A Fractionation and Reconstitution Method for Saltine Cracker Flours[1]

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ABSTRACT

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Five cracker flours and one hard wheat flour were baked into crackers using a laboratory-scale cracker baking procedure. Established fractionation and reconstitution techniques for bread and cookie flours were attempted and modified. In the best procedure, cracker flours were slurried in water and centrifuged, and the centrifugate was remixed prior to being hand washed. The lyophilized fractions were dry-blended, rewetted, and air-dried prior to the final particle size reduction. Four of the resultant reconstituted flours had baking qualities comparable to those of the parent flours. However, the quality of a poor quality flour was greatly improved by this procedure, as evidenced by the stack weight changing from unsatisfactory to excellent. Those results suggest that disaggregation of flour particles during the fractionation procedure was beneficial to cracker production.

The approach of separating flour components and then interchanging them between flours of differing quality to establish the role of each component has been used for bread and cookie flours. It is essential that no changes occur in the functional properties of the flour constituents from the fractionation procedure (Finney 1943, MacRitchie 1980). Therefore, it is necessary that when all the separated fractions are reconstituted into flour of the original composition, the functional baking properties are equal to those of the original flour.

Finney (1943) was the first to successfully develop fractionation and reconstitution procedures for bread flours. Essentially the same technique has been employed by Bechtel and Meisner (1954), Prentice et al (1954), Mattern and Sandstedt (1957), and Shogren et al (1969).

Yamazaki (1950, 1955) applied the methods of Finney (1943) to soft wheat (cookie) flours. He found that changes in the reconstitution procedure were necessary before suitable cookies could be baked from the fractions. The lyophilized fractions were combined to form a dough, which was mixed, dried, ground, and rehydrated to form a reconstituted flour.

Sollars (1956) developed a fractionation method for soft wheat (cookie) that did not depend upon mixing dough and kneading with water. After flour was extracted with water to obtain the water solubles, the residue was extracted with dilute acetic acid to solubilize the protein. The insoluble residue was mechanically separated into tailings and prime starch fractions, and the supernatant was neutralized to recover the gluten.

The objective of this research was to develop a fractionation and reconstitution scheme suitable for cracker flours.

MATERIALS AND METHODS

Ingredients

Four commercial cracker flours provided by Nabisco Brands Inc. (flours 1, 2, 4, and 5, Table I), one soft wheat flour (flour 3, Table I), and one hard wheat flour (flour 6, Table I) that were milled at Kansas State University were used in this study.

Compressed yeast (Anheuser-Busch, St. Louis, MO, or Red Star, Universal Foods, Milwaukee, WI) was aged two to four weeks at 4°C before being used. Minor dry ingredients were supplied by Nabisco Brands, Inc. Hydrogenated vegetable shortening (Crisco, Proctor & Gamble, Cincinnati, OH) was used in the cracker baking.

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Slurry Preparation

Slurries to produce the starter inoculum were prepared by blending flour, water, sucrose, and yeast, according to Doescher and Hoseney (1985).

Absorption Determination

Flour absorption was determined by the mixograph (TMCO-National Mfg, Lincoln, NE) procedure of Rogers and Hoseney (1987).

Cracker Baking

Crackers were baked using a procedure slightly modified from that developed by Pizzinatto and Hoseney (1980) and Doescher and Hoseney (1985). The formula (Table II) was based on 500 g of flour (14% moisture basis). Water content was optimized for each flour (Rogers and Hoseney 1987). All height and weight measurements were made on stacks of 10 crackers.

Fractionation and Reconstitution

A 250-g flour sample was slurried in 600 ml of distilled water (25°C). The slurry was immediately poured into centrifuge tubes, and the flask was rinsed with 150 ml of water. The slurry was centrifuged at $1{,}000 \times g$ for 20 min.

The water solubles were decanted and retained. The centrifugate was transferred to a mixer used for cracker dough and mixed (at 32 rpm) for 5 min. The mixed dough was hand washed with five portions (100 ml each) of fresh water. The spent wash water was passed through a 20-mesh screen (850-μm opening) to retain any small gluten pieces.

The washed gluten was frozen on the wall of a glass jar for lyophilization (shell frozen). The starch was recovered by centrifuging at $1{,}000 \times g$ for 20 min. The decanted water solubles were combined with the retained water solubles, shell frozen, and lyophilized. The starch was slurried with small quantities of water, shell frozen, and lyophilized.

Before reconstitution, the starch and gluten fractions were ground with a Wiley intermediate mill (Arthur A. Thomas Co., Philadelphia, PA) equipped with a 40-mesh (375-μm opening) screen. The water-soluble fraction was reduced in particle size in an Oster blender. Moisture and protein (AACC 1983) were determined on samples of all fractions. Flours were then reconstituted, on a moisture-free basis, to the protein content desired by blending the calculated quantities of each fraction. We assumed that 5% of the total flour was water soluble, and solved simultaneous equations of mass balance and protein content to determine the amount of each fraction to add to yield a reconstituted flour of desired protein content.

TABLE I
Analytical Data for Flours Used for Cracker Baking

Flour Sample	% Protein (14% mb)	% Ash (14% mb)
1	9.56	0.51
2	9.46	0.45
3	9.37	0.45
4	10.08	0.49
5	9.09	0.45
6	9.84	0.36

TABLE II
Cracker Formula

Ingredient	Sponge (%)[a]	Dough (%)[a]
Flour[b]	65.00	35.00
Water	optimum	···
Yeast	0.36	···
Starter (brew)	4.50	···
Salt	···	1.19
Sodium bicarbonate	···	optimum
Shortening	···	7.84

[a] Based on total flour weight.
[b] 14% moisture basis.

Reconstituted flours were mixed sufficiently with 40% water (flour basis) to form a dry, crumbly dough. That dough was placed onto a flat surface and allowed to air-dry to 10–14% moisture, wet basis. This sample was then ground on a Wiley intermediate mill with a 40-mesh (375-μm opening) screen to yield the final reconstituted flour. The flour was placed into a sealed glass jar for a minimum of 48 hr to allow for moisture equilibration prior to being used.

RESULTS AND DISCUSSION

Agglomeration of Lyophilized Flour

In this study, the same flour was used for both sponges and doughs. This strengthens the identification of flour type or fraction controlling the functional performance of the cracker flour and simplifies data interpretation.

At first glance, it would appear that the fractionation techniques established for bread flours could be adapted for use with cracker flours. However, cracker doughs are not developed either during sponge mixing or at dough-up, but rather during sheeting. Wet fractionation techniques, by their very nature, involve some degree of dough development. Therefore, it soon became apparent that one or both of the systems (fractionation or cracker sheeting) had to be modified. We chose to modify the fractionation method, because changing the sheeting procedure would have required large amounts of sample and time.

Initial baking trials with a cracker flour that had simply been slurried and lyophilized, but not fractionated, highlighted a problem with lyophilized flour hydration. The lyophilized flour required substantially greater quantities of water than did the parent flour to give a cohesive dough that could be sheeted. That problem persisted even though the flour had been tempered (exposed to 20°C/85% rh) to bring the moisture to approximately 11%. The crackers resulting from that flour were heavier and had more uneven puffing and cell structure than did crackers baked from the parent flour. Stack heights of the crackers were similar (Table III).

During flour slurrying, the particles expand as they become hydrated. During drying, the particles do not return to their original size or density. In an attempt to reassociate the particles to produce a more dense particle, the lyophilized flour was wetted with a known amount of water and allowed to air-dry before grinding. This procedure is similar to that used by Yamazaki (1950) for reconstituting cookie flours.

Comparison of hydration characteristics of the flours with a mixograph showed that the parent flour at 36% absorption developed to a cohesive dough in approximately 7 min (Fig. 1). The lyophilized flour at 36% absorption did not develop during 20 min of mixing (Fig. 2). The lyophilized flour was rehydrated with 40% water and dried. This agglomerated the flour and produced mixograms that were comparable to the parent flour mixograms. When less than 40% water was used for rewetting, the mixograms

TABLE III
Effect of Wetting and Lyophilizing, Agglomerating, and Grinding Agglomerated Flours on Cracker Baking Performance

Flour	Water (%)	Stack Ht[a] (mm)	Stack Wt[b] (g)	Ht/Wt Ratio
Wetted lyophilized[c]				
Parent	25.0	62.18	27.36	2.28
Lyophilized	28.5	62.72	28.92	2.17
Agglomerated lyophilized[c]				
Parent	25.0	62.58	26.95	2.32
Agglomerated	26.0	62.94	29.70	2.13
Ground agglomerated[d]				
Control	27.0	61.88	31.04	2.00
Wiley mill (40 mesh)	27.0	59.91	29.95	2.00

[a] Stack of 10 crackers. Mean standard deviation = 0.79.
[b] Dry basis. Mean standard deviation = 1.07.
[c] Baked using flour 1; average of two replicates.
[d] Baked using flour 3; average of two replicates.

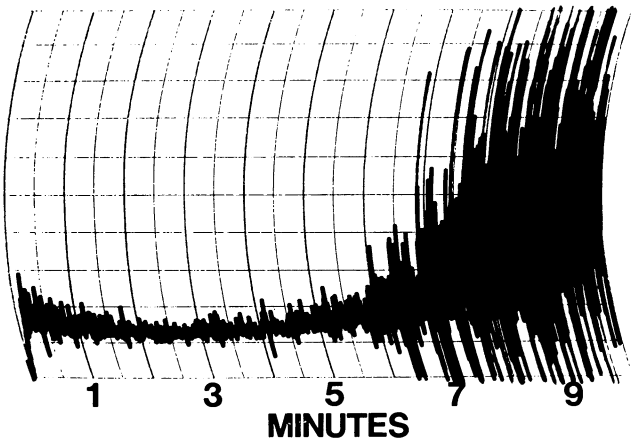

Fig. 1. Mixograph curve produced with the target amount of water (11% higher than the baking absorption).

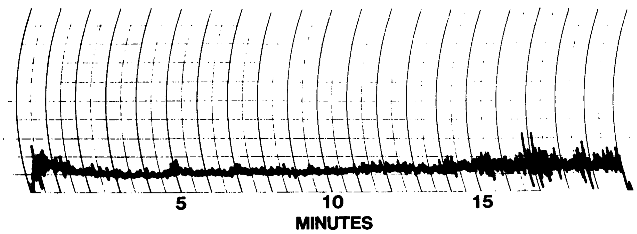

Fig. 2. Mixograph curve of lyophilized flour, using parent flour's target water level.

TABLE IV
Cracker Flours from Modified Reconstitution Method

	% Protein, Dry Basis			% Yield		
Flour	**Gluten**	**Starch**	**Water Solubles**	**Gluten**	**Starch**	**Water Solubles**
Flour 2	82.98	2.21	25.03	9.97	81.39	5.97
Flour 3	81.34	0.72	21.73	9.76	80.69	5.00
Flour 4	74.00	0.56	19.89	...	...	...
Flour 5	66.06	0.45	23.74	...	...	...
Flour A[a]	80.77	0.85	22.78	...	...	...

[a] A 50:50 blend of flours 3 and 6.

TABLE V
Cracker Baking with Modified Reconstitution Method[a]

FLour	Stack Ht[b,c] (mm)	Stack Wt[b,c,d] (g)	Ht/Wt Ratio
Flour 2	57.30 a	30.48 a	1.88
Reconstituted 2	61.00 a	32.93 a	1.85
Flour 3	61.88 a	31.04 a	2.00
Reconstituted 3	60.65 a	29.28 a	2.07
Flour 4	59.72 a	32.37 a	1.84
Reconstituted 4	54.48 b	27.97 b	1.95
Flour A[e]	60.15 a	30.95 a	1.94
Reconstituted A[e]	59.63 a	30.37 a	1.96
Flour 5	58.70 a	29.73 a	1.97
Reconstituted 5	58.10 d	29.42 a	1.97

[a] Minimum of three replicates.
[b] Stack of 10 crackers.
[c] Different letters within flours denote significant differences at the 0.05 level.
[d] Dry basis.
[e] 50:50 blend of flours 3 and 6.

were similar to those of the lyophilized (nonagglomerated) flour, and, thus, were not acceptable.

The agglomerated flours gave cracker doughs that could be sheeted at water absorption levels used for nonfractionated flours. As with the lyophilized flour, the agglomerated flour produced crackers of equal stack height but greater stack weight than did the parent flour (Table III). The layers within the crackers had a rough, gritty appearance. This problem was alleviated by grinding the flour through a Wiley intermediate mill 40-mesh (375-μm opening) screen.

Crackers made from agglomerated lyophilized flour ground through the 40-mesh screen were lower in stack height and stack weight but the same in height-to-weight ratio compared to the controls (Table III). The cracker layers, puffing, and visual characteristics were comparable to those of the control crackers.

Fractionation and Reconstitution

Having successfully lyophilized and agglomerated the flour, the next step was to fractionate the flour prior to lyophilization.

After preliminary trials following the procedures of Finney (1943) and Sollars (1956), we adopted the procedures of Yamazaki (1950) and Shogren et al (1969), in which flour was slurried with water. However, to eliminate the possible effect of enzymes (Moore 1984), we decanted the water solubles immediately after centrifugation and used fresh water to wash the gluten. Initial trials showed that the gluten fraction had a tendency to disaggregate during washing. Therefore, the procedure was modified to include remixing prior to the gluten washing. The mixing time was less than that required to develop the gluten to minimum mobility, but was sufficient to keep the gluten intact during the hand washing.

Five flours were chosen for fractionation and reconstitution experiments (Table IV). Based on cracker stack height, stack weight, and height/weight ratio, the reconstitution procedure gave good results with four of the flours (Table V). The only sample that was significantly different before and after reconstitution was flour 4, a poor quality cracker flour. The parent flour consistently produced crackers with heavy stack weights. The reconstitution procedure materially improved the quality of the flour, as indicated by the improved cracker stack weight and height/weight ratio. The appearance of the cracker produced with the reconstituted flour 4, particularly the evenness of puff, was also improved.

Apparently, flour 4 has poor quality because it remains as large particles. Fisher sub-sieve analysis (Posner and Deyoe 1986) showed that flours 3 and 4 have mean particle sizes of 13.0 and 17.1, respectively. Therefore, flour 4 is not sufficiently modified during the cracker sponge fermentation. When the particles are destroyed during fractionation, the flour protein becomes available to enzymes during cracker sponge fermentation (Wu 1987). The protein then presumably is modified during the sponge fermentation resulting in crackers with reduced stack weights.

CONCLUSIONS

Lyophilized flour particles must be agglomerated for the flour to yield crackers having normal baking characteristics. A fractionation procedure was developed that was excellent for good quality cracker flours. However, a certain poor quality flour was improved during fractionation. This was apparently because of disaggregation of the original dense flour particles. Although this limits the usefulness of the fractionation and reconstitution procedure, it does show an important attribute of cracker flours.

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