Chlorine Treatment of Cake Flours. I. Effect of Lipids[1]

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ABSTRACT

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Cakes baked from chlorine-treated flour defatted with petroleum ether had slightly lower volumes but much poorer grains than did those baked from nondefatted flour. Cakes baked from untreated flours defatted with petroleum ether did not rise excessively or collapse during baking, but their grain was coarse and open. The baking properties of both Cl_2-treated and untreated flours were restored to their original quality by replacing their extracted lipids. Interchanging the lipid fractions showed that either lipids extracted from Cl_2-treated flour or those extracted from untreated flour would restore the baking properties of the Cl_2-treated flour. Therefore, the beneficial effect of Cl_2-treatment appeared to be on a flour component(s) other than the lipids. Certain commercial surfactants could replace the native flour lipids in cake making.

Cake flour is commonly treated with chlorine gas to enhance its cake-baking properties. Cakes baked using Cl_2-treated flour have higher volume, finer grain, and more tender texture than do cakes baked using untreated flour. The component(s) of flour affected by chlorine have been the subject of many investigations.

Alexander (1933) reported that chlorine bleaches flour pigments and destroys normal gluten properties; Bailey and Johnson (1924) reported that chlorine lowers flour pH. Ewart (1968) found that chlorine, used at levels higher than those used commercially, oxidizes cystine and methionine and destroys or deaminates other amino acids. Tsen et al (1971) observed that chlorine has a twofold effect on dough stability: commercially-used treatment levels increase stability, but higher levels decrease stability. They also witnessed a reduction in the thiol content of Cl_2-treated flour and, for water-solubles, a reduction in UV absorbance at 280 nm. Whistler and co-workers (1962, 1964, 1966) reported that chlorine depolymerizes starch. Fraizer et al (1974) noted that chlorine treatment enhances the gel-forming properties of starch. Shuey et al (1963) and Seguch and Matsuki (1977) reported that chlorine increases the oil-binding capacity of starch, whereas Alexander (1933) and Kulp et al (1972) observed that chlorine-treated starch increases water-binding capacity.

Whistler and Pyler (1969) and Cole (1970) reported that chlorine depolymerizes pentosans; Gilles et al (1964) and Coppock (1960) found that chlorine reduces the degree of unsaturation in flour lipids. Sollars (1958), who investigated the baking properties in reconstituted flours of flour fractions isolated from Cl_2-treated and untreated flours, concluded that the prime starch fraction (and to a lesser degree the gluten fraction) are the flour components affected by chlorine.

Until recently (Kissell et al 1979, Spies and Kirleis 1978) no reports of the effect of lipid fractions on the baking performance of Cl_2-treated and untreated flour were published. This study examines the effect on cake baking of lipids extracted from Cl_2-treated and untreated flours.

MATERIALS AND METHODS

A commercial cake flour milled from soft wheat was used. One portion had received chlorine treatment (protein 8.9, ash 0.40, pH 4.72); the other portion was untreated (protein 8.8, ash 0.40, pH 5.82). Propylene glycol monostearate (Promodan SP) was obtained from Grinsted Products, soy lecithin (refined) from Nutritional Biochemicals, and monoglycerides (Myverol 18-83) from Eastman Kodak Chemicals. The other chemicals used were reagent grade.

Analytical Methods

Moisture, ash, and protein were determined by conventional methods (AACC 1962).

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Lipid Extraction

Lipids were extracted from untreated and Cl_2-treated flours (300 g), using petroleum ether (BP 35–60°C) in Soxhlet apparatus (72 hr). The extracted lipids were filtered through Whatman No. 42 filter paper and the lipids recovered on a rotary evaporator under reduced pressure below 40°C.

Lipid Fractionation

Lipids (3.0 g) were dissolved in 20 ml of petroleum ether, then acetone was added slowly with stirring until that solution became turbid (about 100 ml of acetone). After standing 10 min, that mixture was filtered with Whatman No. 1 filter paper. The residue was washed three times (each time with 25 ml of acetone) and then dissolved in petroleum ether. Those lipids were then recovered as previously described.

Recovery of Lipids

Petroleum ether removed from 0.78 to 0.81 g of lipid per 100 g of flour. Eighty-one percent of those lipids were soluble in acetone and 19 percent were insoluble. Acetone soluble and insoluble lipids have been previously characterized by thin-layer chromatography (Hoseney et al 1970).

Reconstitution

The extracted flours were reconstituted with lipids at levels proportional to those quantities removed by blending those flours and lipids in a Stein Mill for 30 sec. This procedure was also used to supplement defatted Cl_2-treated flour with nonflour lipids.

Cake-baking Method

The cakes were baked using a lean cake procedure that omitted eggs and milk (Kissell 1959). Granular sugar was used in place of the recommended sugar solution, and the dry ingredients plus the shortening (Durkee D-20) were blended together for 3 min at low speed. Otherwise, the cake was baked by Kissell's procedure.

Cake volume was determined by rapeseed displacement. The cake baking data reported are for a minimum of duplicate bakes and, in general, are the averages of several bakes. The standard deviation in cake volumes using Cl_2-treated flour was 15.6 cc.

RESULTS AND DISCUSSION

Baking Properties of Flours and the Effect of Extracted Lipids

Cakes baked from Cl_2-treated flour had higher volumes and better overall quality than did those baked from untreated flour (Table I). The untreated flour gave a batter that rose excessively in the early stages of baking but collapsed in the later baking stages to give a finished cake with a thick, open grain and a flat contour. Cakes baked from petroleum-ether-defatted flour were of poorer quality than those obtained from their respective nondefatted flour. The batter from untreated, defatted flour did not rise excessively during the early stages and did not collapse during the later stages of baking. However, both Cl_2-treated and untreated defatted flours gave cakes with a much poorer grain than did their respective nondefatted flours. Similar conclusions were reached by Kissell et al (1979) and Spies and Kirleis (1978).

The batters produced from defatted flours appeared grainy compared with the smooth-to-fluffy batters from the parent flours. Light microscope studies showed that air cells in batters made with defatted flours (Fig. 1) were aggregated compared with the more evenly dispersed air cells in batters made with nondefatted flours (Fig. 2).

The flours were restored to their original baking quality when the lipids were reconstituted (Table 1). Reconstituting the untreated, defatted flour with lipids extracted from Cl_2-treated flour did not improve the baking properties beyond that of the control (untreated nondefatted flour). Reconstituting the Cl_2-treated, defatted flour with lipids extracted from the untreated flour gave cakes equal to the control (Cl_2-treated nondefatted flour).

TABLE I
Effect on Cake Quality of Exchanging Lipids Extracted from Cl_2-treated and Untreated Flours

Flour	Lipid Source	Volume (cc)	Grain[a]	Contour	Collapse
Control					
Cl_2-treated	. . .	525	F/C	Round	No
Untreated	. . .	445	T/O	Flat	Yes
Defatted with petroleum ether					
Cl_2-treated	. . .	500	T/O	Flat	No
Untreated	. . .	458	C/O	Flat	No
Cl_2-treated	Cl_2-treated	536	F/O	Round	No
Untreated	Untreated	440	T/O	Flat	Yes
Cl_2-treated	Untreated	520	F/C	Round	No
Untreated	Cl_2-treated	461	T/O	Flat	Yes

[a]F/C = fine/close, T/O = thick/open, F/O = fine/open, C/O = coarse/open.

The petroleum-ether-extracted lipids helped disperse the shortening in the cake batter and had a major effect on the grain of the cakes. They also affected the rise and collapse of cakes baked from untreated flour. However, there appeared to be no difference in the cake-baking properties of lipids extracted from Cl_2-treated and untreated flours. Therefore, the beneficial effect of Cl_2-treatment appeared to be on a flour component(s) other than the lipids.

Effect of Acetone Soluble and Insoluble Lipids

Cakes baked from untreated flour collapsed in the oven during the last few minutes of baking. However, cakes baked from defatted, untreated flour did not collapse during baking. Thus, the collapsing property of untreated flour appeared to be related to certain flour lipids.

To determine which lipids of flour were responsible for the collapsing property of cakes baked from untreated flour, cakes were baked from defatted, untreated flour reconstituted with acetone soluble and insoluble flour lipids (Table II). The acetone soluble lipids improved cake volume (cake with a round contour and no collapse), but they had little effect on the crumb grain of the cake. The acetone insoluble lipids produced cakes with a low volume and excessive collapse. Thus, the acetone insoluble lipids appeared to be responsible for the collapsing property of cakes baked with untreated flour.

Effect of Nonflour Lipids on Baking Properties

Howard et al (1968) reported that surface-active lipids were essential for cake baking properties in a system where a commercial wheat starch was used to replace all the flour in a commercial cake formula; they used a liquid shortening containing propylene glycol

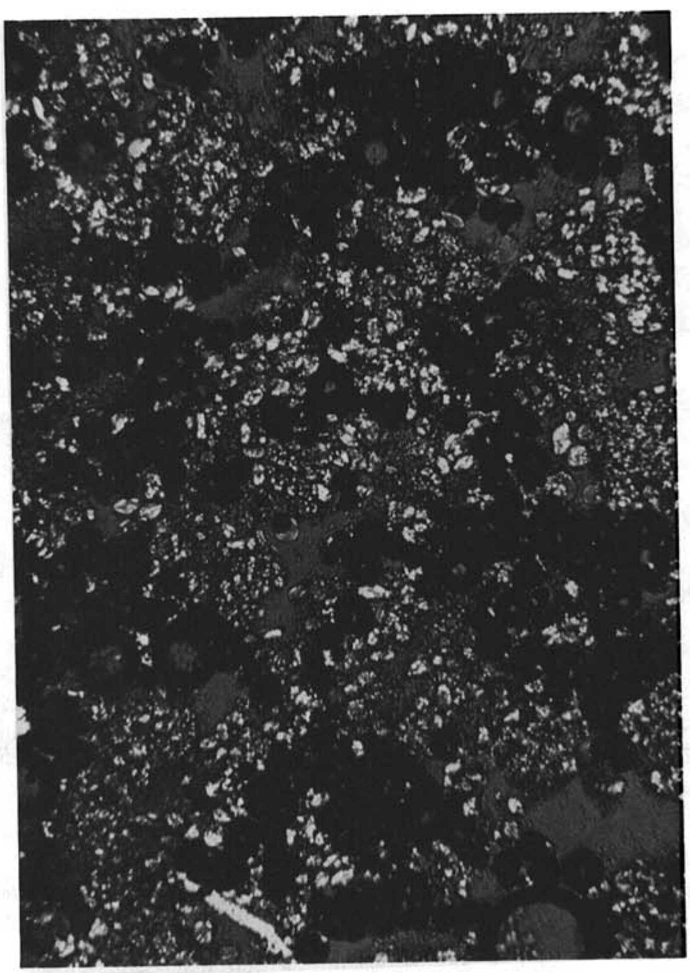

Fig. 1. Photomicrograph of cake batter from defatted flour. (× 79 under polarized light.)

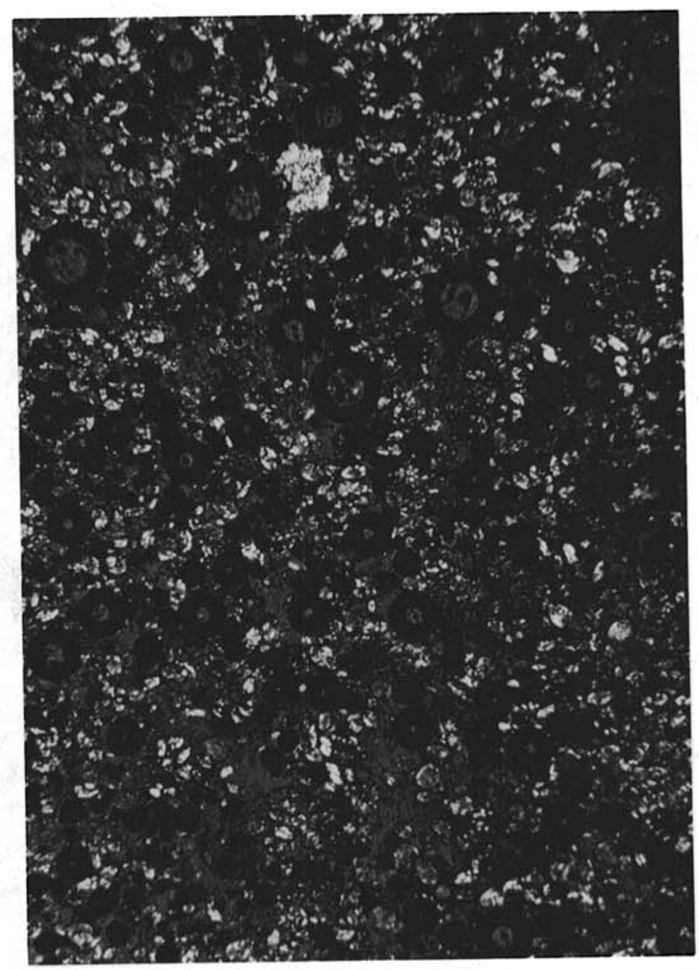

Fig. 2. Photomicrograph of cake batter from nondefatted flour. (× 79 under polarized light.)

TABLE II
Baking Properties of Defatted, Untreated Flour Reconstituted with Acetone Soluble and Insoluble Flour Lipids

Flour	Lipid	Volume (cc)	Grain[a]	Contour	Collapse
Cl_2-treated	...	525	F/C	Round	No
Untreated	...	445	T/O	Flat	Yes
Untreated[b]	0.6% Acetone soluble	563	T/O	Round	No
Untreated[b]	0.2% Acetone insoluble	410	T/O	Flat	Yes

[a]F/C = fine/close, T/O = thick/open.
[b]Defatted with petroleum ether.

TABLE III
Effect of Nonflour Lipids on the Baking Properties of Defatted, Cl_2-treated Flour

Flour	Lipid	Volume (cc)	Grain
Control (nondefatted)	...	525	Fine/close
Defatted	...	445	Thick/open
Defatted	0.8% DMG[a]	530	Fine/close
Defatted	0.2% Soy Lecithin	535	Fine/close
Defatted	1.6% PGMS[b]	515	Fine/close

[a]DMG = Distilled monoglycerides.
[b]PGMS = Propylene glycol monostearate.

monostearate (PGMS) and stearic acid. This implies that the free flour lipids can be replaced by nonflour lipids in cake baking. To confirm this hypothesis, cakes were baked from defatted, Cl_2-treated flour supplemented with nonflour lipids (distilled monoglycerides [DMG], PGMS, and soy lecithin).

The DMG (0.8%) satisfactorily replaced flour lipid in cake baking (Table III). When used at high levels (1.6% or greater based on the flour weight), PGMS performed satisfactorily; at low levels (0.8%), unsatisfactorily. Of the three materials tested, soy lecithin gave the best performance at the lowest level (0.20%) of reconstitution. The results clearly show that nonflour lipids can replace flour lipids in restoring the baking properties of defatted, Cl_2-treated flour.

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