CORRELATION OF DOUGH STICKINESS WITH TEXTUROMETER READING AND WITH VARIOUS QUALITY PARAMETERS

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ABSTRACT

Seven flour streams from a commercial mill were investigated with regard to simple correlations between a number of quality parameters. An evaluation of the best combination of these parameters was made to predict the handling property (stickiness) of the resulting doughs. The most significant correlation was between SH content, based on protein content, and stickiness, but there was no significant correlation between protein content and stickiness. As a single test, ash content, SH content, or proteinase activity was found to provide the most useful information for predicting handling properties.

Aging of wheat flour produces an increase in water absorption and an improvement in breadmaking properties (1–7). However, since long-term storage of flour for natural aging is costly, maturing agents such as bromate or ascorbic acid are generally used to produce effects similar to aging. The improving effects of these agents are usually sufficient in the conventional breadmaking process, but not in the continuous process for which adhesion of dough to handling machines is a particular problem.

In the present study, the texturometer has been examined as a basis for measuring and predicting the machining properties of dough made from various flour streams. A number of other quality parameters have also been examined for possible correlation with dough stickiness.

MATERIALS AND METHODS

Flour was milled on a commercial mill from a grist made up of 70% No. 1 Canada western red spring wheat, 20% U.S. No. 1 dark northern spring, and 10% U.S. No. 1 dark hard winter. Table I provides a description of the seven flour streams selected for study, together with the water absorptions to obtain optimum breadmaking properties.

All data for flour are expressed on a 14% moisture basis. AACC methods (8) were used for test baking and for determining maltose value, α-amylase activity, sedimentation value, ash content, and protein content. Sulfhydryl contents were determined by the procedure of Sokol *et al.* (9). β-Amylase activity was determined by the method of Schwimmer (10) and proteinase by the hemoglobin-Folin method (11, 12).

The total energy required to mix dough for 5 min was estimated with a watt-meter (Yokogawa Electric Works Ltd., Japan) and was expressed as watt-hr per kg of dough. Bromate response was estimated as the ratio of the loaf volume of bread baked with 10 ppm bromate to that of bread without bromate. The bread formula was: 100 g flour, 2 g yeast, 3 g sugar, 1.5 g salt, and 2 g shortening.

A texturometer (General Food Corp., New York) was used to determine dough stickiness and consistency. Doughs were mixed with a 1.5% sodium chloride solution in a pin-type mixer with the proper adsorption (Table I) to obtain optimum breadmaking properties. The dough was shaped into a sheet (15 × 5 × 1 cm) by the Chopin alveograph mixer and then set on the texturometer.

RESULTS

Estimation of Dough Machining Properties with Texturometer

Figure 1 shows a typical curve obtained for dough using the texturometer, a general purpose instrument for assessing texture properties of food samples. The curve represents a record of force-time relationships during the movement of a plunger into the sample (first peak at right), withdrawal of the plunger (negative peak indicates adhesion to the plunger), and, finally, a second movement of the plunger into the dough piece. The sequence was originally intended to simulate the act of chewing the sample twice, but the curve also provides useful information about the behavior of the dough in baking machines.

The height (B) of the first peak for a constant input of 12 V for the texturometer gives a measure of the hardness or consistency of the dough. Consistencies for the seven flour streams (Table II) ranged from 32.8 to 60.8 mm.

TABLE I
Flour Streams Used in the Study and Their Descriptions

Stream Designation	Description	Water Absorption % (14% mb)
2nd Break	2nd Break flour	67.9
O	2nd Low-grade	69.3
X	Chunks	71.7
F	1st Tailings	70.2
A Top	Sizings top	74.2
A Bottom	Sizings bottom	71.2
B Top	1st Middlings top	73.8

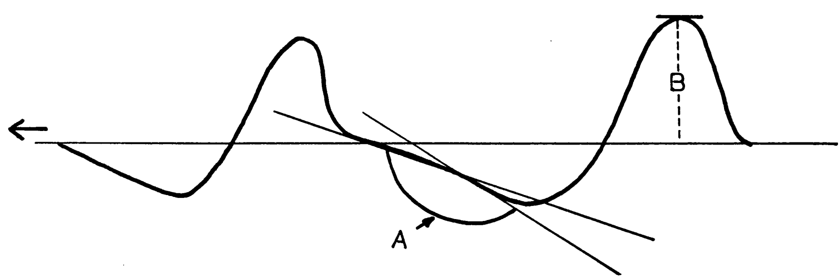

Fig. 1. A typical texturometer curve. Adhesiveness is expressed as angle A and consistency the height of peak B.

TABLE II
Characteristics of Flour Streams

Parameter Streams	2nd Break	O	X	F	A Top	A Bottom	B Top
Dough consistency (mm)	36.8	35.8	32.8	60.8	56.0	53.8	52.8
Dough stickiness (degrees)	151	148	155	167	149	155	142
Ash content (%)	0.46	0.56	0.64	0.99	0.32	0.32	0.35
SH content (μeq/g flour)	1.04	1.05	1.10	1.36	0.62	0.78	0.50
SH content (μeq/g protein)	6.5	6.9	8.1	10.0	5.5	7.4	5.0
Protein content (%)	15.5	15.3	13.5	13.6	11.3	10.5	10.1
Sedimentation value (cc)	66.5	58.3	48.9	29.0	59.7	31.1	39.0
Specific sedimentation value (cc/g protein)	134.1	119.1	113.2	66.6	165.1	93.2	120.7
Maltose value (mg/10 g flour)	86	90	203	211	282	151	253
α-Amylase activity (SKB units)	0.009	0.013	0.009	0.010	0.004	0.002	0.009
β-Amylase activity (meq/g min)	11.40	10.35	8.87	9.02	7.65	7.95	7.65
Proteinase activity (γ tyrosin/g min)	1.14	0.65	0.76	1.76	0.15	0.23	0.26
Mix energy requirement (w hr/kg dough)	38.8	38.8	37.2	39.6	39.8	38.6	40.2
Bromate response	1.05	1.09	...	...	0.95	0.95	0.92

TABLE III
Correlation Coefficients between Either Consistency or Stickiness and Other Quality Parameters

	Sedimentation Value	Specific Energy Value	Maltose Value	Water Absorption	Dough Consistency	Mix Energy Requirement	Bromate Response	Dough Stickiness
Dough consistency						0.73[a]	−0.95*	0.23
Ash content								0.79*
SH content (μeq/g flour)	−0.08	−0.63	−0.48	−0.75[a]	−0.20	−1.23	0.94*	0.79*
SH content (μeq/g protein)	−0.24	−0.87*	−0.09	−0.42	0.31	−0.10	0.67	0.99**
Protein content								0.28
Sedimentation value			−0.32	−0.24	−0.63	−0.15	0.66	−0.48
Specific sedimentation value			0.20	0.37	−0.24	0.15	−0.05	−0.73[a]
Maltose value				0.91**	0.61	0.43	−0.84[a]	−0.04
α-Amylase activity								0.00
β-Amylase activity								0.10
Proteinase activity								0.75
Mix energy requirement							0.64	
Bromate response								0.19
Water absorption					0.48	0.37	−0.85[a]	0.35

[a]Significant at 10%.

Dough stickiness or adhesiveness is indicated by angle A in Fig. 1. This angle has given a good correlation with practical dough stickiness as reflected in build-up of dough on dough-handling machines during breadmaking. Measurement of this angle was preferred to using area of the curve below the line in the region recommended in the texturometer handbook, because bakers in the laboratory found that the angle shows better correlation with dough stickiness than the area does. Dough giving an angle between 140° and 150° has satisfactory machining properties. If the angle is between 150° and 160°, stickiness is medium and likely to present some problem with machining. An angle over 160° indicates extreme stickiness, quite unacceptable for dough-handling machines.

Dough stickiness for the flour streams (Table II) ranged from 142° to 167°. Generally, higher grade streams had lower, acceptable values. Stream F showed extreme stickiness, but quantitatively it is not important since, in North America, flour from hard red spring wheat contains only 1.3% of this flour stream (13).

Correlations between Flour Characteristics

Table II also provides results of a range of quality parameters for the flour streams. The main purpose of making these estimations was to look for possible correlations between them and dough-handling properties. Table III shows correlation coefficients of these characteristics with consistency and with stickiness.

Significant correlations were obtained for dough consistency with bromate response (negative) and with energy requirement (positive correlation). This information thus makes the assessment of consistency of more value to the baker in predicting dough behavior.

Dough stickiness correlated very highly with the sulfhydryl content of the protein, and also significantly with ash content, with sedimentation value (based on protein content), and with proteinase activity. The correlation with ash content is presumably a reflection of the observation, already mentioned, that stickiness is lower for higher grade streams. This correlation is unlikely to indicate a factor causing stickiness.

Other aspects of the results in Table III probably do offer some clues about the chemical causes of dough adhesiveness and, in particular, about the relative roles of starch and protein. The lack of correlation of stickiness with maltose value or with amylase activities strongly suggests that it is not caused by starch properties, such as starch damage. On the other hand, the positive correlation between stickiness and proteinase activity implicates protein. Further evidence for this suggestion comes from the higher correlations with SH content and with sedimentation value if these are based on protein content. Protein content itself did not correlate with adhesiveness, but it might well be expected that only certain specific proteins are involved, possibly those with a high sulfhydryl content. Despite the excellent correlation between SH (based on protein content) and stickiness, the latter did not correlate with bromate response, although bromate response correlated well with SH content ($r = 0.94$). The correlation between bromate response and SH content based on protein level was 0.67.

The results suggest that worthwhile future research would involve the investigation of a range of flours of varying type and quality to determine if the correlation of SH based on protein content with stickiness holds; the fractionation of the proteins of the flour streams to ascertain if specific fractions correlate with stickiness; and treatment with SH-blocking agents to see if stickiness can thus be reduced.

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