Chlorine Treatment of Cake Flours. III. Fractionation and Reconstitution Techniques for Cl_2-Treated and Untreated Flours[1]

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ABSTRACT

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Fractionation and reconstitution studies of Cl_2-treated and untreated cake flours indicate that the starch fraction is responsible for the improved baking performance of Cl_2-treated flours. Although the fractionated and reconstituted flours gave cakes with volume essentially equal to those obtained from the control (unfractionated) flours, the grain of cakes from reconstituted flours was much poorer than the controls. In this study, cakes from reconstituted flours with volume and grain essentially equal to the unfractionated flour were obtained by extracting flours with hexane before wet-fractionation and using a single-stage mixing procedure with a highly emulsified shortening system.

Sollars (1958a,b) developed a cake flour fractionation and reconstitution procedure that allowed him to compare the baking properties of the major flour components isolated from Cl_2-treated and untreated flours. The data clearly indicated that the prime starch fraction of flour was the component responsible for improved baking properties of Cl_2-treated flour. Lamb and Bode (1963) confirmed Sollars' findings.

However, for the reconstituted flour to perform similarly to the parent flour in baking, a doughing step was necessary. The dough from the reconstituted flour was then used to prepare the cake batter. Recently Yamazaki and Donelson (1976) reported that reconstituted cookie flour performed satisfactorily without a doughing step if a defatting step were used prior to the flour fractionation procedure. Our study was to investigate the baking properties of fractionated and reconstituted Cl_2-treated and untreated cake flours.

MATERIALS AND METHODS

The flour used was a commercially milled, soft wheat cake flour. Two flour samples were used; both were from the same grist but one received Cl_2-treatment, whereas the other was untreated. The flours contained 8.7% protein and had 0.34% ash. When slurried with water, the Cl_2-treated flour gave a pH of 4.8; the pH was 5.6 for the untreated flour.

Two shortenings were used: Durkee D-20 emulsified with 4.8% mono- and diglycerides and Proctor and Gamble Nutex emulsified with propylene glycol monostearate (PGMS) and stearic acid. All chemicals used were reagent grade.

Cake-Baking Methods

Lean cake method I: A modified Kissell's lean cake procedure (Kissell 1959) was used with the water optimized for each flour. Modification of Kissell's procedure consisted of the use of granular sugar instead of sugar solution and a 3 min blending (low speed) of all dry cake ingredients before shortening and distilled water (90 ml) were added.

Lean cake method II: Kissell's lean cake procedure was further modified to a single mixing step (4 min medium speed) and a liquid shortening containing PGMS and stearic acid was used in place of emulsified plastic shortening. All baking results were the average of at least two determinations. The standard deviations of volumes of cakes baked from Cl_2-treated flour with lean cake methods I and II were 15.6 and 16.3 cc, respectively.

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Extraction of Flour with Hexane

Flour (300 g) was suspended in 750 ml of hexane and stirred using a magnetic stirrer for 24 hr. The suspension was filtered with a Büchner funnel, washed with hexane, and air dried. The lipids were recovered on a rotatory evaporator (below 40°C) under reduced pressure.

Lipid Reconstitution in Defatted Flours

Defatted flours were reconstituted with lipids in proportion to the quantity removed during the defatting step. The lipids were weighed into a small tared watch glass and transferred to a small mortar containing 5.0 g of flour and made into a mull, then blended with the remaining flour in a Stein mill for 30 sec.

Cake Flour Fractionation Procedures

Untreated and Cl_2-treated flours were fractionated by a modification of Sollars' acetic acid procedures (Sollars, 1958a). The flour was first defatted with hexane, air dried, and then the defatted flour fractionated by Sollars' procedures (Fig. 1). In addition, the flour fractions were freeze dried and then ground in a Stein mill to pass through a 50-mesh Tyler sieve, except for the water-soluble fraction which was passed through a 20-mesh Tyler sieve. The ground flour fractions were stored in plastic bags at 4°C. The yields of fractions by this procedure are given in Table I.

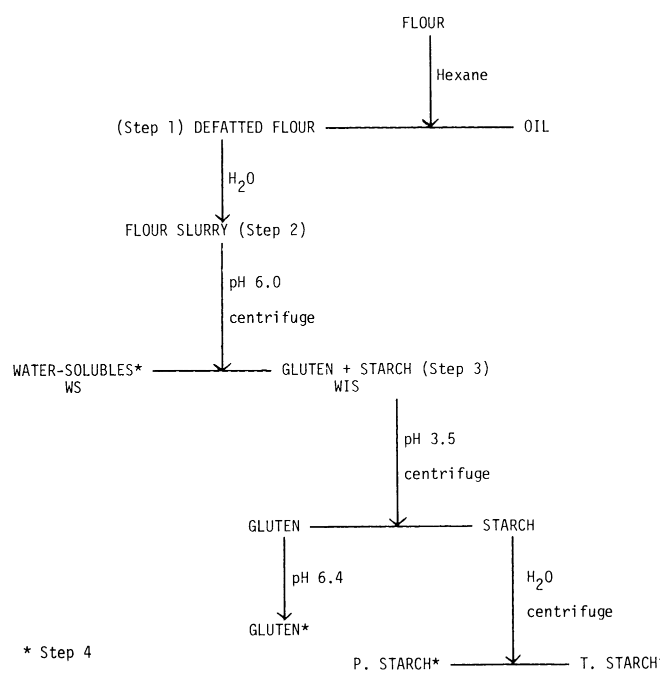

Fig. 1. Cake flour fractionation scheme.

Reconstitution Procedures

The ground, dry flour fractions were combined in proportion to the quantities isolated from the parent flour and blended in a Stein mill for 30 sec. Lipids were restored to reconstituted flour as previously described. The reconstituted flours were then rehydrated to approximately 12% moisture in a humidified cabinet.

Doughing of Reconstituted and Nonfractionated Flours

When doughing was used, 100 g flour and 53 ml of distilled water were mixed into a dough in a 100-g dough pin-mixer (National Mfg. Co., Lincoln, NE).

RESULTS AND DISCUSSION

Both Cl_2-treated and untreated cake flours were fractionated by a slight modification of Sollars' procedure (Sollars, 1958a). Cakes baked from the reconstituted Cl_2-treated flours were comparable in volume to those obtained with the parent flours, but were inferior in grain (Table II). The reconstituted flours from the untreated flour gave cakes with a somewhat lower volume than the unfractionated flour. When the prime starches from the Cl_2-treated and untreated flours were interchanged, the reconstituted flour containing the Cl_2-treated prime starch gave a cake equal in volume to that obtained from the Cl_2-treated control. The reconstituted flour containing the untreated prime starch gave a cake equal in volume to that from the untreated flour. When the gluten fractions from the Cl_2-treated and untreated flour were interchanged, the reconstituted flour containing the Cl_2-treated gluten gave a cake essentially equal in volume to that from the untreated control flour. The reconstituted flour containing the untreated gluten gave a cake equal in volume to that from the Cl_2-treated flour.

The data clearly indicate that the volume difference observed between cakes baked from Cl_2-treated and untreated flours resulted from differences in the baking properties of prime starches from those flours. These results agree essentially with those reported by Sollars (1958b) and Lamb and Bode (1963).

The grain structure of cakes baked from reconstituted flours was, in general, poor.

Effect of Different Treatments on Baking Properties of Reconstituted Flours

The baking properties of Cl_2-treated reconstituted flour were studied in detail to develop a procedure to restore the baking properties of this flour to those of its unfractionated control. Table III summarizes the treatments used and their effects on baking properties of Cl_2-treated reconstituted flours.

The reconstituted flour obtained by dry blending the flour fractions failed to produce a cake. The reconstituted flour performed somewhat better when the 'flour' obtained from blending the dry fractions was first doughed. Defatting before the flour fractionation procedure, and restoring the lipids to the reconstituted flour, appeared to be as good as doughing the reconstituted flours. However, flour reconstituted by the different procedures produced grainy batters and cakes of lower quality than those of unfractionated flour.

The reduced baking quality of reconstituted Cl_2-treated flour relative to the control flour suggested that certain steps in the flour fractionation procedure may harm the baking properties of flour. To determine which steps in the procedure were harmful to the cake-baking properties, we reconstituted fractions produced at certain steps in the flour fractionation scheme and baked them into cakes.

Slurrying flour in water (step 2, Fig. 1) and recovering the flour by freeze drying the flour-water slurry had no adverse effect on

TABLE I
Yield of Flour Fractions

Material	Yield[a] Cl_2-Treated (g)	Yield[a] Untreated (g)
Original Flour	100	100
Lipids	0.78	0.80
Fractions		
Water-solubles	3.6	3.8
Gluten	6.2	6.4
Tailing starch	11.4	10.4
Prime starch	72.5	73.2
Recovery	94.6	95.1

[a]Based on 14% moisture basis.

TABLE II
Comparison of the Baking Properties of Reconstituted Flours Made from Flour Fractions Isolated from Cl_2-Treated and Untreated Flours (Baking Method I)

Flour	Flour Fraction and Source: Gluten	Prime Starch	Tailing Starch	Water-Soluble	Volume (cc)	Grain
Cl_2-treated	...	...	...	...	550	Fine
Untreated	...	...	...	...	440	Thick/open
Reconstituted[a]	T	T	T	T	541	Thick/open
Reconstituted[a]	U	U	U	U	387	Thick/open
Reconstituted[a]	U	T	U	U	545	Thick/open
Reconstituted[a]	T	U	T	T	442	Thick/open
Reconstituted[a]	U	T	T	T	553	Thick/open
Reconstituted[a]	T	U	U	U	465	Thick/open

[a]Defatting step included in flour fractionation procedure. Before baking, lipid extracted from the Cl_2-treated flour was restored to reconstituted flour. T = Flour fraction from Cl_2-treated flour; U = flour fraction from untreated flour.

TABLE III
Effect of Doughing, Defatting, and Dry Blending of Flour Fraction on the Cake-Baking Properties of Reconstituted Cl_2-Treated Flours (Baking Method I)

Flour	Treatment	Volume (cc)	Grain[a]	Batter
Control	...	540	F/C	Smooth
Reconstituted-A	Reconstituted flour derived from a dry blending of the flour fractions	Failed[b]		Very grainy
Reconstituted-B	Reconstituted flour taken through a doughing step	500	T/O	Grainy
Reconstituted-C	Defatting step used in flour fraction procedure. Reconstituted flour obtained by dry blending the flour fractions	560	T/O	Grainy

[a]F/C = fine/close, T/O = thick/open.
[b]Cake came apart when attempted to remove from the pan.

TABLE IV
Effects on the Baking Properties of Flour and Reconstituted Flours at Steps in the Flour Fractionation Procedure (Baking Method I)

Flour	Step of Flour Fractionation Scheme	Volume (cc)	Grain[a]	Batter
Control	...	540	F/C	Smooth
Flour	Step 2: Slurried in water	555	F/C	Smooth
Reconstituted	Step 3: Separated into water-soluble and water-insoluble fractions.	500	T/O	Grainy
Reconstituted	Step 4: Separated into water-soluble, gluten, and crude starch fractions.	535	T/O	Grainy
Flour	Flour taken through a doughing step.	445	T/O	Grainy

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

baking quality (Table IV). Cakes baked from the freeze-dried flour were of the same quality as those obtained from the control flour. However, when the flour was separated into water-soluble and water-insoluble fractions (step 3) and those fractions recovered by freeze drying, the reconstituted flour gave cakes of poor quality. The cakes obtained from that reconstituted flour had reasonably good volume but poor grain. Thus, it was clear that step 3 was detrimental to cake-baking quality.

Flour treated to step 3 of the fractionation procedure had been subjected to centrifugal force. Gluten development was evident and some flour component had been separated from the other components. The poorer baking quality of the flour after such treatment suggested that the integrity of the flour is essential or gluten development is detrimental to the flour's cake-baking properties. Those conclusions are supported by baking results obtained with flour mixed into a dough. Doughing of flour destroys the integrity of the flour and develops the gluten. Because both reconstituted and doughed flours performed poorly in cake baking, it appears that both failed because the integrity of the flour had been destroyed or the gluten had been developed.

Comparison of Baking Procedures

The primary cake-baking procedure used for most of this work was a lean cake formula using a plastic shortening containing 4.8% mono- and diglycerides and two-stage mixing. The reconstituted flour gave a normal appearing batter during the first stage of mixing; however, a grainy batter formed when the second increment of water was added. The batter did not regain a normal appearance when mixing was resumed, even when mixing was extended for 12 min. The parent flour gave batters that were slightly grainy when the second stage water was added but the batters regained normal appearance when mixing was resumed. It appeared that a cake-baking procedure that did not necessitate interruption of the batter structure, once formed, may be beneficial to baking properties of reconstituted flour. Therefore, a new cake-baking procedure (procedure II) with the lean cake formula but with single-stage mixing and a liquid shortening containing PGMS and stearic acid was used.

TABLE V
Effects of Different Cake-Baking Procedures on the Baking Properties of Reconstituted Flours

Flour	Cake-Baking Procedure	Cl_2-Treated	Volume (cc)	Grain	Batter
Control	I	Yes	550	Fine	Smooth
Control	II	Yes	560	Fine	Smooth
Control	II	No	400	Collapse	Grainy
Reconstituted					
Step 3, without defatting	I	Yes	455	Coarse	Grainy
Step 3, without defatting	II	Yes	580	Coarse	Grainy
Reconstituted-defatted					
Step 3	I	Yes	500	Coarse	Grainy
Step 3	II	Yes	570	Fine	Smooth
Step 3	II	No	375	Collapse	Grainy

Cakes obtained from the Cl_2-treated flour with cake-baking procedures I and II were essentially equal in quality (Table V). Flours reconstituted from fractions of a nondefatted flour and prepared by procedure II gave better quality cakes than those prepared by procedure I (omitting step 1, Fig. 1). The cakes produced by procedure II had excellent volume but poor internal quality. However, cakes produced by procedure II and the reconstituted flour (step 3) but with the defatting step (step 1, Fig. 1) included in the flour fraction scheme were of good overall quality: good grain, volume, and quality approaching that of cakes obtained from the control (Cl_2-treated) flour.

Baking the untreated flour by procedure II (Table V) gave a low volume and collapsed grain both for the control flour and the fractionated and reconstituted flour. Thus, to obtain good volume and grain from a reconstituted flour, not only does the starch fraction need to be from Cl_2-treated flour but a baking procedure that gives a smooth batter may also contribute.

The data indicated that procedure II was more suitable for baking reconstituted flours. Cakes baked from reconstituted flour by procedure II, however, were somewhat softer in texture than those obtained from the control flour and the same procedure. No attempt was made to quantify textural differences between cakes obtained from reconstituted and the control flour. The cakes were firm enough for handling, volume measurement, and grading.

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