Components of Cake Batter Expansion in White Layer Cakes[1]

J. R. DONELSON and R. L. CLEMENTS[2]

Cereal Chem. 63(2):109–110

ABSTRACT

Objective measurements were used to study the components of batter expansion in white layer cakes. Free flour lipids are necessary for expansion, but the hexane-extracted flour residue controls the degree of batter expansion in chlorinated patent flours. Cake volume and batter expansion data indicated that shortening emulsifiers probably influence baking performance by contributing to batter aeration, whereas free flour lipids probably contribute to foam stability.

In evaluation of soft wheat cultivars for cake baking potential, the patent flours are first chlorinated. Without chlorination, cakes are of such poor quality (i.e., low volume and dense texture) that differences among flours may appear negligible. Cake flours are evaluated in the Wooster laboratory using the AACC white layer cake method (1976). With this formulation, batters from chlorinated flours exhibit excellent expansion in the oven, whereas batters from typical untreated flours exhibit severely restricted expansion. Factors in this procedure that directly influence batter expansion are the emulsified shortening system and the free flour lipids. Omission of emulsifiers or removal of free lipids from the flour virtually eliminate batter expansion (Kissell et al 1979, Donelson et al 1984), resulting in sharply reduced volumes and sunken contours.

The functionality of free flour lipids from chlorinated flours has been demonstrated by Kissell et al (1979). However, Donelson et al (1984) showed that differences in cake volume among flours are associated with the hexane-extracted flour residue. These results suggested that, although the free flour lipids are necessary for batter expansion, other flour components control the degree of expansion, and therefore the volume. In this report, the influence of the extracted flour residue on baking performance was studied by measuring batter expansion. This technique was also used to study the mode of action of free flour lipids and shortening emulsifiers, because both are needed to assure maximum batter expansion.

MATERIALS AND METHODS

Addition of Emulsifiers to Batters at Different Stages

Our emulsified cake shortening is normally prepared by mixing together Creamtex (92%) and Dur-Em 114 emulsifier (8%) (both from Durkee Famous Foods, S.C.M. Corp., Cleveland, OH). In this study the shortening was split into two components: a) 45.6 g Creamtex and, b) a 9.4-g emulsifier portion containing a mixture of 5.0 g Creamtex and 4.4 g Dur-Em 114. In a series of treatments involving Oasis flour, the emulsifier component (b) was added at the first, second, or third mixing stage, mixed with the batter 20 sec before scaling, or left out entirely.

Addition of Flour Lipids to Batter at Different Stages

Hexane extracts from a chorinated Arthur patent flour and a chlorinated soft red wheat composite patent flour were evaporated in an air stream to recover the free lipids. The semisolid lipids were then added to batters prepared from the hexane-extracted flours at the first, second, or third mixing stage, mixed with the batter 20 sec before scaling, distributed without mixing on the batter surface after scaling, or left out entirely.

Lipid Extractions of Flours Differing in Quality

Seven soft red winter wheats and one hard red spring wheat were milled into 50% patent flours (wheat basis). Flours were pin milled at 9,000 rpm (Alpine Kolloplex, type 160Z mill), and chlorinated to pH 4.70–4.83 (Kissell and Marshall 1972). Duplicate 300 g aliquots of each flour were placed in cloth bags, and all eight flours were extracted simultaneously with hexane for 24 hr in a large Soxhlet extractor to obtain the free flour lipids (Clements 1977). Each flour sample was recovered separately; the lipid fraction was recovered by distillation for use as a composite lipid source in subsequent reconstitutions for baking studies.

TABLE I
Cake[a] Volume and Batter Expansion as Affected by Stage at Which Emulsifier[b] is Added

Mixing Schedule[c] Stage	Min	Volume (cm^3)	Batter Height Maximum (cm)
I	9.5	1,106	6.0
II	5.0	1,034	5.4
III	2.5	1,000	5.2
Batter	0.33	911	4.5
Without emulsifier		858	3.8

[a] AACC white layer cake test, method 10-90 (1976); flour, Oasis 50% patent.
[b] Dur-Em 114 emulsifier.
[c] Stage at which emulsifier was added and time emulsifier was in contact with batter prior to baking.

TABLE II
Cake[a] Volume and Batter Expansion as Affected by Stage at Which Free Flour Lipids are Added

Mixing Schedule[b]		Arthur		SRW[c] Composite
Stage	Min	Volume (cm^3)	Batter Height (cm)	Volume (cm^3)
I	9.5	1,006	5.7	1,072
II	5.0	1,009	5.7	1,070
III	2.5	1,004	5.8	1,089
Batter	0.33	1,009	5.7	1,092
Surface		822	3.6	942
Without lipid		811	3.6	929

[a] AACC white layer cake test, method 10-90 (1976). (Flours: hexane-extracted Arthur 50% patent and a hexane-extracted soft red winter composite 50% patent.)
[b] Stage at which lipids were added and time lipids were in contact with batter prior to baking.
[c] Soft red winter.

[1] Cooperative investigation of the North Central Region, Agricultural Research Service, U.S. Department of Agriculture, and the Department of Agronomy, Ohio Agricultural Research and Development Center, The Ohio State University, Wooster. Approved for publication as Journal Article 80-85 of the Ohio Agricultual Research and Development Center.

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

[2] Chemist and research chemist, respectively, at the Soft Wheat Quality Laboratory, Ohio Agricultural Research and Development Center, Wooster 44691.

TABLE III
Cake Volume and Maximum Batter Height Data for Parent Flours and for Hexane-Extracted Flours Reconstituted with a Composite Lipid from the Parent Flours

Flour	Class[a]	Protein[b] (%)	Ash[b] (%)	Cake Volume (cm^3) Parent Flour	Cake Volume (cm^3) Reconstituted Flour	Maximum Batter Height (cm) Parent Flour	Maximum Batter Height (cm) Reconstituted Flour
Arthur	SRW	10.1	0.353	1,016	1,020	5.4	5.4
Oasis	SRW	10.6	0.324	1,126	1,114	6.2	5.8
McNair 1003	SRW	7.3	0.276	1,137	1,140	6.7	6.3
Blend	SRW	7.7	0.314	1,093	1,088	5.7	5.9
Blend	SRW	7.8	0.314	1,094	1,098	5.9	5.9
Blend	SRW	11.5	0.346	1,031	1,053	5.4	5.7
Blend	HRS	11.1	0.391	895	926	4.3	4.7
Logan	SRW	10.1	0.347	1,100	1,103	6.0	6.0
Mean				1,062	1,068	5.7	5.7

[a]SRW = soft red winter; HRS = hard red spring.
[b]Analytical data (14% mb) for 50% patent flours.

Baking and Batter Measurement Procedures

AACC method 10-90 (1976), modified for use with single 8-in. layers (Kissel et al 1979), was used throughout these studies. All bakes were replicated. Cake volumes were determined by rapeseed displacement; least significant difference for volumes was 20.6 cm^3 ($P = 0.05$). Batter height was measured at approximately 0.5-min intervals during baking (23 min) as described by Clements and Donelson (1981).

RESULTS AND DISCUSSION

Effect of Stage of Addition of Emulsifiers

Results of cake volume and maximum batter height measurements (Table I) indicated that baking response (expansion) was directly related to the total length of time the emulsifier was present during mixing. Cake volume was greatest (1,106 cm^3) when the emulsifier was added during the first-stage mixing; however, the volume decreased more than 100 cm^3 when the emulsifier was added at the third stage. The minimum treatmemt with emulsifiers, 20 sec mixing before scaling, resulted in a further loss of 89 cm^3 (to 911 cm^3, only 53 cm^3 greater than the cake baked without the emulsifier). Overall, these results confirm studies by Handleman et al (1961) who proposed that shortening emulsification could affect cake batter systems by permitting incorporation of more air into the batter.

Effect of Stage of Addition of Flour Lipid

Cake volume and maximum batter height data for the lipid sequence study (Table II) show that normal bake responses are obtained regardless of the mixing stage at which the free lipids are introduced, even though there was a nearly 30-fold range in lipid/batter contact time between the treatment extremes. Distributing the lipid on top of the batter after scaling was totally ineffective, and the bake response was equivalent to that when the lipid was omitted entirely. These results suggest that free flour lipids are not essential during the mixing (aerating) stage, but need only be mixed in the batter before baking. It may be that free flour lipids influence baking performance by contributing to batter foam stability.

Effect of Extracted Flour Residues on Batter Expansion

Analytical data for the eight patent flours described earlier and cake volumes for the parent flours and the extracted flours reconstituted with the composite lipid are presented in Table III. The seven soft wheat flours encompassed a range in cake volume normally encountered at our laboratory. Comparisons between parent and reconstituted flours show that cake volumes of reconstituted flours closely reflect those of the parent flours. Because the reconstituted flours had a common lipid fraction, the differences in volumes among them are entirely a result of their extracted flour residues.

Maximum batter heights of cakes from reconstituted flours (Table III) were concordant with heights of cakes from corresponding parent flours ($r = 0.95$). A correlation of 0.98 was obtained between maximum batter height and cake volume for the reconstituted flours. This indicates that the extracted flour residues were controlling the degree of batter expansion and therefore influencing cake volume.

LITERATURE CITED

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

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

CLEMENTS, R. L., and DONELSON, J. R. 1981. Note on a simple device for monitoring batter expansion in layer cakes during baking. Cereal Chem. 58:153.

DONELSON, J. R., YAMAZAKI, W. T., and KISSELL, L. T. 1984. Functionality in white layer cake of lipids from untreated and chlorinated patent flours. II. Flour fraction interchange studies. Cereal Chem. 61:88.

HANDLEMAN, A. R., CONN, J. R., and LYONS, J. W. 1961. Bubble mechanics in thick foams and their effects on cake quality. Cereal Chem. 38:294.

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., 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.

[Received June 28, 1985. Revision received September 26, 1985. Accepted September 26, 1985.]