NOTE

High-Fiber White Flour and Its Use in Cookie Products[1]

G. S. RANHOTRA, J. A. GELROTH, and G. J. EISENBRAUN[2]

ABSTRACT

White flour subjected to repeated autoclaving and cooling cycles showed an increase in total dietary fiber more than three times that of bread flours and four times that of pastry flours. The increase was primarily due to the formation of resistant starch. The treated flour was substituted for 75 and 50% of the untreated flour of the formulas for chocolate chip and oatmeal raisin cookies, respectively, before physical and organoleptic characteristics became adversely affected.

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In recent years, various fiber sources have been developed for use in food products to provide more fiber, which is recommended in the diet (Cronin and Shaw 1988). These fiber sources are usually derived from plant material and are considered to provide no energy value. In contrast, starch—a complex carbohydrate-like fiber—is a major source of energy in the diet. Heat processing of starchy foods increases the digestibility of starch (Ring et al 1988) and may further enhance the caloric contribution of starch in the diet. However, certain heat-processing conditions may cause a fraction of the starch to become resistant to human digestive enzymes and thus take on physiological characteristics more typical of fiber than of an energy source. Retrogradation of amylose is believed to lead to the formation of resistant starch (RS) (Berry 1986, Ring et al 1988).

RS in foods may have health benefits. When present in significant amounts, it lowers the caloric density of food products. Also, it is reported to elicit a low glycemic response (Jenkins et al 1982, Ring et al 1988), and because it increases fecal bulk (Ranhotra et al 1991), it could provide protection against colorectal cancer (Englyst and Cummings 1985).

Many bakery products contain up to 3% RS; some breakfast cereals and extruded products contain even more (Englyst and Cummings 1985, Englyst et al 1987). Studies have been conducted (Berry 1986, Björck et al 1987) to identify parameters that favor the formation of RS in isolated wheat starch (and possibly in intact flours as well) and thus permit an increase in the level of fiber in food products where some or all or the regular (untreated) flour can be replaced with treated flour. This flour would also add a more complete complement of nutrients than would treated starch. The studies reported here were undertaken to examine some of these possibilities.

MATERIALS AND METHODS

Preparing High-Fiber Flour

Samples of 10 (five bread and five pastry) flours were mixed with distilled water (1:5, w/w), autoclaved (128°C, 15 psi) for 1 hr on each of five successive days, freeze-dried, and finely ground to pass through a 40-mesh sieve. After each 1-hr autoclaving step, samples were stored at 4°C for 24 hr. This treatment resulted in a substantial increase in the content of total dietary fiber (TDF) in these flours (Table I), apparently because of the formation of RS (Ranhotra et al 1991). One pastry flour was then processed to obtain bulk quantities for use in test products.

Test Products

Two cookie products—chocolate chip and oatmeal raisin cookies—were tested using the formula in Table II. Various dough-processing parameters, e.g., mixing and baking times, did not vary between the two products. The regular flour in the products was replaced with treated flour at levels of 0% (cookies A and AA), 50% (cookies B and BB), 75% (cookies C and CC), or 100% (cookies D and DD). Because of the near doubling of the water-absorption capacity of the treated flour (determined by farinograph measurements), cookie doughs containing treated flour required additional water (Table II).

Product Characteristics

Cookies were evaluated for physical, organoleptic, and nutritional characteristics (Tables III and IV). Width and thickness were measured according to AACC methods (AACC 1983); taste and texture were evaluated by a trained panel of five bakery technologists.

Analysis

TDF, insoluble fiber (IF), and soluble fiber (SF) in flour samples and resulting cookie products were measured by the enzymatic-gravimetric method of Prosky et al (1988). Cookies were also analyzed for protein (N × 5.7), fat (using ether extraction), moisture, and ash using standard AACC methods (AACC 1983). Carbohydrate and energy values were determined by calculation.

TABLE I
Fiber in Flours and Percent Increase During Processing[a]

Flour Sample	Untreated Flour IF (%)	Untreated Flour SF (%)	Untreated Flour TDF (%)	Treated Flour IF (%)	Treated Flour SF (%)	Treated Flour TDF (%)	Percent Increase in TDF
Bread							
1	1.37	1.40	2.77	9.76	1.83	11.59	318
2	1.36	1.30	2.66	10.08	1.70	11.78	343
3	1.28	1.57	2.85	8.27	2.29	10.56	271
4	1.39	1.42	2.81	8.45	2.23	10.68	280
5	1.26	1.32	2.58	9.64	1.85	11.49	345
Average	1.33 ±0.06	1.40 ±0.11	2.73 ±0.11	9.24 ±0.82	1.98 ±0.26	11.22 ±0.56	311 ±35
Pastry							
1	1.35	1.23	2.58	9.84	1.60	11.44	343
2[b]	1.28	1.10	2.38	12.01	1.49	13.50	467
3	1.20	1.07	2.27	12.32	1.12	13.44	492
4	1.32	1.21	2.53	8.74	1.76	10.50	315
5	1.35	1.09	2.44	11.55	1.41	12.96	431
Average	1.30 ±0.06	1.14 ±0.07	2.44 ±0.12	10.89 ±1.54	1.48 ±0.24	12.37 ±1.34	410 ±77
Overall average	1.32 ±0.06	1.27 ±0.16	2.59 ±0.19	10.07 ±1.45	1.73 ±0.36	11.79 ±1.14	361 ±77

[a]Insoluble fiber (IF) and soluble fiber (SF) were measured; total dietary fiber (TDF) reporesents the sum of IF and SF.
[b]Flour used in cookie products.

[1]Presented at the AACC 75th Annual Meeting, Dallas, TX, October 1990.
[2]American Institute of Baking, 1213 Bakers Way, Manhattan, KS 66502.

RESULTS AND DISCUSSION

Fiber in Treated Flour

The untreated bread and pastry flours used in these studies averaged 2.73 and 2.44% of TDF, respectively (Table I). These values closely match values reported earlier (Ranhotra and Gelroth 1988a,b). IF and SF each made up about half of the TDF in both flours. The treated bread and pastry flours contained over three and four times more TDF, respectively, than did the untreated flour. The treatment procedure was the same as that used earlier for isolated wheat starch (Ranhotra et al 1991).

The increase in TDF after processing was primarily in the IF fraction (Table I) and likely represented the formation of RS, as was the case with isolated wheat starch (Ranhotra et al 1991).

TABLE II
Formulas and Procedure Used in Two Cookie Products Tested

	Amount (g)							
	Chocolate Chip Cookies				Oatmeal Raisin Cookies			
	A	B	C	D	AA	BB	CC	DD
Ingredients								
Section 1[a]								
Margarine, sugar, salt	372	372	372	372	485	485	485	485
High fructose corn syrup	···	···	···	···	25	25	25	25
Section 2[b]								
Liquid eggs and vanilla	54	54	54	54	92	92	92	92
Water	···	60	80	100	···	40	60	80
Cinnamon	···	···	···	···	2	2	2	2
Section 3								
Flour (untreated)	250	125	62	···	250	125	62	···
Flour (treated)	···	125	188	250	···	125	188	250
Baking soda	2	2	2	2	3	3	3	3
Baking powder	···	···	···	···	4	4	4	4
Section 4								
Chocolate chips	100	100	100	100	···	···	···	···
Quick oats	···	···	···	···	188	188	188	188
Raisins	···	···	···	···	200	200	200	200

Procedure
Cream all ingredients in section 1 for 2 min at second speed (in a Hobart A-120 mixer); add ingredients in section 2 and mix for 2 min at second speed; add ingredients in section 3 and mix for 2 min at first speed; add the ingredients in section 4 and mix at first speed until incorporated well. Deposit dough (30-g piece) on double sheet pans using a No. 40 scoop; flatten evenly by pressing a sheet pan on top of deposited doughs (same height) and bake at 380°F for 12 min.

[a]Margarine, 170 g; brown sugar, 100 g; granulated sugar, 100 g; and salt, 2 g (chocolate chop cookies). Margarine, 233 g; brown sugar, 125 g; granulated sugar 125 g; and salt, 2 g (oatmeal cookies).
[b]Liquid whole eggs 50 g (88 g for oatmeal cookies); and vanilla, 4 g.

TABLE III
Characteristics of Two Cookie Products Tested With and Without Treated Flour

	Chocolate Chip Cookies				Oatmeal Raisin Cookies			
	A	B	C	D	AA	BB	CC	DD
Treated flour (%)[a]	0	50	75	100	0	50	75	100
Characteristic								
Width (mm)	77.0	79.0	75.0	66.2	78.0	68.2	58.3	57.7
Thickness (mm)	13.0	11.8	12.8	14.7	12.5	15.5	18.0	18.9
Spread (ratio)[b]	5.9	6.7	5.9	4.5	6.2	4.4	3.8	3.1
Taste[c]	7.9	6.4	6.3	5.0	8.2	7.2	6.9	5.8
Texture[c]	7.9	6.6	7.0	6.1	8.4	6.8	6.7	5.6

[a]Percent substitution for the regular (untreated) flour.
[b]Width to thickness.
[c]Based on a scale of 0 (poor) to 10 (best); 6 or above is acceptable.

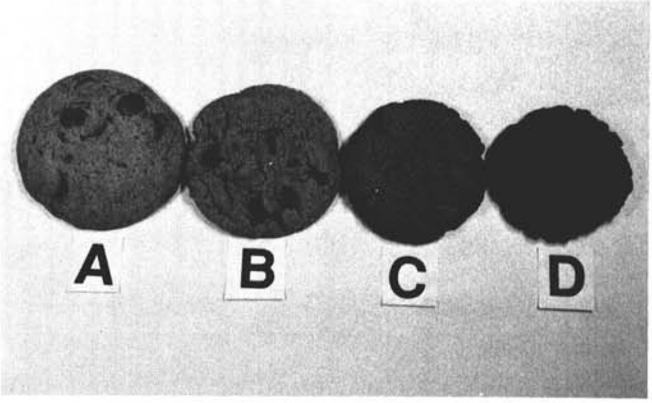
Cookie Products and Characteristics

Bread and other leavened products are difficult to make with treated flour because of the loss of gluten functionality. However, this functionality is less critical in many other bakery products, e.g., cookies and crackers. Thus, two cookie products were made to replace untreated with treated flour, using a replacement range of 0–100%. Cookie width, thickness, and spread were little affected in chocolate chip cookies up to a replacement level of 75% (Fig. 1, Table III). However, complete replacement of untreated flour with treated flour (cookie D) adversely affected these parameters as well as organoleptic characteristics (taste and texture). At the 75% replacement level (cookie C), the panel liked the cookies nearly as well as they liked the control product (cookie A). Replacement could be achieved only up to the 50% level for the oatmeal raisin cookies (cookie BB) before the product quality became unacceptable; this unacceptability was based more on organoleptic characteristics than on physical measurements of the product.

TABLE IV
Nutritional Composition (%) of Two Cookie Products Tested[a]

	Chocolate Chip Cookies				Oatmeal Raisin Cookies			
Component	A	B	C	D	AA	BB	CC	DD
Total dietary fiber	1.5	2.8	3.5	4.3	2.7	3.9	4.4	4.8
Soluble fiber	0.6	0.5	0.5	0.5	0.9	0.9	1.0	1.0
Insoluble fiber	0.9	2.3	3.0	3.8	1.8	3.0	3.4	3.8
Protein (N × 5.7)	4.7	3.7	3.5	3.4	5.8	6.1	5.8	5.5
Ether extract	23.4	17.2	17.5	17.7	17.9	19.1	18.8	18.4
Moisture	3.8	5.1	5.9	6.0	7.3	8.0	10.5	10.9
Ash	1.4	1.2	1.1	1.5	2.0	2.0	1.7	1.9
Carbohydrates	65.2	70.0	68.5	67.1	64.3	60.9	58.8	58.5
Energy content (kcal/100 g)	490	450	446	441	442	440	428	422

[a]As-consumed basis.



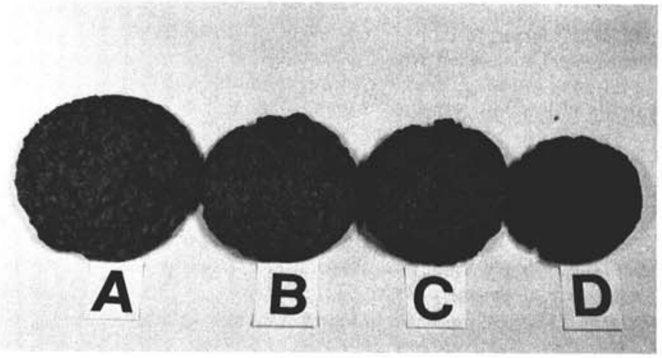


Fig. 1. Chocolate chip cookies (top) and oatmeal raisin cookies (bottom) with untreated flour replaced by treated flour at levels of 0% (A), 50% (B), 75% (C), and 100% (D). (In text and tables, oatmeal cookies A–D are referred to as AA–DD.)

Nutrient Profile of Cookies

The formula variations in each of the two cookie products tested were primarily due to the replacement of the untreated flour with treated flour (Table II). As such, fiber was the major component that varied in the products (Table IV). The TDF content in chocolate chip cookies increased from 1.5% at the 0% replacement level (cookie A) to 3.5% (cookie C) at the 75% flour replacement level (the level consistent with product quality). In the oatmeal raisin cookies, the maximum desirable flour replacement level was 50%, with a consequent increase in the TDF content from 2.7% (cookie AA) to 3.9% (cookie BB). The increase in TDF was solely due to the IF fraction represented as RS. Since the water added to the cookies (Table II) could not all be baked off, the moisture content of the test products increased with the level of treated flour used in the formula. Because of the differences in the TDF and moisture contents, the energy value of the cookie products decreased as more of the treated flour was used in the formula.

Further research with other types of cookie products may allow for total substitution of untreated with treated flour. Under these circumstances, the TDF content would increase significantly, accompanied by some decrease in the energy content of the products as well.

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