NOTE

# Modified Adhesion Test for Measuring Stickiness of Sorghum Porridges[1]

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Despite the usage of sorghum for many years as a staple food in the arid regions of Asia and Africa, little is known about the chemical and physical properties of sorghum grain that relate to food quality. The lack of information and the wide diversity in the preparation of traditional sorghum foods contribute to the lack of progress in sorghum-breeding programs for food grain quality.

As with most foods, texture of the cooked sorghum paste or gel is important in the consumer acceptance of traditional foods containing sorghum. Textural quality is especially important for such traditional foods as thick sorghum porridge, commonly known as *tô, tuwo, ugali, bogobu,* and *mudde* (Murty and House, 1980). In West Africa, *tô* (a thick gel prepared from sorghum flour and water) is eaten with the fingers and therefore should be stiff enough to enable one to scoop portions with the fingers but should not stick to the fingers or teeth (Scheuring 1980). In addition, leftovers should maintain their stiffness overnight and not be mushy after storage. Thus, direct textural measurements of sorghum foods are useful criteria for determining their acceptability. The importance of texture has been demonstrated in other cereals such as rice (IRRI 1979), in which the texture of the cooked grain or paste has been evaluated by amylography (Fukuba and Yamamoto 1954), parallel plate viscometry (Endo et al 1976), Haake consistometry (Kumar et al 1976), Brookfield viscometry (Endo et al 1976), and gel consistency (Cagampang et al 1973, Juliano and Pascual 1980).

A quantitative method for evaluating the textural properties of these foods could provide a means of evaluating the acceptability of different sorghum cultivars. Accordingly, we have developed a test cell for quantitatively measuring the adhesion force (stickiness value) of cooked sorghum flour-water pastes, using the Instron model 1132 testing machine.

## MATERIALS AND METHODS

### Paste Preparation

Six cultivars of sorghum of various grain hardness were used in the study (Table I). Grain hardness, as measured by percent of vitreousness, indicates the proportion of the hard endosperm to the entire endosperm (Kirleis and Crosby 1981). These cultivars were grown at the Purdue University Agronomy Farm in West Lafayette, IN, during the 1980 crop year. All the grain samples were uniformly pearled using a combination of two types of Strong-Scott barley pearlers (Burrows Equipment Co., Evanston, IL). One type was equipped with a carborundum wheel, and the other type was modified by replacing the carborundum wheel with three wire brushes (Rooney and Sullins 1969). Initial pearling of 15 sec in the carborundum pearler, followed by 30–75 sec of pearling with the wire brush pearler, removed the pericarp, testa, and most of the germ and minimized grain breakage. The pearled grain, which accounted for about 70% of the whole grain, was ground by a Udy cyclone mill into a flour to pass through a screen with 0.4-mm round holes.

Ten grams of flour (in duplicate) were thoroughly mixed with 90 ml of distilled water in a 250-ml beaker. The mixture was cooked for 20 min in a Tatung automatic rice cooker (Tatung Company of America, Compton, CA) with 1.5 L of water in the outer pot. To ensure evenness in the cooked paste, the mixture was uniformly mixed every 5 min without removing the beaker from the cooker. The cooked paste was removed from the cooker, covered with paraffin, and left undisturbed at room temperature for 1 hr before being tested for stickiness.

### Stickiness Measurement

As shown in Fig. 1, the fabricated test cell used for measuring the gel adhesion on the Instron model 1132 testing machine (Instron Corporation, Canton, MA) consisted of a plastic cap (diameter = 33.2 mm) covered with a plexiglass plate 6.35 mm thick. The test cell was attached to a 2-kg tension load cell with three pieces of plumber's chains (each 170 mm) and a three-pronged fishhook. A 1-kg weight was placed in the center of the plastic cap, and the entire rig was lowered onto 10 g of paste, which was weighed on the center of a flat aluminum plate. Extreme care was taken during the compression of the sample to prevent air entrapment between the gel surface and test cell and to distribute the sample paste evenly on the aluminum plate. The diameter of the test cell was marked at the center of the plate to facilitate the centering of the paste.

When the chains slackened (no load showing on the graph recorder), the 1-kg compressor weight was allowed to remain on top of the gel for 10 sec, then was removed, and the test was run in the tension mode. A crosshead speed of 5 cm/min and a chart speed of 10 cm/min were employed. As the recorder graph showed symmetrical sample peaks (Fig. 2), stickiness values (adhesion force in grams) were obtained by measuring peak height.

## RESULTS AND DISCUSSION

The ability of the method to detect differences in cooked paste stickiness value of the six sorghum cultivars tested is shown in Table I. The range of stickiness values was from 435 g for SC283-14 to 1,755 g for 850649. The mean coefficient of variability for the test was 4.51%.

Our method has several advantages over other types of Instron adhesion testing. The test cell is inexpensive, has relatively large surface area for its low weight, allows excess sample to extrude freely around the edges such that the sample does not interfere with the adhesion values, is very light, and requires less "zero compensation," thus allowing the use of a more sensitive load cell, and is much faster to clean. Finally, the sensitivity of the test cell suggests that it would be useful as a screening method for sorghum breeding programs.

**TABLE I**
**Stickiness and Hardness Values of Some Sorghum Grains**

| Cultivar | Stickiness Value (g)[a,b] | Vitreousness (%)[a] |
|---|---|---|
| SC283-14 | 435 a | 87.6 a |
| IS0452 | 945 b | 55.3 bcd |
| CS3541 | 1,010 bc | 60.6 bc |
| M35-1 | 1,040 bc | 47.3 cd |
| IS1461 | 1,480 def | 26.1 e |
| 850649 | 1,755 f | 10.0 f |

[a] Means followed by the same letter are not significantly different ($P = 0.01$).
[b] Means of two values.

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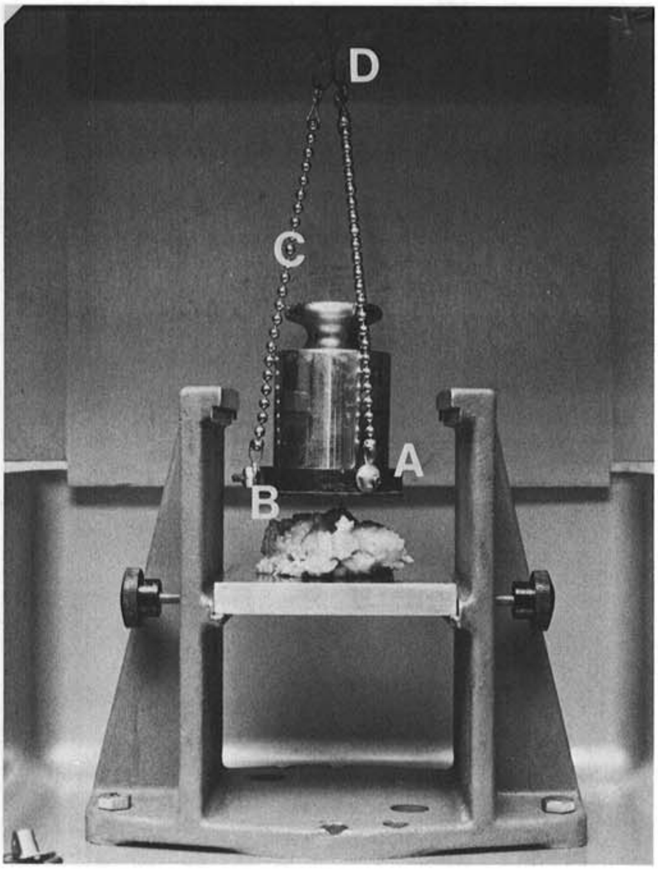

**Fig. 1.** Modified adhesion test cell mounted in the Instron model 1132 food tester. **A,** plastic cup; **B,** plexiglass plate; **C,** plumber's chain; **D,** three-pronged fishhook.

For the same set of samples, grain hardness values (as measured by percent of vitreousness) ranged from 10.0 to 87.6% (Table I). Grain hardness is a very important physical attribute of the grain because it reflects the milling quality of the grain as well as the texture of the cooked products. Murty and House (1980) reported the relation of sorghum grain hardness to the particle size distribution of the resulting flour, milling recovery, and milling time. They found that less vitreous grains have a softer endosperm texture and are less suited for most of the traditional porridge preparations. In this study, grain hardness is very highly correlated with Instron stickiness ($r = -0.989$, significant at $P = 0.01$). Obviously, aside from its potential as a sensitive method of evaluating texture of cooked sorghum paste, the test is also a reliable index for predicting the degree of grain vitreousness.

Our work on establishing the relationship of the Instron stickiness value with the other grain quality indices is the subject of another study, which is in progress.


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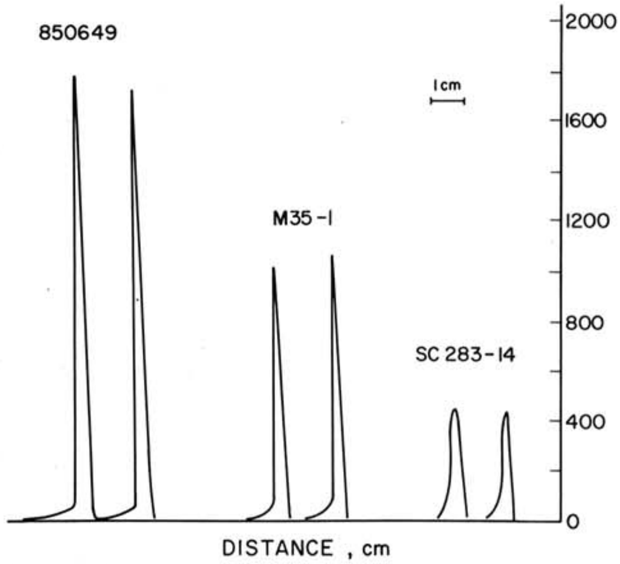


**Fig. 2.** Adhesion peaks of sorghum cultivars differing widely in degree of vitreousness: SC283-14 (high), M35-1 (intermediate), and 850649 (low).

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