

Properties of Sorghum Grain and their Relationship to Roti Quality

V. Subramanian and R. Jambunathan*

175

Summary

Physicochemical characteristics of 45 sorghum genotypes were determined. The 100-grain weight, grain hardness, protein, water soluble protein, amylose, and sugars contents in the grain showed considerable variation. The roti quality of flour from the 45 genotypes was evaluated for color, appearance, taste, flavor, and texture by a trained taste panel. The texture of dough was measured using an Instron machine. Relationships between the physicochemical characteristics of grain and roti qualities were identified. The quantity of water soluble protein, amylose, and sugars jointly influenced the roti quality of the sorghum genotypes studied.

Sorghum grains are used as the staple food in several regions of Africa, China, and the Indian subcontinent particularly in the semi-arid tropics. It has been well established that chemical components such as protein, starch, lipids, and ash of wheat flour influence the breadmaking quality (Pomeranz et al. 1979). Studies on rice (Juliano 1979) indicated the importance of amylose and protein on the cooking and eating quality of rice. Physicochemical characteristics of sorghum and their effect on sorghum food products have not been well documented. Miller and Burns (1970) studied the relationship between the starch characteristics and organoleptic qualities of sorghum bread and reported that varieties with high amylopectin content were preferred for sorghum bread. However, Miche et al. (1976) indicated that the role of lipids during pasta manufacture and the role of amylose, amylopectin of sorghum starch, and other protein fractions had not been investigated. The role played by chemical or physical factors of sorghum grain on food quality appears to be a complex phenomenon. Our work on *roti* evaluation (Subramanian and Jambunathan 1980) revealed that physicochemical factors jointly influence the *roti* quality of sorghum. In this paper the properties of sorghum

flour and their relationship to *roti* (*chapati*) quality from 45 cultivars are discussed.

Materials and Methods

Physical Properties

Forty-five sorghum cultivars of varying grain characteristics (Table 1), grown at ICRISAT Center during the post-rainy seasons of 1979 under uniform field conditions, were studied. Grain hardness ($\text{kg}\cdot\text{cm}^2$) was measured as the force required to break the grain using a Kiya hardness tester. Whole grains were ground to flour in a UDY Cyclone Mill to pass through a 60-mesh sieve. The flour was defatted using n-hexane for further analysis. The swelling capacity of flour was determined by treating 0.5 g flour in 15 ml water and the contents were kept in a heating block maintained at 90°C for 1 hr. The volume and weight increase of flour were determined and expressed as the ratio between initial volume and final volume (v/v) or weight (v/w). The solute content of the water extract of flour at 90°C , designated as the water soluble flour fraction (WSFF), was determined as follows. A quantity of flour, 0.5 g, was heated with 15 ml water for 1 hr at 90°C with periodical shaking. The contents were cooled and centrifuged. The supernatant was made up to 50 ml. An aliquot was evaporated to dryness and the weight of the dissolved solids was designated as WSFF.

* Subramanian is Biochemist; Jambunathan is Principal Biochemist, ICRISAT.

content should be confirmed by isolation of the starch.

It appears that both environment and genetic factors affect the level of amylose in nonwaxy sorghums. However, significant heritable differences in amylose content have not been clearly demonstrated in nonwaxy sorghums.

References

BOLLICH, C. N., and WEBB, B. D. 1973. Inheritance of amylose in two hybrid populations of rice. *Cereal Chemistry* 50: 631-636.

DEATHERAGE, W. L., MACMASTERS, M. M., and RIST, C. E. 1955. A partial survey of amylose content in starch from domestic and foreign varieties of corn, wheat and sorghum and from some starch-bearing plants. *Transactions American Association of Cereal Chemists* 13: 31-42.

JOHNSON, B. T. 1981. A nutritional evaluation of *tô*, a staple African food, cooked using three different processing methods. M.S. thesis, Texas A&M University, College Station, Texas 77843, USA.

JULIANO, B. O. 1971. A simplified assay for milled rice amylose. *Cereal Foods World* 16: 334-340, 360.

JULIANO, B. O. 1979. Amylose analysis in rice. Pages 251-260 in a review in chemical aspects of rice grain quality. International Rice Research Institute, Los Banos, Laguna, Philippines.

JULIANO, B. O., ALBANO, E. L., and CAGAMPANG, O. B. 1965. Variability in protein content, amylose content and alkali digestibility of rice varieties in Asia. *The Philippine Agriculturist* 234: 241.

MURTY, D. S., and HOUSE, L. R. 1980. Sorghum food quality; its assessment and improvement. Report submitted to the 5th Joint Meeting of the UNDP-CIMMYT-ICRISAT Policy Advisory Committee. 14-18 Oct 1980. Patancheru, India.

NORRIS, J. W., and ROONEY, L. W. 1970. Wet milling properties of four sorghum parents and their hybrids. *Cereal Chemistry* 47: 64-69.

PAULE, C. M. 1977. Variability in amylose content of rice. M.S. thesis, University of Philippines, Los Banos, Philippines. 82 pp.

ROONEY, L. W. 1970. Unpublished data.

ROONEY, L. W., and SULLINS, R. D. 1969. A laboratory method for milling small samples of sorghum grain. *Cereal Chemistry* 46(5): 486-490.

STALEY. 1973. Values for amylose standards. Unpublished data. Staley Manufacturing Company, 2200 Eldorado St. Decatur, Illinois 62525.

TECHNICON. 1978. Glucose (hexokinase): Technicon Method No. SF4-0046FAB. Tarrytown, New York.

WEBB, B. D. 1972. A totally automated system of amylose analysis in whole kernel rice. *Cereal Science Today* 17: 9, 141.

Table 1. Grain characteristics of 45 sorghum cultivars.

| Cultivar | Grain color | Corneousness ^a | Grain hardness (kg cm ²) | 100-seed weight (g) |
|-----------------|-------------------------------|---------------------------|---|------------------------|
| PJ-7R | White with red spots | 3 | 6.4 | 4.32 |
| PJ-16R | Creamy white | 3 | 6.0 | 3.90 |
| PJ-18R | Light yellow | 3 | 6.3 | 4.04 |
| PJ-19R | White with brown spots | 3 | 6.6 | 4.14 |
| PJ-1K | White with red spots | 3 | 6.0 | 4.44 |
| PJ-2K | White with red spots | 4 | 5.6 | 4.68 |
| PJ-4K | White with red spots | 4 | 6.3 | 4.65 |
| PJ-12K | Creamy white | 4 | 6.4 | 5.45 |
| PJ-14K | Creamy white | 3 | 6.3 | 2.77 |
| PJ-31K | Creamy white | 4 | 6.1 | 4.65 |
| PJ-32K | Creamy white | 4 | 6.8 | 4.88 |
| Maldandi local | Creamy white | 4 | 7.3 | 3.93 |
| Karad local | Creamy white | 3 | 6.8 | 3.70 |
| SS-2 | White with brown spots | 3 | 6.7 | 3.53 |
| Pickett-3 | White with red spot | 3 | 8.2 | 3.31 |
| GM-2086 | Light brown | 4 | 6.6 | 4.05 |
| Jimila | Light brown with subcoat | 4 | 7.2 | 2.65 |
| NJ-1346 | Creamy white with brown spots | 2 | 8.3 | 3.38 |
| NJ-1953 | Creamy white | 4 | 7.9 | 4.53 |
| Dholio | White with brown spots | 4 | 5.2 | 5.01 |
| Surat-1 | Creamy white | 4 | 5.9 | 4.49 |
| Aispuri | Dull white | 4 | 5.0 | 3.57 |
| K. white grain | White with brown spots | 3 | 7.2 | 3.57 |
| Vidisha 60-1 | Dull white | 4 | 5.4 | 4.26 |
| BP-53 | Dull white | 4 | 7.0 | 4.60 |
| FR-178 | White with brown spots | 3 | 6.1 | 3.19 |
| H-102 | Creamy white | 3 | 6.0 | 3.61 |
| H-107 | White with brown spots | 3 | 6.7 | 3.54 |
| SPV-35 | White with red spots | 3 | 7.8 | 3.38 |
| S-302 | White with red spots | 3 | 7.8 | 4.11 |
| 269 | Creamy white | 3 | 7.9 | 3.27 |
| 285 | Creamy white | 3 | 6.5 | 3.01 |
| 296 | Dull white | 4 | 6.7 | 4.09 |
| 370 | Creamy white | 3 | 7.4 | 3.13 |
| 1235 | Creamy white | 3 | 7.5 | 2.75 |
| S-12611 | Dull white | 3 | 11.8 | 4.24 |
| E-12-5 | Creamy white | 2 | 11.8 | 3.36 |
| E-35-1 | White | 2 | 6.7 | 3.54 |
| Bodgawanda-wani | White with pink spots | 4 | 6.6 | 3.88 |
| Mau-wani | White with pink spots | 5 | 3.0 | 2.65 |
| Vani-Wani | White with pink spots | 4 | 5.2 | 3.20 |
| Naraliguti Wani | White with pink spots | 4 | 6.1 | 3.77 |
| Pandori-Wani | Creamy white | 5 | 4.9 | 2.30 |
| Bilora-Wani | Creamy white | 4 | 7.3 | 4.57 |
| Lahi-Wani | White | 3 | 5.6 | 4.22 |

a. Corneousness was measured on a scale of 1-5, where 1 is more corneous and 5 is floury.

Chemical Characteristics

Protein was determined by the microKjeldahl method (AOAC 1970). Water soluble protein of flour was extracted by shaking 1 g flour in 15 ml water at room temperature. The extraction was repeated with 10 ml water and the extracts were combined and made to 50 ml. A 10 ml aliquot was treated with trichloroacetic acid (TCA) to yield a final concentration of 10%. The resulting precipitate was dissolved in 1 ml of 0.1 N NaOH and the protein content was determined by the method of Lowry et al. (1951). The amino acid composition was determined using Beckman (120-C) amino acid analyzer. Starch content was estimated using the enzyme glucoamylase as reported by Singh et al (1980). Total amylose was determined according to Williams et al. (1958); water soluble amylose was estimated colorimetrically (Juliano et al. 1968). Total sugars were determined by the phenol-sulphuric acid method (Dubois et al. 1956) and the reducing sugars by using Nelson Somogyi reagent (Somogyi 1952). Fat and ash contents were analyzed by the AOAC (1970) methods. For gel filtration chromatography of the water soluble protein, a solution containing 5 mg protein was applied on a Sephadex G.100 column (82 × 1.5 cm). The protein was eluted using 0.01 M phosphate buffer (pH 7.6) containing 0.01 M mercaptoethanol, 0.4 M sodium chloride and 0.05% sodium azide. Absorbance of the eluent was recorded by a LKB 8300 UVCORD monitor.

Dough and *Roti* evaluation

Dough quality was evaluated subjectively for kneading and rolling qualities. Dough stickiness was evaluated using an Instron machine. Dough was prepared by mixing 50 g flour with 40 ml water. After kneading well, the contents were divided into three equal parts by weight. The dough was placed in the back extrusion cell of the Instron machine (Model 1140) and compression was made. The force required for back extrusion, area and slope of the curve were determined from the recorded tracings.

Rotis were made as per the procedure outlined by Subramanian and Jambunathan (1981). The organoleptic properties such as color and appearance, flavor, taste, texture, and general acceptability were evaluated with a trained taste panel consisting of 12 persons.

Results and Discussion

Physicochemical Characteristics

The grain hardness showed a wide variation of 3 to 12 kg (Table 1). The range and mean values of physicochemical characteristics of sorghum flour are given in Table 2. Swelling capacity of flour varied from 5 to 8 on a volume basis. The WSFF ranged from 19 to 35 mg/100 g. The protein content of the 45 cultivars varied from 8 to 14%. The protein content in the water soluble fraction of the flour ranged from 0.3 to 0.9% of grain. Gel filtration of water soluble proteins on Sephadex G-100 in phosphate buffer at pH 7.6 yielded two major peaks (Fig. 1). Though variation was observed for the amino acid composition of the water soluble fraction of the two cultivars (Table 3), further studies are needed to draw proper conclusions.

Starch is the major constituent of sorghum grains. The role of starch in the breadmaking quality of wheat is well known due to its effect on water absorption (Alsberg 1927). The starch content of the grain of the 45 sorghum cultivars varied from 62.6 to 73.3% and the amylose content ranged between 21.2 and 30.2% (Table 2). Hulse et al. (1980) reported that the amylose content in 100 sorghum lines ranged from 7.1 to 31.3%. Waxy sorghums are reported to have a low amylose content. The water soluble amylose of the 45 cultivars ranged from 4.8 to 12.7% of the grain. Sorghum grains contain five different sugars, i.e., sucrose, stachyose, raffinose, glucose, and fructose in varying proportions (Subramanian et al. 1980). The fat content in sorghum samples varied from 2.3 to 4.7% and ash from 1.3 to 2.2% (Table 2).

Relationship among the Physicochemical Characteristics

The relationship among the physicochemical characteristics of sorghum grain has been worked out and some are given in Table 4. The 100 grain weight showed a negative association with protein while it was positive with amylose. Swelling capacity of flour was not associated with any of the chemical factors. Protein content showed a strong negative relationship with starch and water soluble amylose contents in the grain and was positively related with water soluble protein, and

