The Contribution of High-Protein Fractions from Cake and Cookie Flours to Baking Performance

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ABSTRACT

Reconstituted cake and cookie flours were used to study the contribution of high-protein flour fractions (starch tailings, gluten, and water solubles) to baking performance. Substituting starch for starch tailings or water-soluble fractions resulted in significant losses in volume for reconstituted cake flours; however, exchanging starch for the gluten fraction gave normal baking responses although crumb scores were lower. Significant improvements in baking performance (larger cookies) were obtained for reconstituted cookie flours in which starch was substituted for either the gluten or starch tailings fractions. Hydration data for these treatments indicated that gluten and starch tailings fractions may influence cookie spread because of their hydrophilic properties.

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Interchange studies involving the hexane-extractable lipid fraction from cake and cookie flours and their extracted flour residues show that differences in baking performance among flours are due to components in the extracted flours (Kissell et al 1971, Donelson et al 1984). Extracted flours may be fractionated by aqueous procedures to obtain a large quantity of a low-protein prime starch fraction and lesser quantities of high-protein fractions: gluten, water solubles, and starch tailings. These dried and ground fractions may be reconstituted for baking simply by blending them together in the proper proportions and restoring the free lipid component recovered from the hexane extraction (Yamazaki and Donelson 1976, Gaines and Donelson 1982). In this study reconstitution procedures were used to study the contribution of the high-protein flour fractions to baking performance: specifically, the effects on cookie and cake baking performance as a result of omitting each fraction from reconstituted flours.

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MATERIALS AND METHODS

Flours

The samples were three straight-grade cookie flours and four 50% cake patents (wheat basis) from Miag Multomat millings of soft and hard wheats. The cake flours were pin-milled at 9,000 rpm (Alpine Kolloplex, type 160Z) and chlorinated, pH 4.74–4.83 range (Kissell and Marshall 1972). Aliquots of each were extracted with hexane to recover the free lipid fraction (Clements 1977).

Fractionation and Reconstitution

The hexane-extracted cookie flours were fractionated by an aqueous procedure described previously (Yamazaki et al 1977). The procedure was modified for use with chlorinated cake flours by the addition of sodium carbonate (1:1,000) to the flour before fractionation (Gaines and Donelson 1982).

In the fraction-omission treatments, reconstituted flours were prepared in which prime starch was substituted (g/g) for either the gluten, water-solubles, or starch tailings fractions. Control treatments were fully reconstituted flours. All treatments were duplicated. Protein (N × 5.7) and alkaline water retention capacity were determined in duplicate by methods 46-12 and 56-10 (AACC 1983), respectively.

TABLE I
Yield Data for Flour Fractions

Fraction	Cake Flours SRW-1[a] (%)	HRS[b] (%)	SRW-2 (%)	SRW-3 (%)	Cookie Flours SRW-B (%)	SRW-C (%)	HRW[c] (%)
Prime starch	79.6	72.1	81.9	81.2	73.9	77.2	76.4
Starch tailings	5.7	11.0	6.8	6.7	9.1	12.7	11.1
Gluten	12.6	13.9	8.6	9.3	13.7	7.1	9.8
Water solubles	2.1	3.0	2.7	2.8	3.3	3.0	2.7

[a] SRW = soft red winter.
[b] HRS = hard red spring.
[c] HRW = hard red winter.

TABLE II
Cake Volume, Crumb Score, and Protein Content (N × 5.7) for Reconstituted Flours and Parent Flours

Fraction Omitted	Soft Red Winter-1 Volume[a] (cm^3)	Score (%)	Protein[b] (%)	Hard Red Spring Volume[a] (cm^3)	Score (%)	Protein[b] (%)
None (control)	1,087	76	10.3	986	74	11.5
Starch tailings	1,043**[c]	66	9.8	922**	62	10.7
Water solubles	992**	64	9.6	915**	71	10.8
Gluten	1,088	66	1.4	985	67	1.9
Parent flour	1,101	84	10.6	974	83	11.6

[a] Least significant difference for cake volume = 17.5 cm^3.
[b] Data on 14% mb.
[c] ** Significant at the 1% level of probability.

TABLE III
Cake Volume Data for Reconstituted Flours and Parent Flours Baked by the Procedure of AACC Method 10-90 and the Kissell Lean Formula

Treatment	Soft Red Winter-2 AACC 10-90 Volume (cm^3)	Kissell Volume (cm^3)	Soft Red Winter-3 AACC 10-90 Volume (cm^3)	Kissell Volume (cm^3)
Control	1,081	577	1,065	576
Gluten omitted	1,097	585	1,061	583
Parent flour	1,075	568	1,065	568

Baking Procedures

Two cake formulations and baking procedures were employed: a high-ratio white layer cake procedure using 8-in. layers, method 10-90 (AACC 1983); and, a lean formula procedure using 6-in. layers (Kissell 1959). The formula weights were reduced to 55%, which is sufficient for single layers with each procedure. Cake volumes were determined by rapeseed displacement; crumb scores were evaluated in accordance with method 10-90 (AACC 1983).

Cookies were baked by the procedure of method 10-52 (AACC 1983). Cookie diameters are sums of diameters of two cookies; top grain scores (Fig. 1) indicate the extent of surface breakup, a desired attribute.

RESULTS AND DISCUSSION

Yield data (Table I) show that substituting starch for individual high-protein flour fractions increased starch content of the reconstituted flours by 2–14 percentage points, with the water-solubles treatments having the least and most uniform effect on composition. Mean protein contents (14% mb) are 0.4, 6.6, 67.8, and 20.7% for prime starch, starch tailings, gluten, and water-solubles, respectively.

Reconstituted Cake Flour Studies

Cake baking data from the high-ratio formulation (AACC 10-90) for the complete reconstitution series (Table II) show that substitution of starch for either the starch tailings or water-solubles fraction had a detrimental effect on baking performance, resulting in significant reductions in cake volume as well as lower crumb scores. However, substituting starch for the gluten fraction had essentially no effect on cake volume although crumb scores were lower. Using fractions from nonextracted flours and employing a preliminary dough step with reconstituted flours, Baldi et al (1965) reported substantial reductions in volumes of cakes in which starch was substituted for starch tailings. The differences in yields of the gluten and water-soluble fractions of the cake flours (Table I) and their sharply contrasting effects on baking performance in the starch substitution series indicate the results reflect properties unique to the fractions and are not the result of corresponding increases in starch content.

When starch was substituted for gluten, the protein content of the reconstituted flour was reduced to about 15% that of the control of treatments (Table II). However, the small quantity of flour protein was supplemented by milk and egg protein in the cake formulation. In order to determine if these nonflour protein sources contribute to baking performance, "gluten-free" treatments and control reconstitutions were prepared from fractions from soft red winter (SRW)-2 and SRW-3 flours and baked with the Kissell lean formula, which omits both milk and egg sources of protein. Because the structural components must be supplied by the flour fractions, the Kissell formula may be considered to be a more specific test of cake-baking capability. In addition, companion treatments were baked with the AACC 10-90 formulation.

Cake volume data for this study are presented in Table III. Similar results were obtained with the Kissell lean formula for the control sample and the reconstituted flours in which the gluten fraction was replaced with starch. Bake results for this study with the AACC 10-90 procedure agree with those obtained in the previous experiment (Table II). Within the limitations of the experimental procedures described here and the cake-baking procedures employed, it appears that the gluten fraction, the major source of flour protein, is not essential to layer cake baking performance. Successful baking responses with so little flour protein are not surprising in view of research by Howard et al (1968) and Cauvain and Gough (1975) who employed cake formulations in which starch was substituted entirely for flour.

Reconstituted Cookie Flour Studies

Bake results for the complete reconstitution series of the cookie flours are presented in Table IV. The cookies shown in Figure 1 are typical of these treatments. Baking performance was either unaffected or significantly improved when the high-protein fractions were left out and replaced with starch. Significant increases in cookie spread and improved appearance were obtained in nearly every treatment, with exceptional improvements obtained in the absence of the starch tailings fraction. The latter response no doubt reflects the elimination of the "purified tailings," a hydrophilic component of starch tailings, which has been shown by Yamazaki (1955) and Gilles (1960) to exert deleterious effects on cookie spread. The improved baking performance of the gluten-free reconstitutions indicates that this major source of flour protein is not essential to sugar-snap cookie baking performance, paralleling results obtained for companion treatments with cake flours (Table II). Because the cookie ingredients supply only a small amount of supplemental protein (3% dry milk solids), it appears that very little protein is needed for normal baking performance with this cookie formulation.

TABLE IV

Cookie Diameters (CD), Protein Content (N × 5.7), and Alkaline Water Retention Capacity (AWRC) for Reconstituted Floures and Parent Flours

Fraction Omitted	Soft Red Winter-B			Soft Red Winter-C			Hard Red Winter		
	CD[a] (cm)	Protein[b] (%)	AWRC[b] (%)	CD (cm)	Protein (%)	AWRC (%)	CD (cm)	Protein (%)	AWRC (%)
None (control)	17.7	9.5	67.4	17.4	5.9	70.0	16.2	8.1	83.0
Starch tailings	18.7**[c]	8.9	59.7	18.6**	5.3	58.9	18.1**	7.4	68.8
Water solubles	17.5	8.4	72.2	17.5	5.5	73.9	16.8*	7.0	83.4
Gluten	18.6**	1.4	60.8	17.8*	1.5	64.2	16.7*	1.3	70.9
Parent Flour	17.7	10.1	49.3	17.6	6.5	53.2	16.1	8.7	62.5

[a] Least significant difference for cookie diameter = 0.36 cm.
[b] Data on 14% mb.
[c] *, ** Significant at the 5% and 1% levels of probability, respectively.

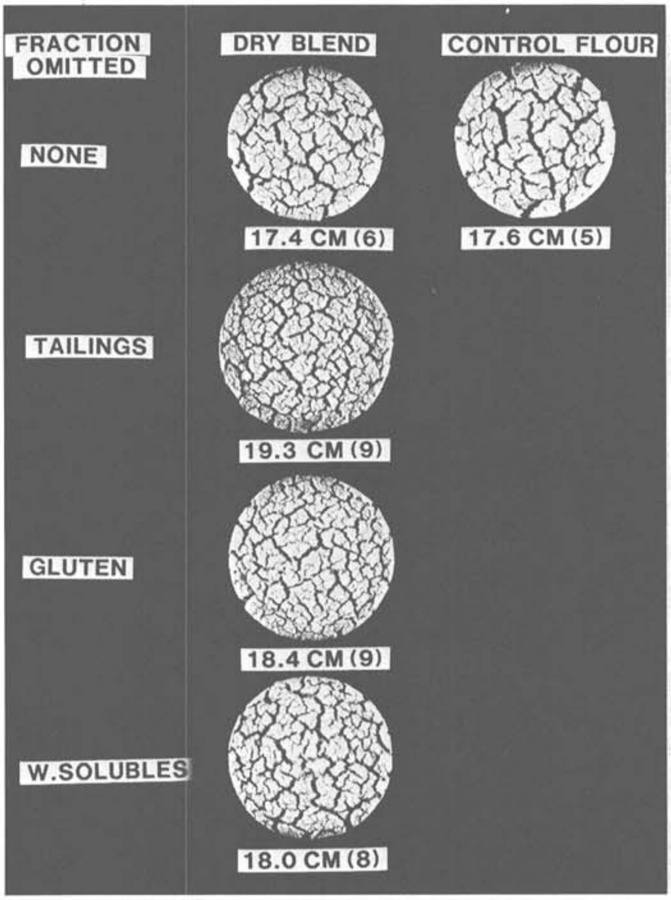

Fig. 1. Cookie diameters (cm) and top grain scores for fraction-omission series.

Omitting the starch tailings or the gluten fraction resulted in significant increases in cookie spread in every case, which suggests a common functionality for them in controlling cookie spread in flours. The hydration properties of these fractions, measured as alkaline water-retention capacity (AWRC), were from 2.5 to 4 times greater than their respective starch fractions. Thus, substituting starch for each of these fractions resulted in substantial reductions in AWRC (Table IV). Treatments with the lowest AWRC produced the largest cookies, in accordance with the negative relationship between AWRC and cookie spread established for cookie flours and reconstituted cookie flours (Yamazaki 1953, Yamazaki et al 1977).

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