Measurement of Bread Firmness by Universal Testing Machine

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Objective

The objective of this method is to quantitatively determine the force required to compress a baked product by a preset distance. The firmness may be taken as a measure of freshness and quality. The method specifies only the machine parameters and data calculation method to be used. This method is applicable to research and quality control evaluation of white pan breads. The principle may also be used to study other loaf types and similar products, such as cakes, if sample preparation, indenter size, and load-cell capacities are adjusted appropriately.

Apparatus

1. Universal testing machine.
2. Compression load cell, 500 g maximum.
3. Plunger, aluminum, 36-mm diameter (10.179 cm^2) with edges blunted to remove sharpness. This size should be used for pound or larger loaves. For 100-g pup loaf, a 21-mm (3.464 cm^2) aluminum plunger is recommended.

Procedure

Preparation of sample

Total sample thickness is 25 mm. Loaves may be sliced either mechanically or by hand, 25 mm or 12.5 mm thick. See Notes 1 and 2.

1. For 12.5-mm thick slices: use two slices stacked together for test sample; discard two to three end slices with heels of loaf.
2. For 25-mm thick slices: use one slice for test sample and discard heel slices of loaf.

Method

1. Position upper crosshead limit so that compression plunger is 1 mm above center surface of sample.
2. Position lower crosshead limit at 40% compression (10-mm compression depth).
3. Set crosshead speed (rate of compression) at 100 mm/min.
4. Set chart speed at 500 mm/min (5:1 ratio of chart to crosshead extension).
5. Set full scale (range) at 1 kg or desired range.
6. Center prepared sample under compression plunger, avoiding any irregular or nonrepresentative areas of crumb.
7. Compress sample approximately 10 mm (40% compression). Force reading will be measured at 25% compression but curve will be drawn beyond 25% to 40%.

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8. Return compression plunger to upper limit position.
9. Discard test slice.
10. Repeat steps 6–9 until desired number of slices have been evaluated for firmness. Evaluate six slices per loaf.

Calculation

Refer to Fig. 1 for identification of curve characteristics. Compression force reading will be taken at point on curve where sample has been compressed by 25%.

1. Ratio of chart to crosshead speed: 500 mm/min chart speed to 100 mm/min crosshead speed = 500/100 or 5:1 ratio of chart to crosshead. For every 1 mm of crosshead extension, chart records 5 mm.

2. A 25% compression of 25-mm thick sample = 6.2-mm extension of crosshead. A 6.2-mm crosshead extension × (5-mm chart extension/1-mm crosshead extension) = 31-mm chart extension. A 25% compression occurs 31 mm from beginning of curve.

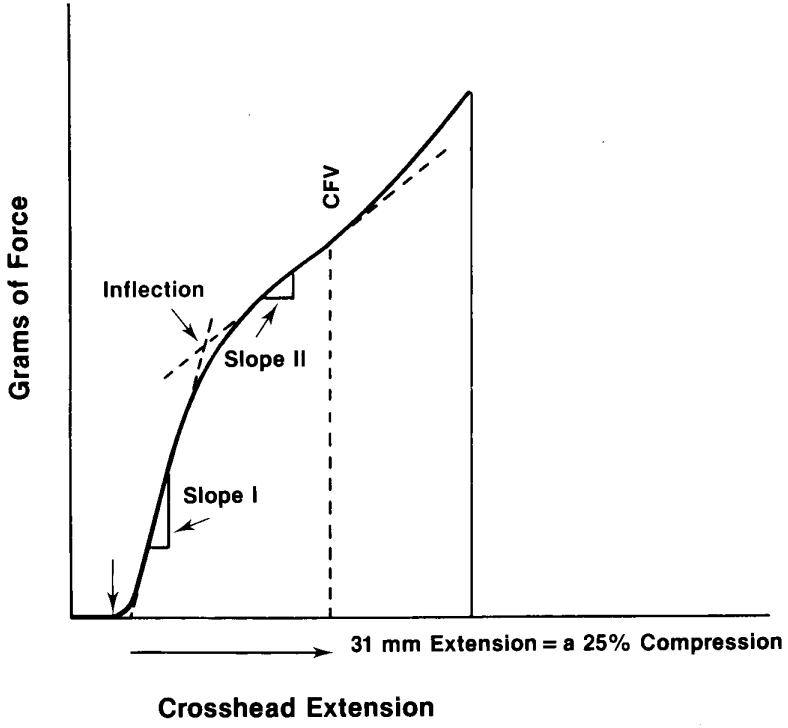

Fig. 1. Firmness curve. CFV = compression force value.

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3. For compression force value (CFV) measurement, a line is drawn through first half of curve (first slope) to baseline. CFV is taken 31 mm from the start of this interpolated intersect of curve with baseline.

4. Mean CFV of all readings per loaf (or loaves) may be reported in one of the following ways. See Note 3.

a. in kilograms of force. This value is read directly off chart.

b. in newtons of force. Many testing machines may be calibrated directly in newtons (N), an SI unit. If this capability is unavailable, conversion is as follows: N = kilogram × (9.8 m/sec^2).

Example: kg of force = 0.3

$$\left(0.3\ \text{kg}\right)\left(9.8\ \text{m}/\text{sec}^2\right) = 2.94\ \text{N}$$

Notes

1. Storage, packaging, and handling of sample before testing with UTM are considered parts of variable conditions under which bread is tested, not parts of standard testing procedures. However, it is important to identify these conditions when reporting results of firmness tests. Within any given laboratory, they must be kept constant for comparison purposes.

2. Cutting crust off the bread immediately before the compression test is also considered a variable testing procedure. For "typical" pan bread, the crust does not interfere with compression by a 36-mm diameter plunger. However, if a larger plunger or a different type of bread is used so that crust does resist compression, the crust may be removed from the bread sample before testing.

3. Stress can be measured indirectly by converting the CFV (measured in newtons) to newtons of force/unit area of plunger = N/(1.0179 × 10^{-3} m^2).

$$\text{Example: } \frac{2.94\ \text{N}}{1.0179\times10^{-3}\ \text{m}^2} = 2888.3\ \text{N}/\text{m}^2$$

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