Chlorine Treatment of Cake Flour. II. Effect of Certain Ingredients in the Cake Formula[1]

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ABSTRACT

Untreated cake flour gave lower volumes as the amount of shortening was increased. At high shortening levels the cakes rose excessively during the early stages of baking but then collapsed. Cake baked from Cl_2-treated flour was insensitive to shortening over the range used in this study. Egg whites improved both the volume and grain of cakes baked from untreated flour but did not materially improve the baking properties of Cl_2-treated flour. Whole eggs had a deleterious effect on the baking properties of untreated flour but did not significantly affect the baking properties of Cl_2-treated flour. Cakes baked from untreated flour did not collapse when wheat or corn starch was used to replace part of the wheat flour. Although the wheat or corn starch improved the volume, it did not improve the grain of the cakes.

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The beneficial effect that Cl_2-treatment has on the baking characteristics of cake flour has long been recognized. However, depending on the type of cake, untreated flour may produce an acceptable or a totally unacceptable cake (Sollars 1958). For example, untreated flour is less suitable for baking yellow layer cake than it is for baking white layer cake. Several studies (Kissell 1967, Kissell and Marshall 1962, Miller and Trimbo 1965) have shown the effects of formula ingredients on Cl_2-treated flours. However, little information is available on the effect of ingredients on untreated flour. The purpose of this study was to investigate the effect of different cake ingredients on the baking properties of Cl_2-treated and untreated flour.

MATERIALS AND METHODS

A series of commercial cake flours was used. Analytical data and baking data for the flours are given in Table I. The egg white and whole egg solids were from Seymour Food, Inc. The corn starch was Argo Corn Starch from CPC, and wheat starch was from Midwest Solvent, Inc. A shortening, Durkee D-20, containing monodiglycerides was used. The baking powder was Fleischmann. The other chemicals used were reagent grade.

Kissell's lean cake procedure (1959) was modified by using granular sugar instead of a sugar solution, by the inclusion of 4% (based on the flour) egg solids, and by blending all dry ingredients at low speed for 3 min. White layer cakes were baked by AACC Method 10-90 (1969). All cake volumes were the average of at least duplicate cakes. Sufficient cakes were baked at different water levels to ascertain optimum absorption. Standard deviation was 15 cc.

RESULTS AND DISCUSSION

Effect of Shortening on Cl_2-Treated and Untreated Flours

Cl_2-treatment of flour is generally believed to enhance the shortening carrying ability of cakes baked from that flour. Kissell and Marshall (1962) showed that different shortening levels have little effect on cake volume. Because it was not clear how untreated flours respond to different levels of shortening in cake baking, we investigated the effect of shortening levels on the baking properties of Cl_2-treated and untreated flours (Table II).

Untreated flour gave higher volume cakes at shortening levels below 28%, but the cakes had a coarse grain. Cakes without shortening had a fine grain but were very firm. Cakes with 28% or more shortening were of low volume and had a poor grain. The baking properties of cakes baked from Cl_2-treated flour were less sensitive to shortening. With the Cl_2-treated flour, an increase in gumminess was noted as the shortening level was increased in cakes. Thus, shortening level affected the volume of cakes baked from untreated flour more than that of cakes baked from Cl_2-treated flour.

Effect of Egg White and Whole Egg Solids

Sollars (1958, 1961) reported that white layer cakes made with commercial formula from untreated flour had volumes from 95 to 101% of those of Cl_2-treated flour. Our results indicated that white layer cakes made with the AACC formula from untreated flour did not collapse in the oven, although cakes baked from the same flour using a lean cake procedure did collapse. The lean cake formula used is a sensitive formula for evaluating cake flours. Commercial formulas include eggs or egg whites as an added structural component. Thus, eggs seemed to enhance the structural properties of cakes baked from untreated flour. The effect of egg on the collapsing property of cakes baked from untreated flour was investigated, using a lean cake formula modified to include 4% dried egg solids.

Cakes baked from the control Cl_2-treated flour had good volume, fine grain, and good overall quality (Table III). Cakes baked from the control untreated flour had low volume, poor internal quality, and flat contour and tended to collapse in the oven. Egg whites improved both the volume and grain of cakes baked from untreated flour but did not materially improve the baking properties of the

TABLE I
Analytical and Baking Data for Flours

Flour	Protein (%)	Ash (%)	pH	Cake Volume (cc)
Cl_2-treated (A)	8.8	0.39	4.8	520
Cl_2-treated (B)	8.9	0.35	4.7	540
Cl_2-treated (C)	8.3	0.38	4.8	600
Untreated (A)	8.9	0.40	5.6	445
Untreated (B)	8.8	0.34	5.8	445
Untreated (C)	8.3	0.38	5.8	545

TABLE II
Effect of Shortening Levels on Cakes Baked from Cl_2-Treated and Untreated Flours

Shortening (%)[a]	Cl_2-Treated Flour (A) Volume (cc)	Grain[b]	Collapse	Untreated Flour (A) Volume (cc)	Grain[b]	Collapse
0	...	...	...	500	F/C	No
15	...	...	...	560	T/O	No
20	520	F/C	No	565	T/O	No
24	510	F/C	No	530	T/O	Slight
28	515	F/C	No	470	T/O	Yes
32	500	F/C	No	420	...	Severe
36	515	F/C	No	370	...	Severe

[a]Based on flour weight.
[b]F/C = fine/close, T/O = thick/open.

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TABLE III
Comparison of the Baking Properties of Cl_2-Treated and Untreated Flours Containing Added Whole Egg and Egg White Solids

Flour	Egg[a]	Volume (cc)	Grain[b]	Contour	Collapse
Cl_2-treated (A)	...	525	F/C	Round	No
Untreated (A)	...	445	T/O	Flat	Yes
Cl_2-treated (A)	Whites	530	F/D	Round	No
Cl_2-treated (A)	Whole	510	F/D	Round	Slight[c]
Untreated (A)	Whites	545	F/O	Round	No
Untreated (A)	Whole	380	C	Dipped	Severe

[a]4% based on flour weight.
[b]F/C = fine/close, T/O = thick/open, F/D = fine/dense, F/O = fine/open, C = collapsed.
[c]Cakes had severe shrinkage or slight collapse.

Cl_2-treated flour. Whole eggs appeared to have a deleterious effect on the baking properties of Cl_2-treated flour. Cakes baked from untreated flour and whole eggs had little structure and were of low volume. Whole egg appeared to enhance the rise of those cakes in the oven during the early stages of baking and caused excessive collapse during the later baking stages.

Egg whites are used in cake baking primarily for their structural properties. Cl_2-treated flour seems to have certain structural properties that are lacking in untreated flour, and egg whites compensate for those structural properties, at least in part. Although the untreated flour and egg whites gave a cake of good volume that did not collapse, the grain was still somewhat inferior to that of cakes baked from Cl_2-treated flour.

The poorer baking properties of untreated flour with whole eggs is believed to be due to the lecithin in eggs. Soy lecithin and wheat flour acetone insoluble lipids (Johnson et al 1979) have a similar effect on the baking properties of untreated flour. Soy and wheat flour acetone insoluble lipids did not adversely affect the baking properties of Cl_2-treated flour.

Substitution of Starch for Flour in Cake Formulas

Cakes baked from untreated flour tend to collapse during the last few minutes of baking. Angel food cakes, even when baked from Cl_2-treated flour, frequently collapse when cooled. However, when wheat starch is used to replace up to 50% of the flour in an angel food cake formula, the cake is less likely to collapse. The purpose of this part of the study was to determine if partial replacement of flour with starch would prevent collapse in cakes made with untreated flour.

Cakes were baked from untreated flour in which 23–45% of the flour in the formula was replaced with a commercial wheat starch (Table IV). Substitution of 23% of the flour with starch resulted in cakes of higher volume that did not collapse. The grain of those cakes was poor, however. Replacing 45% of the flour with wheat starch did not materially affect the quality of the cakes. Substitution of wheat starch for part of the flour clearly prevented the collapse of cakes baked from untreated flour and thus improved the volume of the cakes. Wheat starch did not, however, improve the grain of the cakes.

As shown previously, whole eggs increased the collapse of cakes baked from untreated flour but did not affect those baked from Cl_2-treated flour. We therefore next investigated the effect of whole eggs on the baking properties of untreated flour containing added starch (Table V). Cakes made with whole eggs and untreated flour containing added starch were of better quality (reduced collapse, higher volume, and better grain) than those made with whole eggs and untreated flour. However, they were not comparable to cakes made with whole eggs and Cl_2-treated flour.

Cakes made from whole eggs and defatted untreated flours containing added starch were nearly equal to those cakes obtained from Cl_2-treated flour and whole eggs. The cakes did not collapse, had a fine grain, and were of high volume. It therefore seems that added wheat starch will prevent collapse of cakes made with untreated flour, but added wheat starch will not eliminate collapse of cakes containing whole eggs. Added wheat starch will prevent collapse of cakes baked with untreated flour and eggs, provided that part of the flour lipids have been removed. Added wheat starch appears to overcome the deleterious effect of the acetone insoluble lipids from either flour or eggs but not from the combination.

Sollars and Rubenthaler (1971) reported that corn starch, when substituted for wheat starch in reconstituted flour, gave cakes of generally poor quality. To determine if corn starch would effec-

TABLE IV
Effect of Wheat Starch on the Baking Properties of Untreated Flour (B)

% Flour Replaced with Wheat Starch	Volume (cc)	Grain	Collapse
None	440	Thick-open	Yes
23	520	Thick-open	No
33	525	Thick-open	No
45	515	Thick-open	No
Cl_2- treated (B)	540	Fine	No

TABLE V
Effect of Wheat Starch on the Collapsing Properties of Cakes Baked from Untreated Flour and Whole Eggs

Flour	Wheat Starch[a]	Whole Eggs[b]	Volume (cc)	Grain[c]	Collapse
Untreated (B)	No	No	440	T/O	Yes
Cl_2-treated (B)	No	No	550	F/C	No
Untreated (B)	No	Yes	393	Collapsed	Yes
Cl_2-treated (B)	No	Yes	630	F/C	No
Untreated (B)	Yes	Yes	512	M/F	Slight
DF Untreated (B)[d]	No	Yes	430	Collapsed	Yes
DF Untreated (B)[d]	Yes	Yes	570	Fine	No

[a]23% of the flour replaced by wheat starch.
[b]4% based on the flour.
[c]T/O = thick/open, F/C = fine/close, M/F = medium/fine.
[d]DF untreated = hexane defatted untreated flour.

TABLE VI
Effect of Corn Starch on the Collapsing Properties of Cakes Baked from Untreated Flour and Eggs

Flour	Corn Starch[a]	Whole Eggs[b]	Volume (cc)	Grain[c]	Collapse
Untreated (B)	No	No	451	T/O	Yes
Untreated (B)	Yes	No	518	T/O	No
Cl_2-treated (B)	No	No	541	F/C	No
Cl_2-treated (B)	Yes	No	540	F/C	No
Untreated (B)	No	Yes	350	Collapse	Yes
Cl_2-treated (B)	No	Yes	605	F/C	No
Untreated (B)	Yes	Yes	510	M/F	Slight

[a]18% of the flour replaced by corn starch.
[b]4% solids based on the flour.
[c]T/O = thick/open, F/C = fine/close, M/F = medium/fine.

TABLE VII
Effect of $Al_2(SO_4)_3$, Citric Acid, and $CaCl_2$ on the Baking Properties of Untreated Flour

	Additive	Volume	Grain
Cl_2-treated (C)	. . .	600	Fine
Untreated (C)	. . .	547	Coarse
Untreated (C)	Citric acid[a]	620	Medium Fine
Untreated (C)	$CaCl_2$[a]	675	Medium Fine
Untreated (C)	$Al_2(SO_4)_3$[b]	720	Medium Fine

[a]400 mg/350 g of batter.
[b]Use of Calumet baking powder instead of Fleischmann.

tively eliminate collapse of cakes made from untreated flour, we used corn starch to replace 18% of the flour in the lean cake formula. The baking results obtained with corn starch in cakes baked with Cl_2-treated and untreated flours are summarized in Table VI.

When used to replace part of the flour in the lean cake formula, corn starch gave cakes of improved volume that did not collapse on cooling. It apparently did not affect the grain of cakes baked from untreated flour or the baking quality of Cl_2-treated flours. Corn starch was partially effective in preventing collapse of cakes baked from untreated flour with a formula containing eggs. The data suggested that corn starch was primarily beneficial in improving the volume of cakes baked from untreated flour and partially effective in preventing collapse of cakes baked from untreated flour and eggs. However, the quality of these cakes was still inferior to those obtained from Cl_2-treated flour.

Effect of $Al_2(SO_4)_3$, $CaCl_2$, and Citric Acid

Howard et al (1968) showed the beneficial effects of polyvalent cations on starch cakes. Our results show that $Al_2(SO_4)_3$, $CaCl_2$, and citric acid improve untreated cake flour (Table VII). White layer cakes baked with untreated flour produced a cake with a coarse grain. However, in the presence of citric acid or calcium chloride, that flour gave a higher volume cake with an improved grain. Similarly, if a baking powder containing $Al_2(SO_4)_3$ was used, untreated flour gave higher volume cakes with a medium fine grain.

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