Contribution of Chlorinated Flour Fractions to Cake Crumb Stickiness[1]

C. S. GAINES and J. R. DONELSON[2]

ABSTRACT

Cakes from two flours were evaluated objectively for stickiness and cake volume by interchanging fractions (ie, prime starch, tailings, gluten, water solubles, and hexane-extracted lipids) from chlorinated and unchlorinated flour. Stickiness of cakes made from chlorinated flour resulted primarily from chlorine alteration of the prime starch fraction. Cake volume improvement was caused primarily by chlorine alteration of flour lipids.

Cereal Chem. 59(5):378–380

Chlorination of cake flour changes the hexane-extractable lipids of flour, resulting in greater cake volume (Kissell et al 1979) caused by improved batter expansion during baking (Clements and Donelson 1982a, 1982b). Chlorination also alters the starch fraction of flour (Kulp et al 1972, Russo and Doe 1970), allowing the cake to retain its greater oven expansion and to shrink less during cooling (Kissell and Yamazaki 1979). Thus, the improvement in cake volume due to flour chlorination results from changes both in lipids (batter expansion) and in starch (retention of expansion). Hydrolytic effects, increased solubility, and other effects of chlorine on flour proteins and gluten were reviewed by Gough et al (1978).

In addition to improved volume, cake from chlorinated flours exhibits a crumb with a drier, less sticky mouthfeel (Kissell and Yamazaki 1979) and therefore with different eating quality than cake from unbleached flour. The objective measurement of cake crumb stickiness has been linked to the amount of chlorine gas necessary to bleach cake flour to a prescribed pH (Gaines 1982). The present study identifies which bleached flour fractions (ie, starch, tailings, gluten, water solubles, or hexane-extractable lipids) contribute to the altered eating quality of bleached cake

[1]Cooperative investigation of the Soft Wheat Quality Laboratory, North Central Region, Agricultural Research Service, U.S. Department of Agriculture, and the Department of Agronomy, Ohio Agricultural Research and Development Center, Wooster 44691. Approved for publication as Journal Article 196-81 of the Ohio Agricultural Research and Development Center, Wooster 44691.

Mention of a trademark or proprietary product does not constitute a guarantee or warranty of a product by the USDA and does not imply its approval to the exclusion of other products that may also be suitable.

[2]Research food technologist and chemist, respectively, Soft Wheat Quality Laboratory, Ohio Agricultural Research and Development Center, Wooster 44691.

flour. This is determined by alternately interchanging one bleached fraction at a time with fractions from an unbleached flour and vice versa and by objectively measuring cake crumb stickiness.

MATERIALS AND METHODS

Two soft red winter wheat blends from the 1980 crop were obtained from two locations in Ohio, and 50% patent flours were milled on a Miag mill and pin-milled at 9,000 rpm. Patent flour A contained 7.7% protein and 0.314% ash (14% mb). Patent flour B contained 7.8% protein and 0.314% ash (14% mb). Quantities of flours A and B were chlorinated to pH 4.83 and 4.81, respectively (Kissell and Marshall 1972), using 0.35 and 0.38 cc of chlorine per gram of flour, respectively. The bleached and unbleached portions of both flours were extracted with hexane (Clements 1977) and fractionated into starch, gluten, tailings, and water-solubles by the procedure of Yamazaki et al (1977), modified for chlorinated flour by the addition of sodium carbonate (1:1,000) to the flour before fractionation. The protein content of each fraction was determined according to AACC method 46-12 (1976). Each flour was reconstituted with all five bleached or unbleached fractions (controls) and with one fraction interchanged, such that a flour contained four bleached or unbleached fractions and one fraction of the other type.

White layer cakes were baked according to AACC method 10-90 (1979). After cooling in the pan for 1 1/2 hr, cake volumes were 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 on a Struct-O-Graph (C. W. Brabender, South Hackensack, NJ) fitted with a 2,000-cmg spring and a 30-mm plastic disk plunger, a standard accessory to the Struct-O-Graph. The moveable platen was operated at the fastest rate of 132 mm/min (setting 10.0). The pen arm was set on zero 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 (500 line) to the 1,000 line. When compression was released, the pen returned to the 500 line and, because it was spring-mounted, went above the 500 line when the sample adhered to the disk and platen. The distance above the 500 line was recorded as the amount of crumb stickiness in cmg.

A cake crumb piece was compressed between the disk and platen for 1 min at the 1,000-BU chart line, equaling 1,000 cmg of 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 compression time, on each crumb piece. The crumb piece was not moved during the five cycles. Another 5 × 5 × 2-cm decrusted crumb piece was cut from the other cake half and 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 total 10 measurements on the two cake halves. Higher mean stickiness values indicate greater crumb stickiness. Stickiness values of 0 cmg indicate a sample with stickiness too low to be measured by the 2,000-cmg spring. Cooling, volume, and stickiness measurements were conducted at 21°C room temperature and 60% rh.

Reported data are the means of four bakes (two replicates of each flour). Statistical significance of change in cake crumb stickiness was determined by logarithmic transformation of data to stabilize the stickiness variance, which was proportional to the mean. A Student's *t*-test was then performed to determine significant difference from the reconstituted control flour. Statistical significance of change in cake volume, relative to reconstituted control flour, was determined by a Student's *t*-test, using the pooled variance of all treatments.

RESULTS AND DISCUSSION

Flour fraction weights and protein contents included in each treatment are shown in Table I. The weights were based on the percent recovery of each fraction during the fractionation procedure. The protein contents and fraction weights were similar, minimizing effects of weight differences among the treatments.

The lipids fraction interchanges produced much greater change in cake volume than did the starch, tailings, gluten, and water-solubles interchanges (Table II). The inclusion of chlorinated lipids with unbleached fractions significantly increased cake volume (187 cc) to a volume similar to that of cakes baked from the bleached, reconstituted control flour and other bleached treatments. When unbleached lipid was included with bleached fractions, cake volume significantly decreased (135 cc) to a volume similar to those of the unbleached control and other combinations containing unbleached lipids. These reconstituted flours were not of the unstable type that tend to collapse when unchlorinated prime starch is included. Therefore, starch interchange had only a relatively small effect on cake volume stability.

The effect of the starch fraction on objective stickiness of cake crumb was much greater than that of the other fractions (Table II). Bleached starch fractions significantly decreased mean crumb stickiness (>−289 cmg), and unbleached starch fractions significantly increased mean crumb stickiness (+285 cmg) compared to the reconstituted control flours. The faster swelling rate (Kulp et al 1972) and/or increased hydration capacity of chlorinated starch may decrease the free water in cake crumb, causing less stickiness and, therefore, drier mouthfeel.

The tailings fraction, which contains a large proportion of damaged starch, also affected crumb stickiness. The bleached tailings fraction significantly decreased mean crumb stickiness (−60 cmg), whereas the unbleached tailings fraction significantly increased mean crumb stickiness (+16 cmg).

The hexane-extracted lipids fraction also affected crumb stickiness. Chlorinated lipids significantly increased mean crumb stickiness (+61 cmg). Nonchlorinated lipids, however, significantly decreased mean stickiness (>−19 cmg). When hexane is evaporated from extracted flour lipid, the chlorinated lipid looks more viscous and is more tacky than unchlorinated lipid (Clements and Donelson 1982a). Perhaps this phenomenon physically influences cake crumb stickiness. The bleached gluten fraction also significantly increased mean crumb stickiness, but the relative effect was small, and the effect of the unbleached gluten fraction was not significant.

TABLE I
Protein Content and Weights of Flour Fractions Used in Fraction Exchange

Flour Fraction	Percent Protein[a] of Flour Fractions				Fraction (Dry) Weight Exchanged[b]			
	Unbleached Flour A (%)	Bleached Flour A (%)	Unbleached Flour B (%)	Bleached Flour B (%)	Unbleached Flour A (g)	Bleached Flour A (g)	Unbleached Flour B (g)	Bleached Flour B (g)
Starch	0.3	0.3	0.3	0.3	77.2	76.6	77.7	76.3
Tailings	6.4	7.3	7.2	7.1	6.2	6.2	5.5	5.8
Gluten	71.4	72.2	68.6	68.2	8.3	7.9	8.3	8.7
Water solubles	22.8	20.5	24.0	21.5	2.6	2.6	2.7	2.6
Lipids	···	···	···	···	0.8	0.8	0.8	0.8

[a]Calculated on 14% moisture basis.
[b]Weights based on fraction recovery percentages.

TABLE II
Effects of Chlorinated and Unchlorinated Soft Wheat Flour Fraction Interchange on Cake Crumb Stickiness and Cake Volume

Flour Fraction Interchange	Cake Volume[a] (cc)	ΔCake Volume[b,c] (cc)	Crumb Stickiness[a] (cmg)	ΔCrumb Stickiness[b,c] (cmg)
Unfractionated, unbleached	799	...	232	...
Unbleached, fractionated, and reconstituted control	933	...	289	...
with bleached starch	969	+36**	0[d]	>−289**
with bleached tailings	958	+25**	229	−60**
with bleached gluten	916	−17**	316	+27*
with bleached water solubles	977	−44**	306	+17 ns
with bleached lipids	1,120	+187**	350	+61**
Unfractionated, bleached	1,128	...	18	...
Bleached, fractionated, and reconstituted control	1,110	...	19	...
with unbleached starch	1,102	−8*	305	+286**
with unbleached tailings	1,123	+13**	36	+17**
with unbleached gluten	1,113	+3 ns	15	−4 ns
with unbleached water solubles	1,114	+4 ns	17	−2 ns
with unbleached lipids	976	−134**	0[d]	>−19**

[a] Mean of two replications each of two flours.
[b] ns = not significant at $P = 0.05$, * = significant at $P = 0.05$, ** = significant at $P = 0.01$.
[c] Change in cake volume or stickiness from the reconstituted unbleached or bleached control flour.
[d] Crumb stickiness too low to register with 2,000-cmg spring.

CONCLUSIONS

Flour chlorination causes only small increases in cake crumb stickiness, resulting from changes in gluten and lipids. However, the contribution of the chlorinated prime starch flour fraction causes the reduced stickiness (drier mouthfeel) of cakes made from chlorinated cake flour.

LITERATURE CITED

AMERICAN ASSOCIATION OF CEREAL CHEMISTS. 1979. Approved Methods of the AACC. Method 10-90, approved October 1979; and Method 46-12, approved October 1976. The Association, St. Paul, MN.

CLEMENTS, R. L. 1977. Large-scale laboratory soxhlet extraction of wheat flours and of intact and cracked grains. Cereal Chem. 54:865.

CLEMENTS, R. L., and DONELSON, J. R. 1982a. Role of free flour lipids in batter expansion in layer cakes. I. Effects of "aging." Cereal Chem. 59:121.

CLEMENTS, R. L., and DONELSON, J. R. 1982b. Role of free flour lipids in batter expansion in layer cakes. II. Effects of heating. Cereal Chem. 59:125.

GAINES, C. S. 1982. Note: Technique for objectively measuring relationship between flour chlorination and cake crumb stickiness. Cereal Chem. 59:149.

GOUGH, B. M., WHITEHOUSE, M. E., and GREENWOOD, C. T. 1978. The role and function of chlorine in the preparation of high-ratio cake flour. CRC Critical Reviews in Food Science and Nutrition. 10(1):91.

KISSELL, L. T., DONELSON, J. R., and CLEMENTS, R. L. 1979. Functionality in white layer cake of lipids from untreated and chlorinated patent flours. I. Effects of free lipids. Cereal Chem. 56:11.

KISSELL, L. T., and MARSHALL, B. D. 1972. Design and construction of a reactor for gaseous treatment of flour. Cereal Sci. Today 17:152.

KISSELL, L. T., and YAMAZAKI, W. T. 1979. Cake baking dynamics: Relation of flour-chlorination rate to batter expansion and layer volume. Cereal Chem. 56:324.

KULP, K., TSEN, C. C., and DALY, C. J. 1972. Effect of chlorine on the starch component of soft wheat flour. Cereal Chem. 49:194.

RUSSO, J. V., and DOE, C. A. 1970. Heat treatment of flours as an alternative to chlorination. J. Food Tech. 5:363.

YAMAZAKI, W. T., DONELSON, J. R., and KWOLEK, W. F. 1977. Effects of flour fraction composition on cookie diameter. Cereal Chem. 54:352.

[Received December 14, 1981. Accepted February 25, 1982]