Textural Properties of Sorghum Dough

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ABSTRACT

Textural properties of dough prepared from the flours of eight sorghum cultivars were evaluated subjectively and also measured using a back-extrusion cell in an Instron Food Testing Instrument. The force and energy required for the extrusion of good quality cohesive dough were high. A poor quality dough was compressed into the cell without extrusion. The influence of flour-water-soluble components on dough conhesiveness are discussed.

INTRODUCTION

IN THE CENTRAL PARTS of India, which account for most of the sorghum production, *roti* (coarse, unleavened bread) is the most popular sorghum food. Sorghum *roti* is prepared from whole grain flour by making a dough, similar to that prepared from wheat. *Roti* quality can be judged by the ease with which the dough can be rolled using a wooden rolling pin or flattened to a disc by deft strokes of the hand and the quality of baked *roti* can be evaluated with respect to softness, chewing property, taste, and aroma. Detailed methods of processing of sorghum and the procedures for making *roties* have been reported earlier (Subramanian and Jambunathan, 1980, Murty and Subramanian, 1982). The kneading quality of dough is important and the dough should be fairly cohesive and pliable. The importance of rheological properties of wheat flour dough is well recognized. Rheological tests on dough serve as an important tool in testing wheats and flours for their baking performance (Rasper, 1976). Water-soluble components are known to influence the quality of wheat flour dough (Udy, 1956). The textural properties of sorghum *roti* (after baking) were studied using an Instron machine (Waniska, 1976). Diehl (1982) reviewed the importance and applications of various techniques for measuring the texture of sorghum food products. Studies of the textural properties of dough from nonwheat flours such as sorghum are lacking. A brief account on the textural characteristics of dough for a few sorghum cultivars has been reported earlier (Subramanian and Jambunathan, 1982). In this paper the textural properties of doughs made from different sorghum flours and the effect of sorghum flour-water solubles on dough cohesiveness are discussed.

MATERIALS & METHODS

SORGHUM GRAIN SAMPLES were obtained from 6 cultivars grown at ICRISAT Center, Patancheru (India) during the post-rainy season (Sept.-Dec.), 1979 (Table 1). Grains of P.721 were obtained from the 1980 post-rainy season. A bulk of grain of the cultivar M.35-1, a common variety used in India, was obtained from the Agricultural Research Station, Mohol (India). M.35-1 and P.721 grains were used for standardizing the instrumental tests and also to study the effect of flour-water solubles on dough quality. Whole grain was ground to pass a 0.4 mm screen in a Udy cyclone mill.

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Chemical analysis

The flour was extracted with n-hexane in soxhlet apparatus for 6 hr and fat content was determined (AOAC, 1975). Protein and ash contents were estimated by AOAC (1975) methods. Starch content was determined using the enzyme glucoamylase (Sigma) as described by Singh et al. (1980) and the glucose released was estimated by the phenol-sulphuric acid method (Dubois et al., 1956).

Dough preparation

All operations were carried out at ambient temperature (25 ± 2°C). To 50g flour, distilled water was added in small increments and the dough was mixed well by hand and kneaded until appropriate consistency was obtained. The quantity of water (ml) required for achieving the desirable dough consistency was noted. After kneading, the cohesiveness was evaluated subjectively using a score of 1 to 3, where 1 was good and 3 was poor. The reproducibility of the method was tested by using 8 replicates each of 4 sorghum cultivars M.35-1, P.721, yellow, and white market samples. All the samples were assigned a code number at random and evaluated by 4 panelists.

Instrumental measurements

The physical characteristics of dough were measured with an Instron Food Testing Instrument (Table model 1140) using a back extrusion cell consisting of two units: a cylindrical sample vessel and a plunger (Fig. 1). The sample vessel was of aluminum, 95 mm high, 35 mm internal diameter and 3.5 mm thick walls. A plunger with a circular disc (34 mm diameter and 9 mm thick) bolted to the lower end moves freely into the sample vessel. The plunger was threaded to the crosshead of the Instron machine.

The dough was prepared and divided into three equal parts by weight. The dough was molded to a cylindrical shape and placed into the back extrusion cell and then compressed by the crosshead at 50 mm/min. The force required for the compression-extrusion process and the slope of the curve obtained were recorded. The energy used was determined from the area under the curve measured by a planimeter and calculated in energy units. The measurements were repeated at least two times for each cultivar and averaged.

Extraction of water solubles

Four cultivars, two of which (M.35-1 and IS-12611) possessed good dough qualities and two (Simila and P.721) poor dough qualities were used to study the effect of flour-water solubles on dough cohesiveness. Flours were individually extracted with distilled water: (1:4, w/v) by shaking for 1 hr at room temperature. The resulting slurry was centrifuged for 15 min at 2,500 rpm (754 x *g*). The supernatant, defined as 'water-solubles', was used for preparing the dough and 40 ml of water-solubles were added to 50g flour of each sample in place of distilled water. Water-solubles extracted from Simila and P.721 flours were mixed with flours of IS-12611

Table 1—Proximate composition of sorghum grains (%)

Cultivar	Protein	Starch	Fat	Ash
Simila	12.1	64.2	3.2	1.6
P.721	12.0	64.2	4.2	1.8
PJ-12-K	9.1	71.2	3.2	1.4
Karad local	10.7	67.0	3.3	1.6
269	10.5	69.4	2.3	1.4
IS-12611	11.2	67.0	3.4	1.5
IS-1235	9.6	67.9	3.2	1.5
M.35-1	10.7	66.3	3.9	1.7

and M.35-1, respectively. Similarly, the water-solubles obtained from IS-12611 and M.35-1 were added to flours of Simila and P.721, respectively. The resulting dough samples from these combinations were tested with the Instron as described above.

RESULTS & DISCUSSION

STARCH AND PROTEIN CONTENTS of flours of the eight genotypes used varied widely (Table 1). Variation in fat and ash contents were small.

Dough must be sufficiently cohesive and resilient in consistency to produce good *roties*. The results of subjective evaluation and Instron measurements on doughs are given in Table 2. The optimum quantity of water required to make satisfactory doughs varied considerably. The kneading quality of flours from IS-12611, 269, IS-1235 and M.35-1 were good, while it was poor for Simila and P.721. The mean scores and variation in the standard errors for evaluating the kneading quality of 4 sorghum cultivars by 4 panelists were as follows:

P.721: 3.0, 0–0.08; yellow market sorghum: 1.9, 0–0.13; white market sorghum: 2.4, 0–0.21; M.35-1: 1.0, 0. The doughs made from flours of M.35-1, IS-12611 and 269 could be easily rolled into *roties*, whereas, the flours of Simila and P.721 were difficult to roll into *roties*.

A typical force-distance curve for the back extrusion test for normal cohesive sorghum dough is given in Fig. 2. The complete understanding of the curves obtained would be difficult. However, we have attempted to bring out explanations based on the interpretations of Voisey et al. (1972). Initially the dough was compressed to pack the cell volume tightly as indicated by points A-B-C (Fig. 2). The force at point C was sufficient to compress the dough and initiate extrusion through the annulus between the plunger and walls of back extrusion cell. Point C is taken as the "initial

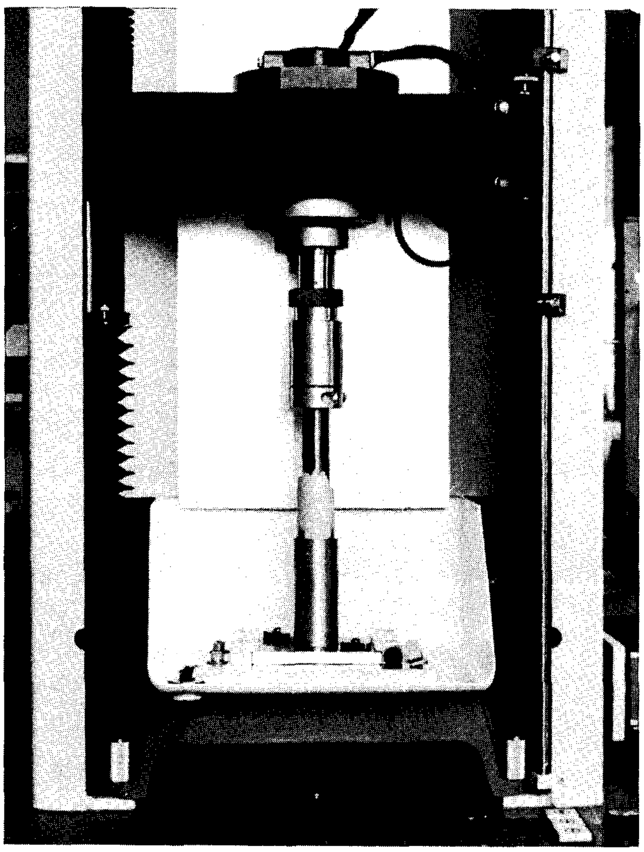

Fig. 1—Measurement of sorghum dough characteristics using a back extrusion cell in an Instron Food Testing Instrument (Table model 1140).

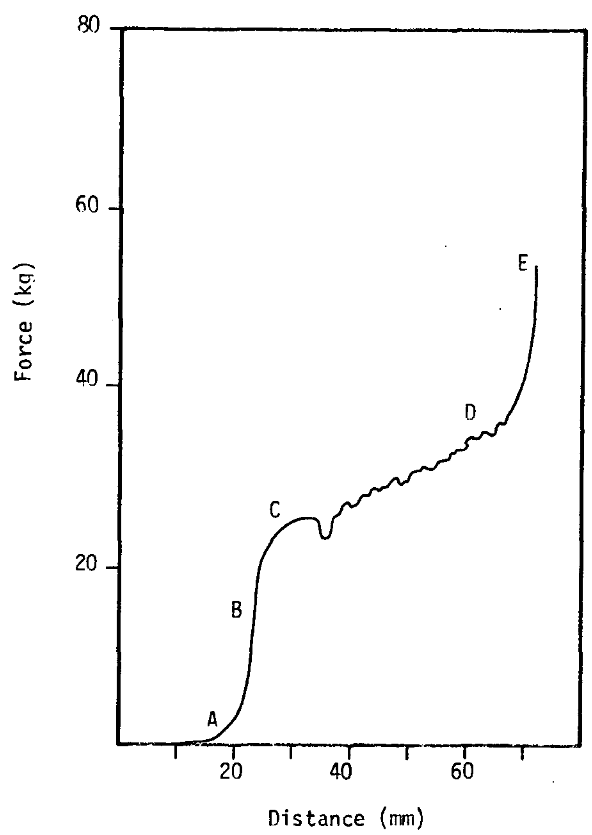

Fig. 2—Typical force-distance curve of sorghum flour dough in the Instron obtained with back extrusion cell.

Table 2—Subjective evaluation and instrumental readings of sorghum dough

Cultivar	Water for making dough (ml/50 g flour)	Kneading quality[a] (score)	Initial force[b] (kg)	Yield point[b] (kg)	Work done (Joules)	Slope (kg/mm)
Simila	42	3			no plateau	
P.721	43	3			no plateau	
PJ-12-K	36	2	12.5	20.0	1.08	0.25
Karad local	40	2	19.3	25.7	1.53	0.24
269	40	1	27.5	39.0	2.41	0.40
IS-12611	42	1	35.0	48.8	2.84	0.49
IS-1235	41	1	43.3	53.7	3.24	0.40
M.35-1	40	1	32.8	58.0	3.43	0.60

[a] Kneading quality was scored subjectively over a scale of 1 to 3, where 1 is good and 3 is poor.
[b] Instron values.

force" at which extrusion commences. Extrusion then continued until the test was terminated at point E. The force indicated by point D, referred to as 'yield point', is the sum of combined effects of apparent elastic behavior and extrusion of the dough sample, the latter showing the combined effects of adhesion, cohesion and shearing. The plateau CD shows the force needed to continue the extrusion process at a constant rate. The plateau slope may be an index of cohesiveness and firmness. The total area under the curve is "work done or energy."

The force-distance curves for doughs subjectively judged as good, medium, and poor quality are shown in Fig. 3. An example of a typical profile of good dough is shown in Fig. 3a. For a medium quality dough, (Karad local) the force required for the process of back extrusion, the area under the curve (energy), and also the plateau slope were comparatively lower (Fig. 3b). Interestingly, the poor doughs made from Simila and P.721 flours did not produce a plateau in the curves and the yield point was not evident indicating poor dough cohesiveness. For these two flours the force could be measured but initial and yield points were not evident (Fig. 3c). The initial force ranged from 12.5 to 43.3 kg for medium and good quality doughs (Table 2). Cohesiveness of dough was shown by an increased force during the process of back extrusion as observed for flours of M.35-1, IS-12611 and IS-1235 (Table 2) and their slopes of the plateaus were also greater.

Water-soluble components such as pentosans, though only present in small amounts, significantly influence flour performance due to their chemical nature and physical characteristics in wheat (Yeh et al., 1980). Hence an attempt was made to study the effect of water-soluble components on the dough consistency of sorghum flours. Doughs made from M.35-1 and IS-12611 with 40 ml distilled water possessed good cohesiveness. However, the doughs made from Simila and P.721 flours with 40 ml distilled water, broke apart easily and failed to develop cohesiveness when kneaded. In order to test the effect of water-solubles on the flours, the flour-water soluble extract ratio was kept constant by using 50g flour and 40 ml water-solubles. When the dough was made by mixing water-soluble flours of Simila and P.721 with water-solubles of IS-12611 and M.35-1 flours respectively, the cohesiveness and consistency showed moderate improvement as observed by the back-extrusion results (Fig. 4 and 5). The cohesiveness of dough prepared by mixing Simila flour with water-solubles of IS-12611 flour considerably improved the consistency (Fig. 4d) even though the volume of liquid (40 ml) used was less than the volume (42 ml) used previously for Simila flour (Table 2). However, the flours of Simila and P.721 contain their original quantities of water-solubles and the water-solubles content was not quantitatively determined. A similar observation was noticed for behavior of dough of P.721 flour when prepared with water-solubles of M.35-1 flour (Fig. 5d). The improvement in cohesiveness and consistency was comparatively better for P.721 than for Simila flour. Although the extrusion patterns for doughs of Simila and P.721 flours prepared by using the water-solubles of IS-12611 and M.35-1 flours respectively showed considerable improvement, the compression effect was not reduced appreciably. This was observed by the high yield point force followed by an abnormal slope of the curve. The dough made by mixing IS-12611 of M.35-1 flours with water-solubles from Simila or P.721 flours respectively did not appreciably alter the force-distance curves (Fig. 4c and 5c). A similar effect was observed when water-solubles of Simila and P.721 flours were used to make the dough with M.35-1 and IS-12611 flours, respectively. The results obtained with a limited number of samples in this study indicate that the back-extrusion technique has a potential of distinguishing between good and poor quality sorghum. As a guideline, it may be suggested that a slope of 0.40 or above indicate an acceptable value for dough cohesiveness of sorghum.

The water-soluble components present in flours may be one of the factors which appear to play an important role in the textural properties of dough. We have compared the amino acid composition of water-solubles of IS-12611 and PJ-12-K and have separated the water-solubles of M.35-1 using Sephadex G100 column chromatography but the results obtained have been inconclusive and further work is in progress. Rheological quality of wheat dough is attributed to the role of water-soluble nonstarchy polysaccharides in changing the water-binding capacity of the

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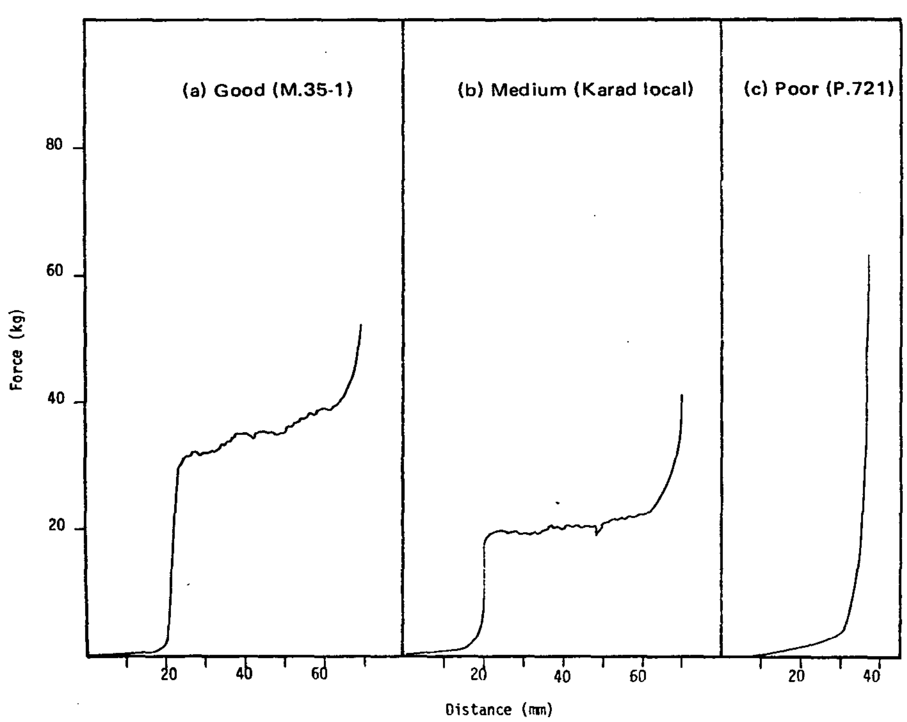

Fig. 3—Force-distance curves for good, medium, and poor quality doughs of sorghum flour (Instron).

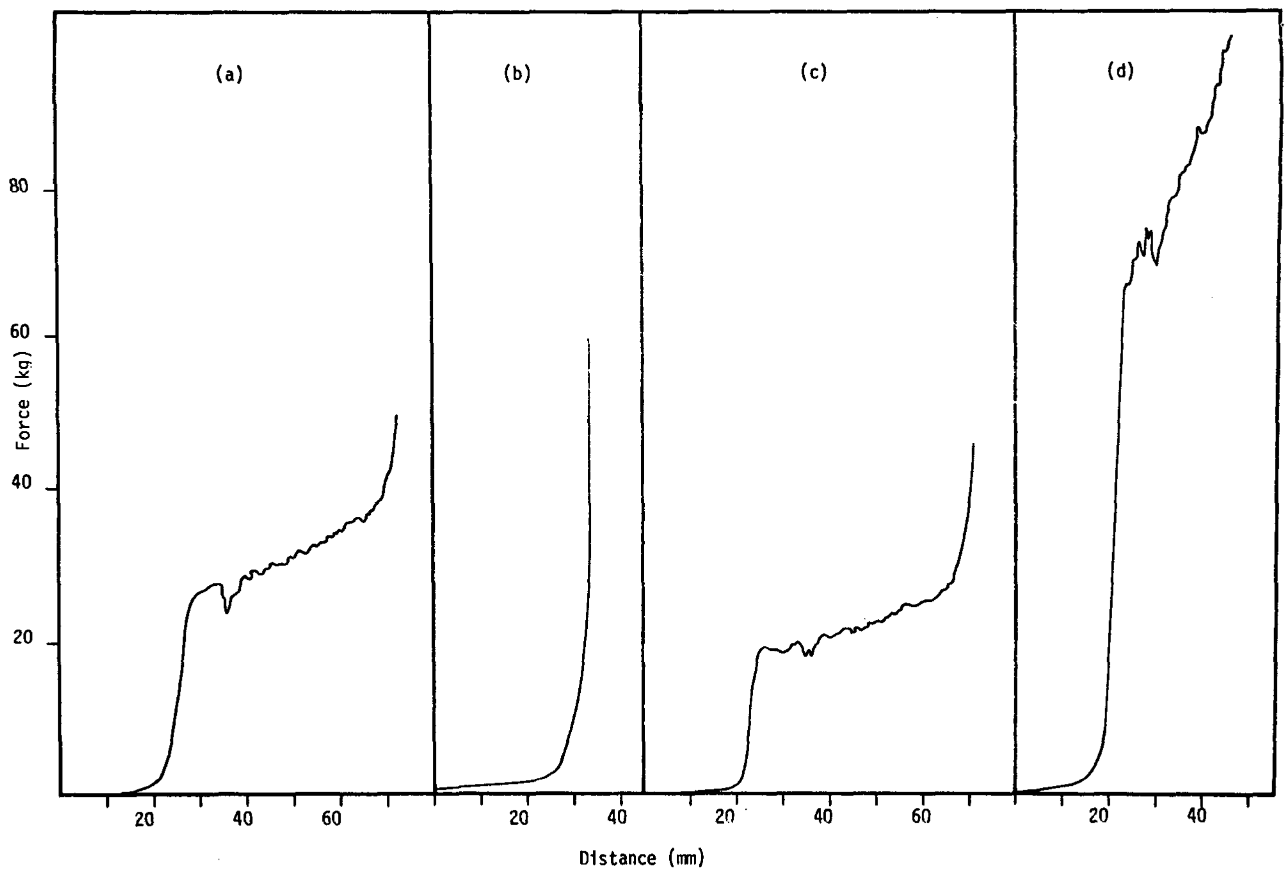

Fig. 4—Force-distance curves of IS-12611 and Simila flour doughs. Dough was prepared by mixing 50g flour with 40 ml water or water-solubles of flour. (a) IS-12611 flour + water; (b) Simila flour + water; (c) IS-12611 flour + water-solubles of Simila flour; and (d) Simila flour + water-solubles of IS-12611 flour.

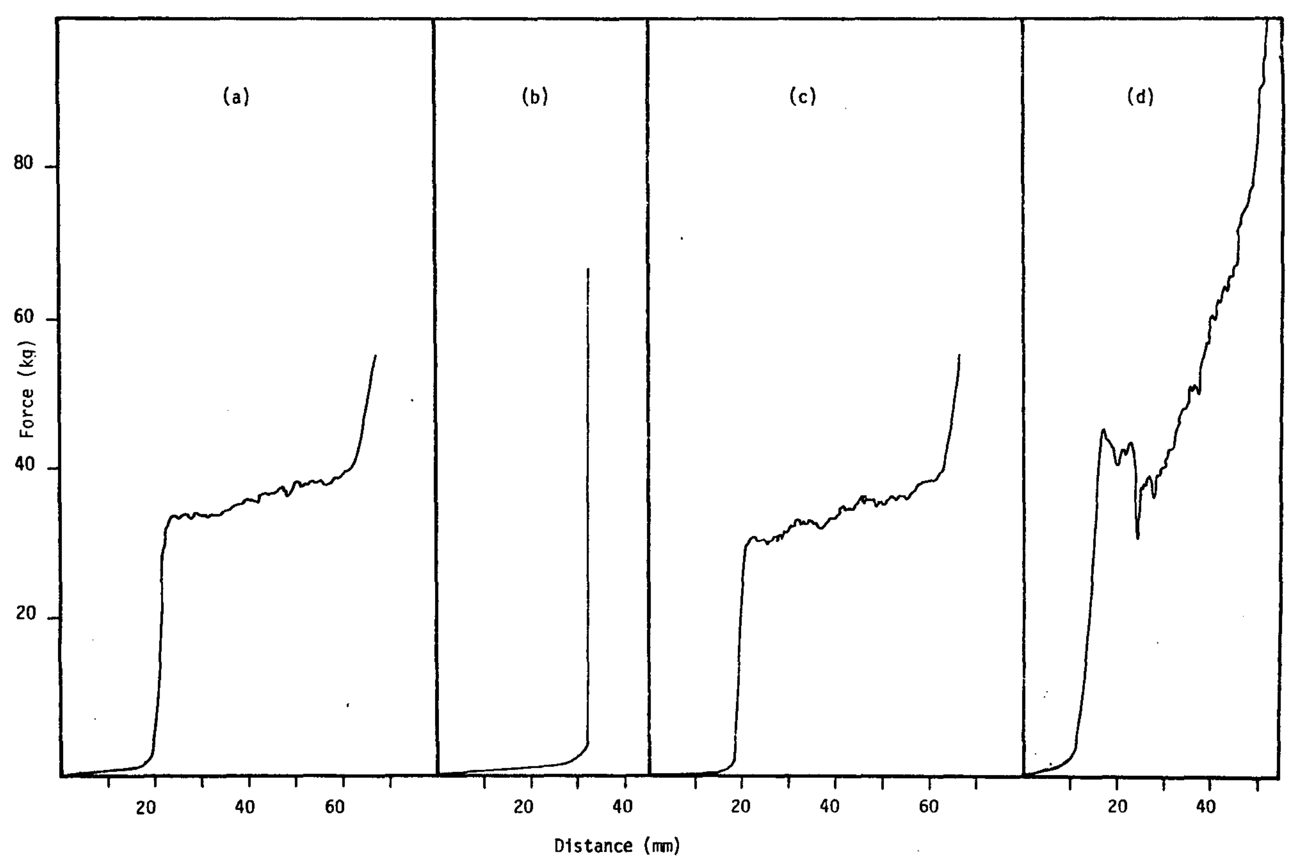

Fig. 5—Force-distance curves of M.35-1 and P.721 flour doughs. Dough was prepared by mixing 50g flour with 40 ml water or water-solubles of flour. (a) M.35-1 flour + water; (b) P.721 flour + water; (c) M.25-1 flour + water-solubles of P.721 flour; and (d) P.721 flour + water-solubles of M.35-1 flour.

acid. No definite conclusions could be drawn as to the relationship of sorbic acid in these products to the retardation of *S. aureus* growth. However, all of the cheese samples which neither supported the growth of *S. aureus* in 2 wk nor showed detectable levels of enterotoxin in 2–20 wk were free of the preservative.

One mozzarella-type cheese supported the growth of *S. aureus* after 6 wk of incubation without producing enterotoxins; however, formulations of the products were too diverse to permit conclusions to be drawn about the influence of composition on the growth of *S. aureus* and its production of toxin. The recommendations for storage of these cheeses are given in Table 1. Some products displayed a "keep refrigerated" statement on the front of the product label; others had no storage specifications at all or carried the recommendation either on the back of the wrapper or in some other less prominent place.

The conditions of abuse examined in this study showed that some varieties of imitation or substitute cheeses could support the growth of *S. aureus* with the subsequent production of enterotoxins. It is important, therefore, that proper storage conditions be spelled out prominently on the labels of these products.

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system (Sefa-Dedah et al., 1977). Further, Hoseney and Faubion (1981) demonstrated that the oxidative gelation phenomenon of water-solubles in wheat increased the viscosity in wheat dough system. It is probable that such components may be present in variable concentrations in sorghum, yielding doughs with good, medium, and poor cohesiveness. It is desirable to test large numbers of sorghum cultivars showing wide variation for cohesiveness of dough, to confirm the role of water-soluble components.

Further research on the nature of water-soluble components including their pentosan content, the role of thiol, and disulfide groups in sorghum flours are needed as they have been reported to influence the rheology of wheat dough (Sullivan et al., 1961).

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