Sorghum *Roti*: I. Traditional Methods of Consumption and Standard Procedures for Evaluation

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Summary

Roti *(an unleavened bread) is the most popular sorghum food consumed in India. The traditional methods of milling, dough and* roti *preparation are described in detail. Standard procedures for the dough and* roti *evaluation evolved at ICRISAT are outlined.*

Sorghum (*Sorghum bicolor* L. Moench) is one of the major coarse grains used for human consumption in the semi-arid tropics and is the staple diet for millions of people, providing the bulk of the calories, proteins, vitamins, and minerals. In India, it is consumed in several forms like *roti* (Hindi – an unleavened bread), *chorru* (Tamil) or *annam* (Tamil, Telugu--boiled grain), *sankati* (Telugu) or *mudde* (Kannada—thick porridge), and *kanji* (Tamil, Telugu—thin porridge) (Ayyer 1944; Rachie 1963; Subramanian and Jambunathan 1980).

A consumer survey of sorghum grain utilization methods was conducted in 171 villages of India belonging to seven states (Subramanian and Jambunathan 1980) and the information compiled for *roti* are reviewed in this paper along with those reported by others. In the central parts of India, which account for most of the sorghum production, *roti* is the most popular sorghum food. It is consumed in rural as well as urban areas; it is served in middle-class hotels of some of the towns. Although precise statistics are not available, on the basis of sorghum grain production figures published by the Government of India (1980) and the dietary habits of the people in various regions, we estimate that approximately 70% of the sorghum produced in India is consumed in the form of *roti*. However, in the state of Maharashtra, more than 95% of the sorghum produced is consumed as *roti*. In the states of Gujarat, Rajasthan, and Madhya Pradesh, *roti* is by far the most important sorghum food product. In Karnataka and Andhra Pradesh, sorghum *roti* is a major portion of the diet for a large segment of the population living in the dry tracts.

Sorghum *roti* is known by various names in the different languages of India: *chapati* (Hindi), *bhakri* (Marathi), *rotla* (Gujarati), *rotte* (Telugu), etc. *Roti* is consumed by children from the age of 2 years as well as adults (Subramanian and Jambunathan 1980). It is eaten at breakfast, lunch, and supper and is frequently stored overnight. Farmers generally carry *rotis* prepared early in the morning to the fields for lunch. *Rotis* are generally stacked in a pile wrapped in cloth and stored in perforated baskets. Occasionally, they are sun-dried and stored for more than a week.

Roti is consumed with several side dishes depending upon the socioeconomic status of the consumer, e.g., cooked vegetables, *dhal*, meat, milk, curd, buttermilk, pickles, *chutneys*, sauce, etc. (Subramanian and Jambunathan 1980). *Rotis* are softened with milk or buttermilk before feeding to old people and children.

Swaminathan et al. (1976) and Pushpamma and Geervani (1981) reported the nutrient composition of sorghum. The average nutrient composition of sorghum *roti* is given in Table 1. Pushpamma and Geervani (1981) have reported the vitamin B losses during the process of *roti* preparation.

Consumers prefer white pale yellow colored, dense and round grains, free from colored spots for *roti* preparation (Murty et al. 1979). Grains of the traditionally grown cultivars *Maldandi* and *Dagdi*

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Table 1. Nutrient composition of sorghum *roti* (per 100 g)

Calories	292
Protein (g)	8.0
Fat (g)	1.2
Carbohydrate (g)	61.8
Ash (g)	2.3
Fiber (g)	2.9
Calcium (mg)	67.8
Iron (mg)	5.3
Thiamine (mg)	0.17
Riboflavin (mg)	0.16
Niacin (mg)	0.80

SOURCE: Pusphamma and Geervani 1981.

are popular and fetch the maximum price in the market.

Domestic Methods of *Roti* Preparation

Milling

Until a few decades ago, whole sorghum was ground to a moderately fine flour in hand-operated rotary stone mills. During the last few decades, about 90% of the milling has been done by small electrical or diesel-operated disc or plate mills (*chakki*) that mill small quantities of grain for consumers (Subramanian and Jambunathan 1980). Generally, enough grain to last the family for a week is milled each time. Usually, flour is not stored more than a week. The flour is sifted through a sieve comparable to U.S. standard 20 mesh and the overs comprising mostly bran and coarse particles are fed to animals. Usually 95–99% extraction is obtained. In some places the flour is used as such without sifting for dough preparation. Particle size distribution of the flour from grain samples of five cultivars ground in four village mills is given in Table 2. The particle size of the flour varies depending upon the mill, grinding pressure, grain sample, etc.

Dough Preparation

Housewives generally use the following procedure for *roti* preparation: Approximately 50 g flour are mixed with 50 ml of warm water in increments and is kneaded by hand on a smooth wooden board (5–7 cm high) into a dough (Subramanian and Jambunathan 1980). As the dough attains proper consistency, it is made into a 6-cm diameter ball and pressed by hand into the form of a circular disc. The disc is placed on the wooden board and flattened by fast and deft hand strokes into a thin circle. Small quantities of dry flour are used as dusting flour to eliminate stickiness during handling. *Roti* size varies from 12 to 25 cm in diameter and 1.3–3.0 mm in thickness depending upon the region. In the villages, farm workers prefer thick *rotis* since they lose moisture slowly and can be stored longer. A creamy white, sticky dough with a characteristic sorghum aroma is preferred.

Sorghum flour is made into a dough occasionally by substituting sugarcane juice, jaggery (a kind of brown sugar) water, milk, etc. for water (Subramanian and Jambunathan 1980). Sometimes finely sliced vegetables, spices, salt, etc., are mixed into the *roti* dough. Sorghum flour is also mixed with that of other grains like green gram, chickpea, and wheat in different proportions. When the dough is made by mixing sorghum with other grains and vegetables, the *rotis* are called by various colloquial names. In some restaurants, small quantities of dough are stored overnight in water and used the next day in small bits to mix with fresh flour to make dough.

Baking

Baking methods vary with the socioeconomic status of the family. In the villages, normally, three stones are arranged in a triangular form and an iron or earthen pan is placed on the stones. The fire is manipulated to give enough heat to the pan (Subramanian and Jambunathan 1980). Permanent hearths made out of mud into semicylindrical structures are also used. Baking temperatures are usually around 300–325° C. The *roti* is placed on the hot pan. Small quantities of water are sprinkled on top of the *roti*. Alternatively, the *roti* is moistened with a wet cloth. When the underside is cooked (normally in 30–40 sec) the *roti* is turned over. The *roti* is removed from the pan after a minute and is placed near the fire, with the unmoistened side exposed to limited heat from the fire that completely puffs the *roti*. In urban and semiurban areas, coal and gas stoves and electric grills are used for baking *rotis*.

Table 2. Particle size distribution of sorghum flour obtained from four Indian village mills.[a]

Cultivar	Percent flour retained on the sieve (U.S. mesh)					
	20	45	60	80	100	100 through
Village Mill-I						
M35-1	0.4	13.1	18.7	14.6	6.6	46.0
CSH-8	0.6	10.0	12.6	12.4	8.5	55.2
Village Mill-II						
Market Sample-1	1.3	6.1	29.8	28.7	16.3	17.4
Market Sample-2	0.4	4.4	24.9	27.7	19.6	21.3
Village Mill-III						
M35-1	0.10	6.20	17.48	17.25	8.82	49.78
	0.12	6.18	16.56	17.00	7.90	50.80
Mean	0.11	6.19	17.02	17.13	8.36	50.29
SPV-354	0.12	5.64	14.93	18.83	9.90	50.59
	0.15	5.47	15.28	17.15	10.82	51.08
Mean	0.14	5.56	15.11	17.99	10.36	50.84
Village Mill-IV						
M35-1	0.12	5.10	18.28	16.80	10.70	48.39
	0.10	4.74	18.00	17.62	9.30	50.10
Mean	0.11	4.92	18.14	17.21	10.0	49.23
SPV-354	0.11	4.70	16.37	15.94	11.70	50.70
	0.10	4.96	15.90	16.25	11.52	50.96
Mean	0.10	4.83	16.14	16.10	11.61	50.83

a. Observations recorded on village mills I and II were based on one sample whereas those on village mills III and IV were based on two samples.

Standard Laboratory Procedures

As mentioned earlier, there are several variations in the domestic methods of *roti* preparation. In order to evaluate *roti* quality of grain samples in the laboratory, *roti* preparation methods were optimized so that they would simulate the domestic methods to the extent possible and yet were controlled enough to reveal significant differences between samples for dough and *roti* quality.

Evaluation of Grain, Dough, and *roti* Characters

The following standard procedures and rating scales were used at ICRISAT to evaluate grain samples for *roti* quality.

1. Grain samples were dried to a moisture level around 10%. In addition to the dough and *roti* characters, it was found useful to record some physical properties of the grain sample including endosperm texture, (on a scale of 1 to 5, where 1 = 100% corneous), color, density (by water displacement), breaking strength (using KIYA Hardness tester), 100-grain weight, and percentage water absorption of grain after 5 hr of soaking in water.

2. Grain, dough, and *roti* colors were compared with Munsell soil color charts and the matching Hue, Value, and Chroma notations were recorded. Rooney et al. (1980) have used a Hunter Laboratory Color Difference Meter for measuring *tortilla* colors and the device could be useful for distinguishing *roti* colors.

3. All grain samples (300 g) were ground with a Milcent (Size 2) Domestic electric flour mill equipped with two vertically placed carborundum grinding stones. A standard grinding-pressure adjustment suitable to grind samples of M35-1 grain was used for all test samples. Small samples of grains were ground with a Udy cyclone mill. The flour was sifted using a U.S. standard 35 mesh

sieve and the throughs were collected to prepare *roti*.

4. A flour sample of 30 g was taken and kneaded into a dough using 25–30 ml water in small increments. The volume of water required to make a dough of satisfactory consistency (subjectively judged) with 30 g flour was recorded.

5. The kneading quality or stickiness of the dough was scored subjectively on a scale of 1 to 3, where 1 = good, 2 = average, and 3 = poor.

6. The dough sample was pressed by hands into a thick disc and rolled to a uniform thickness of 1.7 mm on a smooth laminated board with raised edges using a wooden rolling pin. Four to five g of dry flour was used to prevent the dough from sticking to the board or the pin. The flattened dough was cut into a 17-cm diameter *roti* with a circular die.

7. The rolling quality of the dough was evaluated by using another flour sample and measuring the diameter of the *roti* obtained by continuous rolling with a pin until the *roti* breaks.

8. *Rotis* were baked on an Indoleum pan heated by an electric hot plate and the temperature of the baking pan was maintained at 290–320° C with the help of a dial thermometer. Flattened dough discs of 17-cm diameter were placed on the hot pan. They were sprayed with 1–2 ml of water. *Roti* was turned after 30 sec and again after 1.5 min. The *roti* was removed after it was satisfactorily cooked and puffed showing two separate layers.

9. For routine samples, *rotis* were evaluated by the research technician in the laboratory. Selected samples were evaluated later by a trained taste panel. Keeping quality of the *rotis* was scored for two rotis for each test sample after 5 hr of storage at room temperature in perforated plastic trays. A *roti* was folded around a dowel stick (10 × 2 cm) and the extent of resistance to breakage was observed and scored on a scale of 1 to 5. *Rotis* with good keeping quality could be folded around the stick without any breakage. Storing *rotis* in a Percival Incubator at 30° C and 20% RH for 2 hr followed by rating for keeping quality was a satisfactory test.

Evaluation of Organoleptic Qualities

We found that a trained taste panel could evaluate the organoleptic quality of *rotis* more efficiently than randomly picked tasters. Initially, 20 traditional sorghum consumers were selected for taste panel studies and triangular taste trials were conducted with their help following the methods suggested by Larmond (1977). Each panelist was given three *rotis*, two from the same grain sample and the third from a different one. The panelists were asked to identify the odd sample. Six panelists, who identified the odd samples consistently, were trained further and were used to evaluate the test material. A good *roti* should be smooth, soft, and slightly sweet with a characteristic sorghum aroma (Murty et al. 1979). The trained panelists were asked to evaluate taste, texture, aroma, and overall acceptability of the *rotis*. Sample *rotis* from five cultivars were given to the taste panelists along with that of a blind check. Each day five to six panelists participated in the tests. Finally an average of the scores obtained from the panelists was considered for the evaluation of each individual test entry. Selected samples were replicated over 3 different weeks. The following scales were used for the various organoleptic parameters.

Taste: 1-good; 2-fair; 3-average; 4-bad; and 5-very bad.

Texture: 1-very soft; 2-soft; 3-average; 4-hard; and 5-very hard.

Aroma: 1-pleasant; 2-moderate; and 3-unpleasant.

Keeping quality: 1-good; 2-fair; 3-average; 4-bad; and 5-very bad.

The texture of *roti* could also be evaluated by using an Instron Tester to measure the force required to deform a *roti* and calculate the strain, stress, and modulus of elasticity, which reflect the softness and elastic nature of the *roti* (Waniska 1976).

Dough and *roti* quality characters of 15 sorghum cultivars evaluated using the standard procedures outlined here are presented in Table 3. These procedures were also used to screen a large number of breeding progenies followed by a trained taste panel evaluation of selected lines (Murty et al. 1981). However, more basic studies on the dough and *roti* properties of sorghum might lead to the development of rapid screening procedures useful to breeders. There is a need to develop simple, economic and reliable equipment to measure the textural properties of dough and *roti*.

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Table 3. Grain, dough, and *roti* quality[a] characteristics of 15 sorghum cultivars.[b]

Cultivar	Grain					Dough			Roti				
	Color[c]	Corneousness	Weight (g 100)	Breaking strength (kg)	Water Absorption (%)	Water required (ml)	Kneading quality	Rolling quality (cm)	Color[c]	Taste	Texture	Aroma	Keeping quality
M35-1	5Y 8 4	3	4.24	7.7	18.1	26.1	1.0	23.7	5Y 8 4	1.3	1.5	1.0	1.5
CSH-8	5Y 8 4	3	4.05	6.5	26.4	25.6	1.0	23.0	2.5Y 8 2	2.0	2.0	1.8	2.0
CSH-6	2.5Y 8 4	2	3.67	9.7	20.7	26.5	1.0	22.0	5Y 8 2	1.7	2.0	1.2	2.7
CSV-5	5Y 7 4	3	3.06	7.6	23.8	25.1	1.5	20.5	5Y 7 4	2.0	2.6	1.6	3.5
BG-30	2.5Y 6 4	3	5.16	7.0	32.4	25.2	1.5	21.3	5Y 7 4	2.9	2.8	2.5	3.5
IS-7943	2.5Y 7 6	3	5.64	9.6	37.0	26.1	1.0	22.8	5Y 7 3	3.0	1.8	1.5	3.2
CK60B	2.5Y 8 2	3	3.16	7.0	20.9	28.0	1.5	20.5	2.5Y 7 2	2.4	2.1	1.8	3.0
T-SS-47	2.5Y 6 6	3	4.02	8.6	23.8	28.3	2.0	20.3	5Y 7 4	2.3	2.2	1.4	4.1
IS-12611	5Y 8 2	2	4.64	11.0	22.7	30.9	1.0	22.2	5Y 8 2	1.6	1.5	1.2	3.0
P721	5Y 8 2	5	2.51	6.8	32.7	25.7	3.0	18.1	2.5Y 7 2	3.7	3.3	2.7	4.0
IS-1098	2.5Y 7 6	4	3.15	6.0	37.5	24.3	1.5	20.7	2.5Y 7 2	2.5	3.2	1.5	2.5
M36082	5Y 8 2	1	2.61	10.0	22.7	30.3	1.0	22.8	5Y 8 4	1.4	2.0	1.0	3.0
IS-2328	5Y 8 4	2	3.12	12.4	29.0	26.1	1.2	22.6	5Y 8 4	2.2	2.7	1.7	3.7
PJ33K	2.5Y 8 4	3	5.01	8.8	25.1	27.1	1.0	22.2	2.5Y 8 2	2.2	1.9	1.4	2.7
IS-11024	5Y 8 6	3	7.63	11.0	28.9	24.4	1.0	22.6	5Y 7 2	2.4	2.4	1.5	3.5

a. Methods and rating scales as mentioned in the text.
b. Grain samples were obtained from postrainy season harvest of 1978, ICRISAT Center.
c. All color grades belong to white and yellow shades of Munsell.

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