Total and Soluble Fiber Content of Air-Classified White Flour from Hard and Soft Wheats[1]

G. S. RANHOTRA,[2] J. A. GELROTH,[2] B. K. GLASER,[2] and E. S. POSNER[3]

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ABSTRACT

None of the flour streams from wheat milling that are combined to produce white (straight-grade) flour contain more total dietary fiber (TDF) or soluble fiber (SF) than white flour itself. However, air classification of white flour obtained from hard and soft wheats revealed that a subfraction, termed *A-fine*, contains nearly twice as much TDF and SF as the original flour. The A-fine subfraction also contained about 150% more protein as well as more fat and ash than the original flour. Bread made with the A-fine subfraction contained 14% fewer calories, 63% more TDF, and 67% more SF than bread made with the original flour.

The water-soluble component of fiber (SF) has been reported to be effective in lowering elevated blood cholesterol levels, a risk factor in heart disease, and in regulating blood sugar levels (Anderson 1986, Anderson and Tietyen-Clark 1986, Kinosian and Eisenberg 1988). The insoluble fiber (IF) fraction appears to be more helpful in various disorders of the intestinal tract.

White flour is a combination of several flour streams produced during the milling of wheat. About half of the total dietary fiber (TDF) of white flour is SF (Ranhotra and Gelroth 1988). Ranhotra et al (1990) attempted to identify a stream with more SF than white flour itself that could be used to add more SF, through resultant food products, to the diet. No such stream could be identified. In the continuation study reported here, we air-classified white flour in an attempt to find a subfraction that could be a more significant source of SF than the original flour.

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[2]Nutrition Research, American Institute of Baking, 1213 Bakers Way, Manhattan, KS 66502.

[3]Department of Grain Science and Industry, Kansas State University, Manhattan 66506.

MATERIALS AND METHODS

Air Classification of Flour

White flour from three varieties each of hard red winter wheat (used mainly for breadmaking) and soft wheat (used mainly as pastry flour) was air-classified with a Hurrican-Turbo separator (Pillsbury Co., Minneapolis, MN) at the milling facilities of

Kansas State University. We varied the feed rate and rotor settings of the separator to obtain four subfractions (A–D), each in both fine and coarse form, for a maximum of eight samples per flour (Table I). To establish a pattern of fiber distribution, all eight samples were analyzed for only one of the flours tested. Where needed, samples were secured in sufficient quantity (about 1 kg) and stored frozen until analyzed.

Breadmaking

The original flour from one of the hard wheats (Wheat-1) and its A-fine subfraction were used to make bread (1-lb or 454-g loaves) by the straight-dough method (fermentation time 1 hr, bake time 16 min at 450°F [232°C]). The following formula was used: original flour or A-fine subfraction, 333 g; salt, 7 g; sugar, 20 g; nonfat dry milk, 7 g; compressed yeast, 10 g; shortening, 10 g; mineral yeast food, 1.6 g; and water and ice, 200 g with the original flour, 290 g with the A-fine subfraction. Breads were cooled for 1 hr, bagged, and scored the next day based on external (volume, symmetry, color, and break and shred) and internal (grain, texture, color, aroma, taste, and mouthfeel) characteristics.

TABLE I
Air Classification Settings and Yields

Classifier Setting (rpm)	Rotor Setting: Angle (Louver)	Rotor Setting: Deck[a]	Feed Rate (lb/hr)	Subfraction	Yield (%)[b]
5,860	10°	6F	100	A-fine	2.5
				A-coarse	97.5
5,860	10°	6B	100	B-fine	21.5
				B-coarse	78.5
3,600	10°	2B	50	C-fine	32.0
				C-coarse	68.0
3,600	35°	2B	25	D-fine	49.5
				D-coarse	50.5

[a] Forward (F) or backward (B).
[b] Based on total flour product (as-is basis).

Analysis

The gravitational and centrifugal sedimentation method was used to perform particle size analysis of the different fractions with equipment designed by Horiba Instruments, Inc. (Irvine, CA). Fiber (IF and SF) was determined by the enzymatic-gravimetric method of Prosky et al (1988). TDF values (Table II) represent the sum of determined IF and SF values. Samples were also analyzed for protein (N × 5.7), fat (ether extraction), and ash by standard methods (AACC 1983). Moisture was determined under vacuum (16 hr, 70°C, ≤ 25 mm Hg). Breads were air-dried and then finely ground for analysis; flour samples were analyzed as is.

Because test flours were air-classified once (no replicates), the data were not evaluated statistically. All samples, however, were analyzed for macrocomponents in triplicate and for fiber in duplicate; the values in Table II are means.

RESULTS AND DISCUSSION

Flours Tested and Fiber Content

Hard wheat-I flour and its fine subfractions were analyzed only for TDF and SF (Table II). Because this initial analysis revealed that the subfraction A-fine contained about twice as much TDF and SF as the original flour, all subfractions from the second hard wheat flour (hard wheat-II) were analyzed for fiber and other macrocomponents. The data again showed that the subfraction A-fine contained about twice as much TDF and SF as the original flour; no other subfraction matched or even approached this magnitude of difference. The analysis further revealed that the subfraction A-fine was rich in protein (150% more protein than the original flour) and contained more fat and ash than the original flour. This subfraction, however, represented a modest 2.5% yield (Table I), which is typical of white flours, and probably consisted of particles that originated near the aleurone layer, as suggested by the ash values. We did not attempt to adjust the air classifier setting to increase the yield of this subfraction.

TABLE II
Fiber and Other Macrocomponents inWhite Flour and Its Subfractions

Wheat Type	Flour or Subfraction	Average Particle Size (μm)	Content (%)[a]: Moisture	Protein (N × 5.7)	Ash	Fat	TDF[b]	SF[b]
Hard wheat-I	Original flour	29	...	...	...	...	2.9	1.5
	A-fine	5	...	...	...	...	5.7	2.8
	C-fine	11	...	...	...	...	3.1	1.4
	D-fine	14	...	...	...	...	2.4	1.2
Hard wheat-II	Original flour	32	12.2	11.8	0.45	1.7	2.6	1.4
	A-fine	5	7.1	30.0	0.92	2.9	5.3	2.6
	A-coarse	31	9.3	11.5	0.46	1.4	2.4	1.2
	B-fine	9	8.7	21.1	0.71	2.0	3.2	1.7
	B-coarse	29	9.9	10.3	0.43	0.2	2.2	1.0
	C-fine	15	10.1	14.0	0.56	0.9	2.8	1.7
	C-coarse	38	10.4	11.1	0.42	0.7	2.6	1.3
	D-fine	19	10.0	12.2	0.51	1.0	2.5	1.2
	D-coarse	39	10.4	11.9	0.41	1.0	2.5	1.1
Hard wheat-III	Original flour	36	11.6	11.5	0.49	1.1	2.3	1.1
	A-fine	4	6.1	30.3	1.13	2.8	4.8	2.8
Soft wheat-I	Original flour	19	11.3	9.4	0.44	1.1	2.7	1.1
	A-fine	4	7.8	27.5	0.61	2.2	3.1	1.4
	A-coarse	17	9.6	7.7	0.42	0.5	2.5	1.2
Soft wheat-II	Original flour	19	12.4	8.0	0.41	1.4	2.2	0.9
	A-fine	4	7.7	27.3	0.71	2.8	3.3	2.0
	A-coarse	20	9.4	6.7	0.41	0.9	2.4	1.2
Soft wheat-III	Original flour	22	13.1	8.2	0.44	0.9	2.0	0.9
	A-fine	4	8.3	24.3	0.71	2.4	3.4	1.8
	A-coarse	18	10.1	6.4	0.40	1.1	2.1	0.8

[a] As-is basis.
[b] Total dietary fiber (TDF) and soluble fiber (SF).

TABLE III
Bread Characteristics and Composition

Bread Characteristics and Composition	Original Flour	A-fine Subfraction
Bread characteristics		
Loaf weight, g	477	468
Volume, cm^3	2,400	2,250
Specific volume, cm^3/g	5.03	4.81
Total score[a]	84	79
Bread composition, %		
Moisture	37.1	43.2
Protein (N $\times$ 5.7)	6.6	15.7
Ash	2.0	1.9
Fat	2.0	1.2
Total dietary fiber (TDF)	2.4	3.9
Soluble fiber	0.9	1.5
Carbohydrates[b]	49.9	34.1
Energy, Kcal/100 g	244	210

[a]Based on external and internal (color, taste, aroma, etc.) characteristics; maximum score, 100.
[b]Other than TDF.

The A-fine subfractions from the three soft wheat flours again contained more TDF than the corresponding original flours, but the differences were not as pronounced as with the hard wheat flours (Table II). In two of the three soft wheat flours, SF showed an impressive increase in the A-fine subfraction compared with the original flour, but the overall amount of SF in these flours was lower than in the hard wheat flours. Thus, it seems that the A-fine subfraction from hard wheat flours would contribute more TDF and SF to a finished product than that from soft wheat flours. The A-fine subfractions from the soft wheat flours again contained substantially more protein than the original flours.

Bread Characteristics

The A-fine subfraction is light and fluffy. Processing modifications, therefore, may be needed to produce quality products using this fraction. Because our supply of A-fine subfraction was limited, only one pound-loaf was baked. Compared to the regular flour, the A-fine subfraction required substantially more water (water absorption 60% vs. 87%) to process the dough. Loaf volume and specific volume of the two products, however, differed minimally (Table III). The A-fine bread contained more moisture, about 2.5 times as much protein, and about two-thirds more TDF and SF than the bread made with the original flour. Because of the higher water and fiber content, the A-fine bread was also lower in calories.

The subfraction A-fine may find applications in many products, especially those that require a high-gluten flour, such as bagels. Future studies are needed to investigate the use of the A-fine subfraction in a variety of baked products.

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