Functionality in White Layer Cake of Lipids from Untreated and Chlorinated Patent Flours. II. Flour Fraction Interchange Studies[1]

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ABSTRACT

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Chlorinated and untreated cake flours were hexane extracted to remove free lipids and then fractionated by an aqueous procedure into prime starch, tailings, gluten, and water-soluble fractions. The fractions were reconstituted into dry blends such that one component from the respective flours was interchanged at a time. Bake results with a high-ratio layer-cake formulation showed that chlorinated lipids were the primary component contributing to cake-quality potential. Lipid-interchange studies between varieties and wheat classes indicated that this functionality was general and independent of the lipid source. Differences in cake volume between flours were shown to reside in the hexane-extracted flour residues.

Several workers have used flour fractionation and reconstitution to study the roles of flour components in cakebaking. Sollars (1958) fractionated chlorinated and untreated flours and performed fraction-interchange studies. He concluded that the gluten and prime starch fractions played major roles in cake quality. Lamb and Bode (1963) reported fraction-interchange experiments involving individually chlorinated flour fractions. Statistical analysis of experimental data indicated that starch has the greatest effect on cake volume and internal structure. Donelson and Wilson (1960a), baking chlorinated dry blends composed of various proportions of fractions, found a significant compositional effect on cake quality. In a later paper involving the interchange of fractions from a good- and a poor-quality cake flour, Donelson and Wilson (1960b) reported that gluten had a marked effect on cake volume, but that other components also affected it. In all these studies, whole flour was fractionated; that is, flour was not extracted to remove lipids before fractionation.

Kissell et al (1979) studied the role of free lipids in a white layer-cake formulation by extracting lipids from untreated and serially chlorinated flours and interchanging lipids and extracted residues (base flours). Their results showed that lipids from chlorinated flour improved cake volume and internal scores, and that chlorination modified the functionality of both the extracted lipids and the base flour. Kissell and Yamazaki (1979) demonstrated the relationship between flour chlorination and cake-batter expansion. Clements and Donelson (1982a, 1982b) showed that aged or heated flour lipids are as effective as chlorinated lipids in inducing batter expansion. Some of these results are at variance with studies that attribute improved performance of chlorinated flour to flour components other than the free lipids (Spies and Kirleis 1978; Johnson and Hoseney 1979). Clements and Donelson (1982a) have discussed variables that may contribute to these disparate results.

In this report, the study of Kissell et al (1979) was expanded to include an evaluation of the contribution of individual flour components isolated by aqueous fractionation from hexane-extracted chlorinated and untreated flours. The contributions of the free flour lipids were also assessed. In addition, the effect of variety and wheat class on performance of chlorinated lipids was studied in a series of lipid/base flour interchanges.

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MATERIALS AND METHODS

A commercial soft wheat cake patent flour was obtained from an Ohio mill in both untreated and chlorinated states. Two pure variety soft red winter wheats (Ruler and Arthur) and a hard red winter blend (HRW) were milled on our Miag Multomat mill to 50% extraction (wheat basis). The flours were pin-milled at 9,000 rpm (Alpine Kolloplex), and a portion of each was treated with chlorine gas (Kissell and Marshall 1972).

Part of each flour (except untreated HRW) was extracted with hexane to remove the free lipids (Clements 1977). The lipid content of each was determined gravimetrically. All flours were stored under refrigeration. Analytical data for the untreated flours and pH and lipid content of the chlorinated samples are given in Table I.

The commercial and Ruler extracted flours were fractionated by an aqueous procedure (Yamazaki et al 1977) modified for chlorinated flour by the addition of sodium carbonate to the flour (1:1,000) before fractionation. The fractions were dried, ground, and blended, in proportion to their recovery yields, into 115-g lots. Lipids were restored to the dry blend by contact-wetting with the required volume of lipid solution, after which the solvent was evaporated. The dry blends were hydrated to about 12% moisture content. Compositional effect was minimized because of the similarities in fraction yields between untreated and chlorinated flours (Table II). All reconstitutions were replicated.

The official AACC cake test (AACC 1976), modified by scaling down the ingredient weights to 55% of the specified quantities to bake a single 8-in. layer cake, was used throughout the study. The change was made to accommodate the small quantities of fractions available for the study. To control ingredient variables, we used a commercial, emulsified shortening (Sweetex, Proctor and Gamble Co., Cincinnati, OH) to which we added a quantity of commercial mono- and diglyceride emulsifier (Dur-Em, 195, Durkee Famous Foods, SCM Corp., Cleveland, OH) up to 9%. The optimum liquid level determined for the chlorinated flour was used for the untreated flour and for all reconstitutions. Cake volume was determined by rapeseed displacement and internal structure was scored according to Kissell et al (1979). Pooled standard deviation for cake volume was 15.3 cc.

RESULTS AND DISCUSSION

Cakes from hexane-extracted residues of the untreated and chlorinated ("unbleached" and "bleached") commercial flours (Figs. 1–3) were small and had extremely sunken contours (Fig. 1, first row). There was no batter expansion. Addition of untreated lipids resulted in very little batter expansion and poor-quality cakes (Fig. 1, second row). Addition of chlorinated lipids (Fig. 1, third row) however, resulted in large batter expansions with cake volumes and contours equivalent to those for the chlorinated parent flour.

TABLE I
Analytical Data for Commercial, Ruler, Arthur, and Hard Red Winter Cake Patent Flours (14% mb)

	Untreated Flour			Chlorinated Flour	
	Protein (%)	Ash (%)	Lipids (%)	Lipids (%)	pH (%)
Commercial	8.3	0.35	0.79	0.87	4.75
Ruler	7.8	0.29	0.64	0.66	4.75
Arthur	10.1	0.35	0.72	0.80	4.81
HRW	9.7	0.36	···	0.82	4.83

TABLE II
Fraction Yields from Hexane-Extracted Chlorinated and Untreated Base Flours

Base Flour	Prime Starch (%)	Starch Tailings (%)	Gluten (%)	Water Solubles (%)
Commercial				
Chlorinated	80.9	6.7	9.9	2.5
Untreated	80.5	6.2	10.7	2.6
Ruler				
Chlorinated	81.2	6.5	9.4	2.9
Untreated	80.7	6.4	10.0	2.9

Similar results were obtained when dry blends of fractions from hexane-extracted residues of the untreated and chlorinated commercial flours replaced the residues in the above experiment (Fig. 1, fourth, fifth, and sixth rows). Both experiments showed that chlorinated lipids significantly improve cake volume and crumb scores. This agrees with data of Kissell and Yamazaki (1979) and of Clements and Donelson (1982a, 1982b).

A series of dry blends in which individual fractions from chlorinated and unchlorinated flours had been interchanged were used to evaluate the role of specific flour fractions in cake quality.

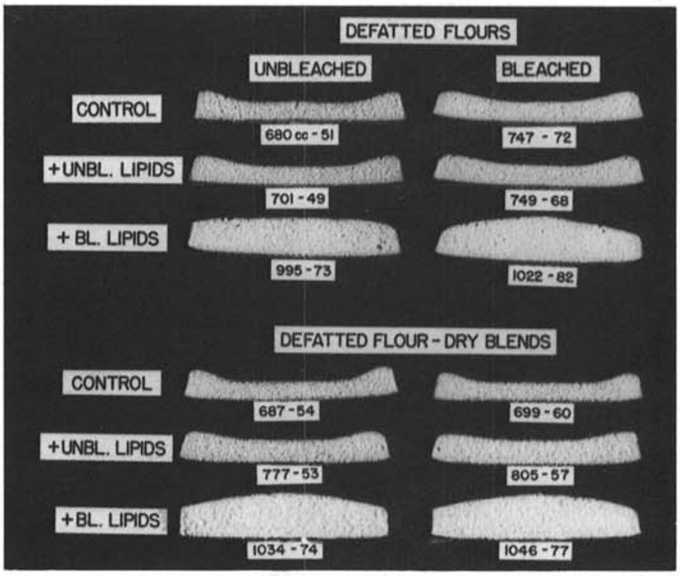

Fig. 1. Top, Cakes from hexane-extracted commercial base flour without added lipids (control) with added lipids from untreated (unbleached) flour, and with added lipids from chlorinated (bleached) flour. **Bottom,** Cakes from dry blends of fractions from hexane-extracted commercial base flour without added lipids (control) with added lipids from untreated (unbleached) flour, and with added lipids from chlorinated (bleached) flour. Labels show cake volume and crumb score, respectively.

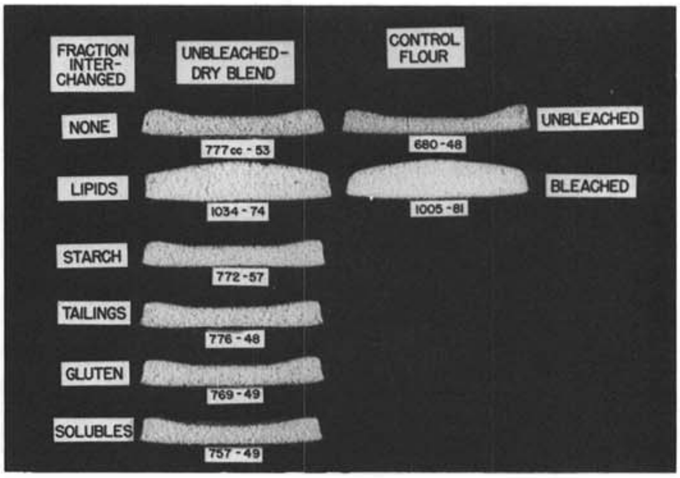

Fig. 2. Cakes from dry blends of fractions from hexane-extracted unbleached commercial flour in which single fractions were substituted with counterparts from chlorinated (bleached) flour. Control flour refers to cakes from untreated (unbleached) and chlorinated (bleached) parent flours, respectively. Labels show cake volume and crumb score, respectively.

The results (Fig. 2) for the commercial flour show the effect of substituting one chlorinated fraction at a time into a series of base blends from unchlorinated flour. The lipid exchange resulted in a cake that resembled a cake from chlorinated flour in volume and contour, even though the blend was less than 1% chlorinated. The remaining interchanges produced results similar to the control dry blend (Fig. 2, top, "None") because of reconstitution with lipids from unbleached rather than chlorinated flour.

On the other hand, cakes baked from dry blends of fractions from chlorinated flour, interchanged one at a time with their counterparts from unchlorinated flour, closely resembled the cake from the parent chlorinated flour (Fig. 3), except when the lipids from the unchlorinated flour were included in the blend.

Fraction-interchange studies were repeated with reconstitutions from Ruler wheat so that these effects could be evaluated on a pure variety that was milled and chlorinated in the laboratory. Cake volume, score, and contour data (Table III) for these interchange treatments confirm the importance of chlorinated lipids to cake volume potential. Overall, these results concur with those of Gaines and Donelson (1982).

The importance of the chlorinated lipids in improving cake volume of base flour and of dry blends of fractions suggested that trials be done to determine whether varietal and wheat class factors were involved. A series of lipid/base flour interchanges was prepared involving the three soft wheat flours. The lipids from each flour were added in turn to the three hexane-extracted base flours and baked into cakes (Fig. 4). Volumes of cakes from base flours to which lipids had been added reflected the base flour rather than the source of the lipids, indicating that inherent varietal differences in cake volume potential lay with base flour components, ie, components other than lipids. Although lipids from chlorinated flour increased cake volume and improved scores, these actions were general and independent of lipid source.

TABLE III
Volume, Score, and Contour of Cakes from Dry Blends of Chlorinated and Untreated Ruler Flours in Which Fractions Had Been Interchanged Singly

	Blend of Chlorinated Fractions with Indicated Fraction from Untreated Flour			Blend of Untreated Fractions with Indicated Fraction from Chlorinated Flour		
Fraction	Volume (cc)	Score (%)	Contour	Volume (cc)	Score (%)	Contour
None	1,070	71	Round	904	66	Sunken
Lipids	940	67	Sunken	1,071	71	Round
Prime starch	1,044	71	Round	919	68	Sunken
Starch tailings	1,070	71	Round	885	58	Sunken
Gluten	1,073	71	Round	889	57	Sunken
Water solubles	1,064	70	Round	904	58	Sunken

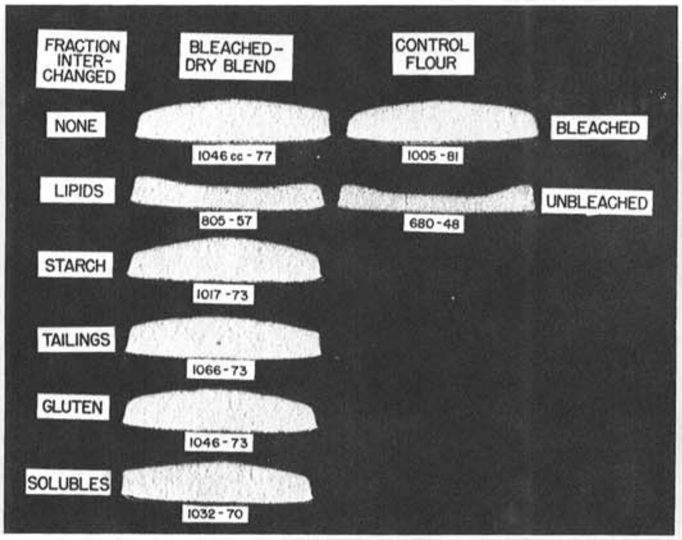

Fig. 3. Cakes from dry blends of fractions from hexane-extracted chlorinated (bleached) commercial base flour in which single fractions were substituted with counterparts from untreated (unbleached) flour. Control flour refers to cakes from chlorinated (bleached) and untreated (unbleached) parent flours respectively. Labels show cake volume and crumb score, respectively.

Similar results were obtained even when wheat class differences were involved (Fig. 5). Interchange of lipids between a chlorinated hard wheat flour and a soft wheat flour again indicated that cake volume potential lay with the base flour rather than with the lipids.

A study with a serially chlorinated cake flour showed that the crumb condition changed from gummy to dry with increasing level of chlorine treatment (Kissell and Yamazaki 1979). Informal taste tests of cakes from dry blends in the present study indicated that the change in crumb condition is associated with the chlorine reaction with the prime starch fraction. This confirms recent objective measurements of cake-crumb stickiness (Gaines and Donelson 1982).

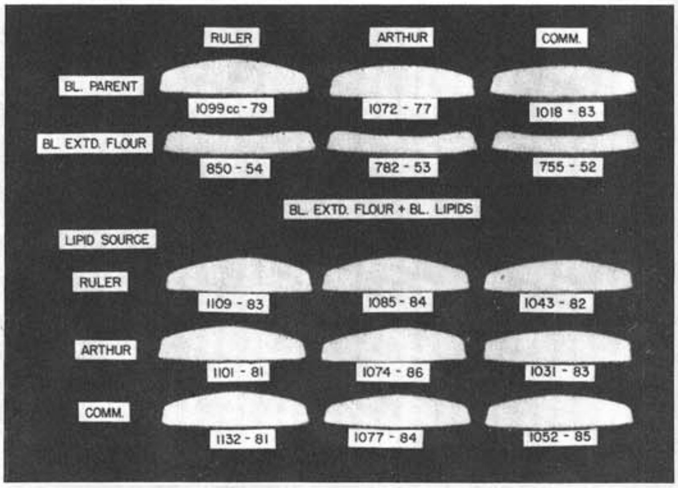

Fig. 4. Cakes from three chlorinated (bleached) flours with interchanged lipids and base flours. First row, parent cake flours; second row, base flours only (hexane-extracted residues); third row, base flours with Ruler lipids; fourth row, base flours with Arthur lipids; fifth row, base flours with commercial flour lipids. Labels show cake volume and crumb score, respectively.

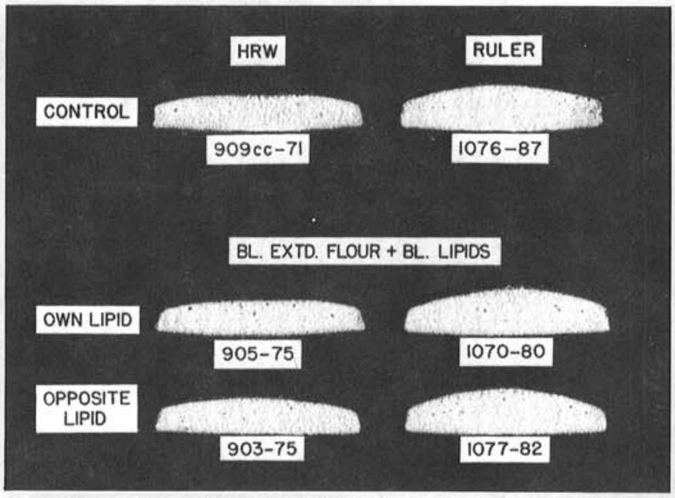

Fig. 5. Cakes from chlorinated (bleached) hard red winter and soft red winter wheat (Ruler) flours, with interchanged lipids and base flours. First row, parent cake flours; second row, base flours with own lipids; third row, base flours with interchanged lipids. Labels show cake volume and crumb score, respectively.

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