EFFECT OF FREE FLOUR LIPIDS ON CAKE-BAKING POTENTIAL[1]

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ABSTRACT

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Chlorinated and unchlorinated flours from four wheat varieties were extracted with hexane, and the free lipids were removed. The free lipids were reconstituted with extracted-chlorinated flour and baked using lean and rich cake formulas. Flours without free lipids produced smaller cakes with poorer textures than did flours with free lipids. Most of the original quality was restored when the free lipids were returned. Flours reconstituted with unchlorinated lipids produced larger cakes with poorer textures than did those reconstituted with chlorinated lipids. Evidence suggests that the cake-baking potential of a flour is not governed by the free lipid fraction of the flour.

Though lipids naturally occur in flour in rather small quantities (1.5–4.0%), they play an important role in baking. Pomeranz et al (1,2), Daftary et al (3), Hoseney et al (4), Ponte and DeStefanis (5,6), and MacRitchie and Gras (7) all studied the role of flour lipids in breadmaking. When the lipids were fractionated into polar and nonpolar components and returned to the flour, the polar fraction increased loaf volume while the nonpolar fraction decreased loaf volume and impaired crumb characteristics. In the polar fraction, the glycolipids have been shown to improve volume substantially more than do phospholipids (2), and the free fatty acids have been shown to decrease volume more than any other nonpolar fraction (6).

Few reports have dealt with the role of flour lipids in soft wheat products, and most of these have dealt with cookie baking (8–10). Seguchi and Matsuki's (11) recent work using a pan-cake formulation containing no shortening showed that the polar lipid fraction was necessary to restore cake volume.

The present study was undertaken to determine some of the effects of free flour lipids on layer cake quality and to assess any change in functionality of these lipids brought about by chlorination.

MATERIALS AND METHODS

Samples

Wheats of four varieties, a hard red winter (HRW) and three soft red winter (SRW) wheats, grown in 1975 were used in this study. Cloud HRW was grown at the Kansas State University Agronomy Farm, Manhattan, KS, and Redcoat, Arthur, and Monon SRW were grown at the Purdue University Agronomy Farm, West Lafayette, IN. Redcoat, Arthur, and Monon were selected for this study, because they are known to possess poor, average, and good cake-baking potential, respectively. The wheats were milled to 50% patent flours (wheat basis) on a Miag mill. The flours were then impact milled (Alpine Kolloplex laboratory

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mill 1602) at 12,000 rpm; each variety was then chlorinated with chlorine gas to its optimum pH as determined by previous baking tests.

Analytic Procedures

Moisture, ash, and pH were determined as described in AACC Methods 44-15A, 08-01, and 02-52, respectively (12). Protein was determined using a block-digestion Kjeldahl method (N × 5.7) (13). Particle size index was determined by modifying Trupp's (14) procedure. Modifications included using a 15-g sample of wheat and grinding the sample for 30 sec with a CRC micro-mill.

Lipid Extraction

Chlorinated and unchlorinated flour samples were extracted with hexane in a Soxhlet extractor for a total of 24 hr to remove the free lipids. The flour residues were air-dried until any trace of solvent, detected by smelling, was removed. The extracts were vacuum filtered through Whatman No. 1 filter paper to remove flour particles, and the hexane was removed under vacuum below 40°C on a rotary evaporator. The lipids were taken up in chloroform to approximately 1% solutions, and stored in amber bottles under nitrogen at 4°C until used. Total lipid concentrations in the chloroform solutions were determined by drying solution aliquots in a vacuum oven at 100°C for 30 min.

Baking Procedures

Lipids were returned to extracted, chlorinated flour the day before baking in 1% solvent solutions. The extracted flour was spread in thin layers in glass baking pans, and the lipid solutions were pipetted on and mixed into the flour. The flour was then allowed to dry overnight at room temperature to remove the solvent.

White layer cakes were baked using 55% versions of a lean formula method (15) and AACC method 10-90 (12) as adapted by Kissell.[3] The 55% cake baking methods are the same as described in the full formula methods except that only 55% of each ingredient is used and one layer cake is baked. After layer cakes cooled to room temperature, volumes were determined by rapeseed displacement, cakes were cut, and their internal characteristics were evaluated. Internal scores were computed as the combined scores of color, grain, cell size, and cell uniformity, with each category based on a 10-point scale.

RESULTS AND DISCUSSION

Sample Analysis

An analysis of the flours milled from the four wheat varieties studied and their free lipid content is given in Table I. The particle size index (PSI) results follow the expected cake-baking potential of all of the flours consistent with the results of Yamazaki and Donelson (16), who found the PSI to be directly related to cake volume. In all cases, more lipids were extracted from chlorinated flours than from unchlorinated flours. The greater amount of lipids extracted probably resulted from addition of chlorine to the lipids during chlorination as others (17–19) have reported, thereby increasing the molecular weight of the lipids.

Baking Results

The experimental cake baking was done on three separate days. The maximum volume range for cakes baked with the same treatment was ± 12 ml. The analysis

[3]Personal communication with L. T. Kissell, Soft Wheat Quality Laboratory, OARDC, Wooster, OH, May 1976.

of variance (20) of cake volume data indicated an interaction between varieties and treatments ($\alpha = 0.05$). Therefore, general conclusions over all varieties cannot be made, and conclusions are based within a variety.

The cake baking data for the lean formula are shown in Table II. Generally, the cake baking performance followed the cake quality rankings of the four varieties. The cakes baked from Cloud HRW wheat flour gave the lowest cake volumes for all treatments. Monon, the highest quality SRW wheat flour, however, did not always give the largest volumes in all lipid treatments, as the cakes baked with Arthur flour were higher in some of the treatments.

Cakes baked with flours from which free lipids were extracted decreased in both volume and internal score compared with their controls (Table II). Cakes baked with the hexane-extracted flours had fallen contours and grainy crumb appearances. This indicates that the free lipids perform a necessary function in cake structure formation.

The control cakes of the SRW wheat flours increased in volume as their free lipid content increased. This may indicate a possible relationship between the percentage of free lipids contained in a flour and its cake-baking potential. This relationship is presently under further investigation in our laboratory.

TABLE I
Analysis of Flours and Free Lipid Extracts[a]

Variety	Protein (%)	Ash (%)	Particle Size Index	pH	Free Lipid Extracts Uncl Flour[b] (%)	Free Lipid Extracts Cl Flour[b] (%)
Cloud	10.5	.32	16.3	4.9	0.73	0.77
Redcoat	9.5	.34	32.1	4.8	0.61	0.66
Arthur	10.8	.33	34.9	4.8	0.71	0.73
Monon	9.0	.27	42.4	4.6	0.76	0.81

[a]All values reported on 14% mb.
[b]Uncl = unchlorinated, Cl = chlorinated.

TABLE II
Responses of Varieties to Chlorinated and Unchlorinated Free Lipids

	Variety[b,c]							
	Cloud		Redcoat		Arthur		Monon	
Flour Treatment[a]	Vol[d]	IS[e]	Vol	IS	Vol	IS	Vol	IS
Control	462	29	520	33	533	33	541	32
Extracted	418	23	454	28	507	27	468	28
+ Chlorinated lipid	447	30	501	32	515	32	529	33
+ Unchlorinated lipid	502	26	519	31	580	28	566	31

[a]Control = original chlorinated flour; all treatments done with original chlorinated hexane-extracted flour.
[b]Average of three bakes.
[c]Standard error of mean for volume, $S_x = 5.0$, internal score, $S_x = 1.1$.
[d]Vol = volume in milliliters.
[e]IS = internal score.

Cakes baked with the parent extracted flours reconstituted with chlorinated lipids ideally should have the same volumes as their respective control cakes. This, however, was not the case, as the chlorinated reconstitution treatments yielded cakes with slightly lower volumes than their respective control cakes. The reconstitution of the flour with the lipids therefore did not restore entirely the original cake-baking quality of the flour. This could have resulted from a change in the functionality of the lipids during extraction, deleterious solvent effects on the flour, or the reconstitution procedure not returning the lipids to the sites they originally occupied before extraction.

To determine if the changes in the lipids brought about by chlorination would affect their functionality, free lipids from unchlorinated flours were reconstituted with extracted, chlorinated flours and baked using a lean formula. The resulting cakes had larger volumes than did the respective cakes baked with flour reconstituted with chlorinated free lipids. The larger volumes, however, also were accompanied by lower internal scores. The lower internal scores resulted from an increase in cell size of the cakes. These results seem to indicate that the functionality of the free lipids in the lean formula cakes is changed when the flour is chlorinated.

Results of an experiment in which free lipids from different varieties were interchanged among different extracted flours are shown in Table III. When

TABLE III
Results of Interchange by Varieties of Free Lipids and Extracted Flours

Flour[a]	Lipid Fraction[b]	Volume[c] (ml)	Internal Score
Redcoat	Redcoat Uncl	530	31
Redcoat	Arthur Uncl	532	28
Arthur	Arthur Uncl	581	29
Cloud	Cloud Cl	440	28
Cloud	Monon Cl	454	28
Monon	Monon Cl	518	32

[a]Hexane-extracted, chlorinated flour.
[b]Uncl = unchlorinated, Cl = chlorinated.
[c]Results of single bake.

TABLE IV
Responses of Rich-Formula Cakes to Chlorinated and Unchlorinated Free Lipids

Variety	Treatment[a]	Volume[b] (ml)	Internal Score
Monon	Control	1,038	40
Monon	Extracted	875	28
Monon	+ Chlorinated lipids	1,007	40
Monon	+ Unchlorinated lipids	1,161	32

[a]Control = original chlorinated flour; all treatments done with original chlorinated hexane-extracted flour.
[b]Results of duplicate bakes.

chlorinated, extracted Redcoat flour was reconstituted with unchlorinated Arthur lipids, the resulting cake volume was the same as when the Redcoat flour was reconstituted with unchlorinated Redcoat lipids. The same trend was found when the chlorinated lipids from the highest quality SRW wheat flour (Monon) were returned to extracted, chlorinated HRW wheat flour (Cloud). These results seem to indicate that factors present in the parent flour, not differences in the free lipid composition, determine the differences in cake-baking potential of flours.

To determine if the same effects found with the lean cake formula occur with a rich cake formula, cakes were baked using a 55% version of AACC method 10-90 (12). Results shown in Table IV indicate that the same general trends found with the lean cake formula were followed. As before, cakes baked with flour that had the free lipids removed had lower volumes and internal scores than did control cakes baked with unextracted flour. The results suggest that the free lipids fraction is necessary to produce a good cake when using either formulation.

The change in free lipid functionality brought about by chlorination was also apparent in rich formula cakes (Table IV). Accordingly, cakes from the unchlorinated lipid treatments again had larger volumes but poorer internal scores than did those baked from the chlorinated lipid treatments.

SUMMARY

The results of this study show a definite need for the free flour lipids to produce a satisfactory cake when using either the lean or rich formula. The ability of the free lipids to perform their functional role appears to be altered somewhat when the flour is chlorinated. Based on the results of this study, the differences in cake-baking potential of flours apparently is determined by factors present in the parent flour, not by differences in the free lipid composition. A relationship may exist, however, between cake baking potential and the amount of free lipid available as determined by the particle size of the flour.

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