NOTE

Technique for Objectively Measuring a Relationship Between Flour Chlorination and Cake Crumb Stickiness[1]

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ABSTRACT

Stickiness of cake crumb was measured objectively and found to be highly negatively correlated with flour chlorination rate. Flour pH and cake volume were not well correlated with objective cake crumb stickiness.

Flour varieties differ greatly in the amount of chlorine gas they require to reach a prescribed pH. One effect of chlorinating cake flour is the production of a cake crumb with a dry mouthfeel. Kissell and Yamazaki (1979) described cake crumb that had been chlorinated at rates of 0–0.05, 0.1–0.15, 0.2–0.4, 0.45–0.5, and 0.75–1.0 cc of chlorine gas per gram of flour as gummy, slightly gummy, moist, slightly dry, and dry, respectively.

In the present study, cake crumb stickiness was measured objectively on a continuum from wet (gummy) crumb to dry crumb. The objective crumb stickiness continuum was experimentally established using flour samples representing a range of factors that may affect crumb stickiness: chlorinated and unchlorinated flour, serial chlorination rate, aged and unaged flour (both unchlorinated), variation in batter liquid level, and wheat sprout damage. The reported objective measurements of crumb stickiness seem to be correlated through chlorine application rate with the organoleptic properties of crumb stickiness previously reported (Kissell and Yamazaki 1979).

MATERIALS AND METHODS

Eleven flours (labeled A through K) were milled and bleached to various levels (Kissell and Marshall 1972) in our Wooster facility. Flour E was a straight-grade flour from Argee variety wheat (soft red winter). The others were 50% patent flours described as follows: flour A, Oasis variety wheat (soft red winter); flour B, hard red spring wheat; flour C, Argee variety wheat; flour D, blended varieties of soft red spring wheats; flour F, commercial soft wheat blend (unaged, stored sealed at 4° C; aged, subjected to airflow for eight weeks at 20° C); and flours G–K, sprout-damaged wheats (soft white winter). Sprout damage levels were 0.2, 2.3, 33.5, 37.9, and 52.3% for flours G–K, respectively, as determined by the Federal Grain Inspection Service. Thirty grams of kernels was evaluated for visual evidence of sprouts, broken-off sprouts, and broken-open germ ends.

White layer cakes were baked according to an AACC method (1979) and cooled for 1 hr. Volumes were then measured by rapeseed displacement and each cake was cut on its diameter. A 5 × 5 × 2-cm crustless crumb piece was removed from each cake half and immediately evaluated for stickiness. One 5-cm side was from the original cut along the diameter.

Stickiness measurements were conducted using a Struct-O-Graph (C. W. Brabender, South Hackensack, NJ) fitted with a 2,000-cmg spring and a plastic disk plunger with a 30-mm diameter. The platen was operated at a rate of 132 mm/min (setting 10.0). The pen arm was zeroed at the 500-BU chart line. The pen arm automatic stop was adjusted to the 1,000-BU chart line. On compression of the sample, the pen arm traveled from the zero point (the 500-BU line) to the 1,000 line. When compression was released, the pen returned to the 500 line and, being spring-mounted, went above the 500 line if the sample adhered to the disk and platen. The distance above the 500 line was recorded as the amount of crumb stickiness in centimeter grams.

A cake crumb piece was compressed between the disk and platen for 1 min at the 1,000-BU chart line, equaling a 1,000 cmg compression force for the 2,000-cmg spring. After 1 min, compression was released and the stickiness measurement was taken. This was one compression/ stickiness measurement cycle. A series of five cycles was rapidly performed, each with 1 min of compression time, on each crumb piece. The crumb piece was not moved during the five cycles. The other 5 × 5 × 2-cm decrusted crumb piece cut from the other cake half was also measured. The platen and disk were wiped with a dry paper towel before each stickiness series began. Stickiness measurements were reported as the mean of the 10 measurements on the two cake halves. Higher mean stickiness values indicate greater crumb stickiness. Data reported here are the means of data (20 total observations) from duplicate cakes. The least significant difference value for cake volume was 31.8 cc. The least significant difference value for crumb stickiness was 2.4 cmg, derived from logarithmic transformation of data, as variances were proportional to the means. Room temperature was approximately 25°C and the relative humidity was approximately 40%.

RESULTS AND DISCUSSION

Flours vary as much as 100% in the chlorine they require to achieve a certain pH, depending on variety, moisture content, particle size, and initial pH. Among the chlorinated flours and treatments in Table I, rate of flour chlorination was much better correlated with cake crumb stickiness than was flour pH ($r = -0.86$, $P = 0.001$; $r = 0.58$, $P = 0.05$, respectively). When the unbleached flours were included, the correlation coefficient between cake crumb stickiness and flour chlorination rate increased to -0.92, $P = 0.001$. This relationship is evident in Fig. 1. Although the propensity of cake crumb to adhere, under pressure, to the Struct-O-Graph's disk and platen is probably not identical to stickiness or lack of it as experienced in the mouth, the continuum of objective measurements does agree with the subjective evaluations reported by Kissell and Yamazaki (1979).

Cake volume was not well correlated ($r = 0.69$, $P = 0.001$) with crumb stickiness. Bleached flour B had a relatively poor volume (Table I) for a bleached flour and a "dry" or relatively less sticky cake crumb. Aged, unbleached flour D, though relatively "wet" and sticky, had a good cake volume. Clements and Donelson (1982) and

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TABLE I
Cake Crumb Stickiness in Relation to Flour Chlorination Rate, Bleached Flour pH, Batter Liquid Level, Cake Volume, and Sprouting Damage

Flour	Chlorination Rate (cc/g)	Bleached Flour pH	Batter Liquid Level[a] (%)	Cake Volume (cm)	Cake Crumb Stickiness (cm/g)	Sprouting Damage (%)
A	0	···	125	862	210	···
	0.37	4.8	125	1,109	24	···
B	0	···	140	939	133	···
	0.45	4.75	140	941	12	···
C	0	···	130	961	251	···
	0.33	4.85	120	1,141	15	···
	0.33	4.85	130	1,089	23	···
	0.33	4.85	140	1,075	27	···
D						
Unaged	0	···	140	858	278	···
Aged	0	···	140	1,052	214	···
E	0.54	4.61	130	1,006	0	···
F	0	···	140	858	182	···
	0.15	5.19	140	1,032	149	···
	0.27	4.86	140	1,079	72	···
	0.32	4.70	140	1,090	60	···
	0.39	4.55	140	1,080	48	···
	0.45	4.46	140	1,042	35	···
G	0.42	4.81	130	1,090	13	0.2
H	0.27	4.85	140	1,050	62	2.3
I	0.20	4.83	140	1,046	74	33.5
J	0.20	4.84	140	1,050	85	37.9
K	0.23	4.84	140	1,059	91	52.3

[a] Percent based on flour weight.

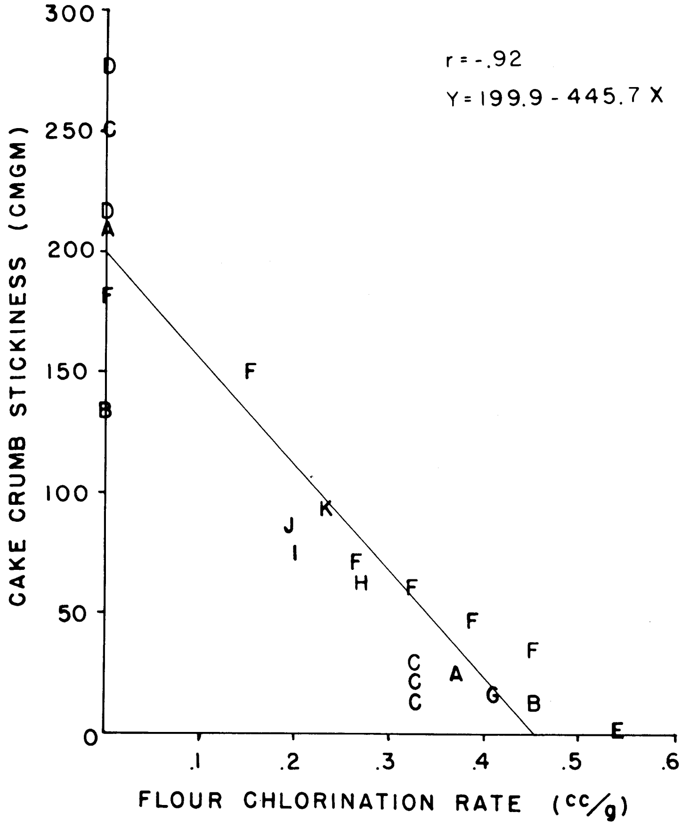

Fig. 1. Relationship of cake crumb stickiness and flour chlorination rate for flours A–K.

Johnson and Hoseney (1980) have shown that aging improves the oven expansion and/or volume of unbleached cake flour.

The effect of batter liquid level on the stickiness of cake crumb of flour C was observed. Even when the batter liquid level was increased by 16.7%, crumb stickiness increased relatively little compared to the variation found among all bleached cakes. Serial chlorination was performed with flour F. Crumb stickiness within this flour was correlated highly (r = −0.98, P = 0.001) with chlorination rate. Straight grade flours usually require a higher chlorination rate than 50% patent flours. The straight grade flour E was inadvertantly overbleached and its stickiness was not measurable by the 2,000-cmg cartridge. The chlorination rate of 0.54 cc/g received by flour E placed it in the slightly dry to dry crumb category described by Kissell and Yamazaki (1979).

The logarithm of percent sprout damage was highly correlated (0.96, P = 0.01) with crumb stickiness, but crumb stickiness was also highly correlated (r = 0.95, P = 0.05) with chlorination rate. Also, stickiness values were close to the regression line in Fig. 1 but not above it, as would be expected if the sprout-damaged flours were, in general, more sticky than their chlorination rate alone would indicate. Therefore, the relatively high crumb stickiness values of bleached, sprout damaged flours could be due to their relatively low chlorination rates. The above relationship of flour chlorination rate to cake crumb stickiness was purposely established over a wide range of possible flour and cake batter quality factors to evaluate the utility of the objective technique for cake crumb stickiness measurement both for research and for routine wheat cultivar flour quality evaluation.

CONCLUSIONS

Stickiness of cake crumb was measured objectively and found to be highly negatively correlated with flour chlorination rate. Flour pH, cake volume, and batter liquid level were not as well correlated with objective stickiness measurements. The crumb of cakes made from sprouted wheats was stickier than expected but this could have been the result of the lower chlorine requirements of these flours. The good correlation between objective cake crumb stickiness and flour chlorination rate suggests the possibility of specifically chlorinating cake flour to achieve a prescribed objective measurement (or organoleptic result such as mouthfeel or moistness).

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