NOTE

Correlations of Sensory and Instrumental Measures of Bread Texture[1]

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Consumer awareness of bread texture as an indication of freshness has served to focus attention on the importance of textural characteristics in determining bread acceptability. Studies have shown that differences in bread texture due to aging are related to changes in such compositional components as starches, proteins, lipids, and water (D'Appolonia and Morad 1981); however, although the firming of crumb structure due to starch retrogradation is well documented, the textural effects due to changes in other components still remain to be explained (Knightly 1977).

A major problem evolving from studies to determine the influence of bread components on texture has been that of the best approach to measuring texture. The AACC standard for such measurements uses the Baker Compressimeter (AACC 1980). This method, which provides a measure of firmness, has been shown to relate well with bread age (Crossland and Favor 1950), but because the ultimate judges of bread texture are consumers, who are influenced by such textural characteristics as cohesiveness, elasticity, and chewiness (Szczesniak 1963) in addition to firmness, consideration of these characteristics and their influence on perceptions of bread texture is extremely important (Kramer 1972). Several instruments have been reported for use in measuring multicomponent aspects of bread texture (Friedman et al 1963, Bashford and Hartung 1976, Kim and D'Appolonia 1977, Kilborn et al 1983), but such reports do not always include information about how well the instruments measure textural attributes of importance to consumers. One instrument that is widely used and has been shown in some cases to be closely associated with human assessments of texture is the Instron. Bashford and Hartung (1976) reported good correlation between sensory evaluations of bread freshness and Instron measurements of mechanical deformation during compression. Moskowitz et al (1979) showed that rheological modulus of elasticity and hysteresis loss were related to panel ratings of some textural characteristics of bread. Because the correlations found in both of these studies varied with such factors as amount of mechanical deformation, sample dimensions, and type of sensory panel (consumer or expert), both groups of authors recommended that more work be directed at standardization of procedures for both sensory and Instron testing.

This study was designed to measure four textural parameters of rye and French breads, using a sensory panel and Instron compression techniques. Correlation coefficients were calculated to determine the relationship between sensory assessments and those made instrumentally for each characteristic and each bread type.

MATERIALS AND METHODS

Unsliced loaves of commercially prepared rye and French breads were obtained within 24 hr after baking from the Heidi Bakery in Silver Spring, MD. The loaves were wrapped in individual plastic bags, sealed, and frozen at −15° C until tested (1–3 wk). Six hours before testing, four loaves of rye and three loaves of French bread were removed from the freezer and allowed to thaw, still wrapped, at room temperature.

Immediately before sensory testing, the loaves were cut into 2.5-cm thick slices. The end slices were discarded and discs, 2.5 cm in diameter, were removed from the other slices. Four discs were cut from each slice of rye bread, and discs from a slice were immediately placed in a plastic bag. Because of the difference in loaf shape, only two discs could be taken from each slice of French bread. Discs from two adjacent slices were placed in a plastic bag. Each bag was given a three-digit code number, and bags were assigned alternately for use in either sensory or instrumental testing.

Sensory evaluation was conducted in the Sensory Evaluation Center of Giant Foods in Landover, MD. The 10 panelists were members of a group being trained to function as a permanent descriptive analysis panel for a variety of foods. Nine of the group were female, and the panelists ranged in age from 22 to 53.

Two 30-min training sessions were devoted to texture of bread products. In the first, texture terminology was discussed and related to bread texture. Panelists were also told how the ballot procedure worked and about the procedures for evaluating each parameter. Unstructured line scales anchored 1 cm from each end by terms representing extremes of the parameters were used. Textural parameter definitions, ballot instructions for evaluating parameters, and the scales used are shown in Table I. In the second session, panelists practiced using the ballot with the two types of bread. They then discussed their evaluations and reviewed any definitions and procedures that caused problems.

Bread samples were evaluated in four sessions held on Tuesdays and Thursdays. At each of the sessions, panelists were given a plastic bag containing four discs of one type of bread. Samples were evaluated using the procedures described on the ballot. When the evaluation was completed, a bag with discs of the second type of bread and a second ballot were provided. The order of presentation of the two types of bread was randomized among test sessions. Numerical values were given to the ratings by measuring (in

TABLE I
Sensory and Instrumental Description for Each Textural Characteristic

Textural Parameter	Sensory Definition[a,b]	Instrumental Definition[c]
Hardness	Force required to compress between the molar teeth. 1 = soft; 14 = hard	Height of curve 1 (kg)
Cohesiveness	Force necessary to break apart; degree of compression by molar teeth before breaking. 1 = compresses a lot before rupture; 14 = ruptures easily	Area under Curve 2 / Area under Curve 1
Elasticity	The degree and quickness of recovery after compressing force of molar teeth is removed. 1 = stays compressed; 14 = quickly returns to size and shape	Width of Curve 2 from start of rise to point of maximum height (ie, during downstroke [mm])
Chewiness	Amount of time (in seconds) required to chew until ready to swallow. 1 = not chewy; 14 = chewy. Number of chews to prepare sample for swallowing	Hardness × cohesiveness × elasticity

[a]From Szczesniak (1963).
[b]A separate bread disc was used for each parameter.
[c]Using an Instron TPA curve (Bourne 1978).

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TABLE II
Sensory and Instrumental (Instron TPA) Scores for Rye and French Breads. Means on the Left of Each Cell are for Sensory Evaluation. Means on the Right are for Instrumental Evaluation[a,b]

Bread	Session	Hardness	Cohesiveness	Elasticity	Chewiness	Number of Chews[c]
Rye						
	1	5.1 / 1.41x	4.0 / 0.53	9.6 / 6.29x	10.4 / 4.63x	26.8
	2	4.7 / 1.48x	3.8 / 0.52	9.1 / 6.38x	9.5 / 4.85x	27.8
	3	6.3 / 1.87x	3.1 / 0.47	7.7 / 6.25x	8.7 / 5.44y	24.8
	4	4.4 / 2.14y	3.8 / 0.47	8.4 / 6.51y	8.7 / 6.38y	24.8
French						
	1	2.6 / 0.60x	3.4 / 0.55	8.1 / 5.70	10.2 / 1.77x	24.1
	2	4.2 / 0.65x	2.1 / 0.51	9.5 / 5.66	8.3 / 1.82x	21.9
	3	3.3 / 0.79y	2.3 / 0.47	7.6 / 5.65	7.3 / 2.12x	20.2
	4	3.1 / 1.04z	2.9 / 0.45	8.6 / 5.08	7.2 / 2.36y	21.6

[a] Each sensory session value is a mean of 8 scores; each instrumental session value is a mean of 10 scores.
[b] Means for values for instrumental tests within a bread type followed by different letters are significantly different at $P<0.05$.
[c] Sensory measure of number of chews associated with TPA chewiness.

centimeters) the distance of the judges' marks from the left end of the scale (Larmond 1977).

Approximately 4 hr after sensory testing, instrumental evaluation was done at the Foods Research Lab, Department of Foods and Nutrition, University of Maryland. A 3.5-cm flat-end round compression anvil attached to an Instron model 1132 and equipped with a 50-kg load cell and having crosshead and chart speeds of 20 mm/min, was used to compress bread discs to 80% of their original height. One disc was selected randomly from each bag for testing. The disc was compressed twice to give a two-bite Texture Profile Curve (Bourne 1978). Values for textural parameters, as defined in Table I, were derived from the curves.

Before determining the correlation between sensory and instrumental evaluations of the parameters, the sensory data were examined for judge consistency, using analysis of variance. As a result, two panelists were identified as being inconsistent with the rest of the panel. Because they also were not consistent with each other, representing a separate group, the data from these two panelists were dropped before subsequent analysis. The sensory panel was considered a single test instrument, so correlation coefficients were calculated using mean values for each characteristic from each panel session correlated with Instron values for that session.

RESULTS AND DISCUSSION

Sensory scores of the textural characteristics of rye and French breads did not differ significantly among the four test sessions (Table II). Chewiness of both types of bread decreased from the first session to the last, but this decrease was not significant. This trend was associated with the tendency of the samples to break apart easily rather than require a long time to chew. This trend was probably the result of changes in structural components caused by aging, which led to increased firmness occurring concurrently with decreased water absorbing capabilities (D'Appolonia and Morad 1981). No patterns existed in the changes in the value for the other sensory parameters.

Comparisons of the instrumental texture profile analysis (TPA) parameters revealed similar trends between the two types of breads. Both breads became significantly harder between the first session and the last. Cohesiveness of both breads decreased slightly during the test period. Chewiness, calculated as the product of hardness, cohesiveness, and elasticity increased between the beginning and the end of testing for both breads. This change was in the opposite direction from that observed with sensory testing and was probably related to the fact that the sensory definition for chewiness involved simply a factor of time, whereas the objective measurement included a factor of both time and force.

Because no significant differences among sessions were found with sensory testing but differences were found with instrumental testing, the question was raised whether the texture of the samples had been affected by the delay between the two types of testing. To determine whether this delay was an important factor, samples of French bread were cut and placed in bags following the procedures used for the test sessions. The samples normally presented to the panel were tested with the Instron. The remainder of the samples were held, as in the previous test, before instrumental testing. The TPA curves for the two sets of tests revealed no significant differences due to the holding period.

Any instrumental measure of texture must ultimately relate to evaluations made by humans (Kramer 1972), so correlation coefficients were calculated between sensory and instrumental values for each paramenter for each type of bread. With rye bread, the two types of tests were significantly ($P<0.01$) correlated for the parameters of cohesiveness ($r = 0.49$) and chewiness ($r = -0.58$), and the sensory measure of number of chews were correlated with the instrumental value for chewiness ($r = -0.58$). With French bread, the only significant relationship was found between sensory and instrumental chewiness ($r = -0.47$).

With both types of bread, the low correlation coefficients may have been due to inherent differences in the two methods of evaluation. A bread disc evaluated by a sensory panelist is subjected to conditions that alter the composition of the sample. The effects of moisture and temperature in the mouth and the physical changes during chewing cause these samples to change constantly. A bread disc tested with an Instron, however, is subjected only to compressive forces. Therefore, although the samples were alike when testing began, they were not comparable throughout the testing period.

Overall, a stronger relationship between sensory and instrumental measurements was found with rye bread than with French. The presence of significant differences among samples found with instrumental evaluation and not with sensory testing suggest that either the panel and the Instron were not measuring the same parameters or that the Instron was more sensitive to slight differences in individual parameters of the samples than were the panelists. Further work is necessary to fully determine whether the two test types are actually measuring the same textural parameters, and if they are not, whether the parameters measured instrumentally have a relationship to textural attributes important to the consumer.

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