. Dusting flour was used and at times a little extra water was added to the dough.

5. The completed dough piece was placed on a hot griddle over a wood fire. It was cooked on one side for 30 seconds, wetted, turned over and cooked for 30 sec. Then final baking was done by placing the warm cooked dough piece directly on hot coals. The dough piece puffed completely in about 1-1.5 minutes depending on temperature. Puffing always occurred for both sorghum and wheat rotis.
6. The warm sorghum roti was pliable, tasted slightly sweet with some burnt flavor notes and was comparable to the wheat rotis. It reminded me of the flour tortillas made in South Texas and Mexico.

The procedure for wheat roti was similar except cooking to gelatinize starch to form a starter dough was not necessary.

Sorghum and wheat rotis were sold at 0.40 R each. More sorghum rotis were produced than wheat roti. Even wealthy people consumed sorghum rotis. The manager of the hotel indicated that maldandi sorghum with a lustre gave the best roti (See Grain Market Section).

Grain Quality in Retail Markets

The retail market in Dharwad had a number of grain and pulse shops with a nice array of sorghums. The sorghums were of the following kinds with price in Rupees per kilogram in parenthesis. Maldandi (1.60-1.80), popping sorghum (1.8-2.0), CSH-5 Hybrid free of mold (1.40-1.50), CSH-5 Hybrid with some mold-not much (1.20), pearl millet (1.20-1.25), wheat (1.70-2.00), Durum wheat (2.20+), rice (2.30-2.60) and Basmati rice (5.0-7.50). No profit potential exists for mixing sorghum with wheat and apparently it is not done. Sorghum in pasta might be profitable since Durum is high.

Hybrid sorghums definitely sold for less than the maldandi types of sorghum. Kernel size and shape were the critical quality criteria. A sorghum that made even better rotis than maldandi would probably be priced lower unless it had the particular size and shape of maldandi. In many market samples, hybrid sorghums had been blended with maldandi types.

The pop sorghums had a high proportion of corneous endosperm and both thick and thin pericarps. They were popped in hot sand. Sometimes the popped sorghum is ground and mixed with other ingredients to produce special foods, i.e. weaning foods.

Central Food Technological Research Institute

Dr. Desikachar and his associates have been working on sorghum, millet and pulse food technology problems for many years. In sorghum and millet, major efforts have involved practical milling studies to produce sorghum and millet products with improved quality. The emphasis is to develop practical methods of use in villages. A weaning food from sprouted *P. mungo* and malted milled ragi (*E. coracana*) was described. (Reprint attached). A sorghum snack made by deep fat frying of toasted, steam flaked, pearled sorghum kernels prepared at C.F.T.R.I. had a nice flavor and taste. They have evaluated some sorghum lines for use in dosai, mudde, roti and other products, but it is not possible to clearly identify specific desirable quality attributes of sorghum needed for each product. Research is continuing.

Current milling research consists of modifying a stone mill by addition of a sieve to remove about 5% of a coarse fraction that is primarily pericarp and adhering glumes. The key to success is to temper the grain immediately prior to the attrition milling so the pericarp (bran) is broken into large pieces which enables separation. Desikachar indicated that the government has discouraged pearling of sorghum because the 10% removed during pearling is thought to reduce the food supply.

Sorghum Use in India

Numerous products are made from sorghum and millet in India, but the greatest bulk of sorghum is consumed by stone grinding the whole grain and baking into roti. The shape, size and thickness of roti differs greatly. Keeping quality, color and taste of the roti are important attributes. Keeping quality relates to the custom of carrying rotis prepared the previous evening or in the morning to work for lunch. Flexibility is desirable. Hybrid sorghum rotis lack in this characteristic. Keeping quality must be defined more clearly in terms of standardized tests.

In South India (Coimbatore), several thin and thick porridge products are made from pearled sorghum that varies in particle size. Sometimes they are made from a mixture of fine flour and coarse endosperm chunks (grits). Pearled sorghum kernels are cooked and used as a rice substitute in some areas. In India, the relative amount of sorghum pearled is considerably less than that used for roti. Pearling is accomplished by hand pounding in a stone mortar. Dr. Murty, ICRISAT, has been conducting pearling studies using a stone mortar and pestle. A hole in the floor of the house is often the mortar. Undoubtedly in India, the major use of sorghum is as whole grain flour, however, significant quantities are pearled and ground.

A wide variety of snacks have been documented by Subramanian. Many of these products are made on special occasions and apparently amount to a very small percentage of total sorghum production.

Special Use Sorghums

Dr. Murty has been developing a scented sorghum. During cooking the flour produces an aroma similar to that evolved by Basmati rice. Vani sorghums (sugary) are grown and roasted in the milk stage. The easy thresh sorghum line (77CS-5) developed by Miller at Texas A&M might be useful to Indian breeders for incorporation into special use sorghums. Pop sorghums are quite common as discussed previously.

International Food Quality Trials

A preliminary draft of major findings based on 1979 data was developed which will be sent by Dr. D.S. Murty to the collaborators. The complete study will be reviewed in the Sorghum Quality Symposium to be held in October 1981 prior to the Sorghum in the 80's Symposium. A draft of the proposed program for the quality symposium is attached.