Incorporation of Corn Fiber into Sugar Snap Cookies

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ABSTRACT

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Sugar snap cookies with added corn fiber (extruded and nonextruded) were compared with a control. Extruded corn fiber was substituted for flour (15%, w/w) in the first treatment, and nonextruded corn fiber (15%) was substituted for flour in the second. The third group, or control, contained no added fiber. The moisture content of the cookies differed significantly depending upon the fiber composition ($P < 0.05$). The cookies prepared without added fiber had the greatest moisture content, followed by cookies with extruded fiber, and finally cookies with nonextruded fiber. Shear values for the cookies containing nonextruded fiber were significantly lower than for cookies formulated with extruded fiber or the control ($P < 0.05$). The addition of either fiber type imparted a darker color to the product. Sensory analysis indicated no significant differences between the nonextruded and extruded fiber cookies, but significant differences in sensory scores were found between cookies containing nonextruded fiber and controls and between cookies containing extruded fiber and controls ($P < 0.05$). In each case the control cookies without added fiber were preferred.

With the increased emphasis placed on the requirement for fiber in the diet, there has been greater interest in successfully incorporating fiber into food products. The incorporation of fiber from various sources into cakes was investigated by Brockmole and Zabik (1976), as was the incorporation of fiber into cookies (Vratanina and Zabik 1978, Gorczyca and Zabik 1979). Fiber incorporation into bread has been more successful, commercially, than incorporation into other food products, although modification of both the formulation and the processing procedures was needed (Dubois 1978). In addition, high-fiber ready-to-eat breakfast cereals, many of which are extruded, have been successfully produced for years (Mongeau and Brassard 1982, Linko et al 1981).

Extrusion has been considered as an approach to modify the functional characteristics of fiber to increase the level of incorporation into food (Fulger and Bradbury 1985). The poor functionality of fiber and the deleterious effects that fiber may have on the functional properties of other food components are two of the problems encountered when formulating high-fiber products (Ellis 1985). Hence, the objectives of this study were to determine whether fiber (corn bran) could be incorporated at moderate levels into sugar snap cookies without a significant detrimental effect on product quality and to determine the effect of extrusion on fiber incorporation into sugar snap cookies.

MATERIALS AND METHODS

Materials

Corn fiber (corn bran containing 4.5% moisture, 8.5% protein, 4.1% free sugars, 10.4% starch, 16.6% cellulose, 55.7% hemicellulose, 1% lignin, and 1% ash) was used as the fiber source (Lauhoff Grain Company, Danville, IL) (Artz et al 1990). Gold Medal all-purpose flour (General Mills, Minneapolis, MN) was purchased locally. All other chemicals were reagent grade.

Extrusion

Corn fiber was extruded in a Werner & Pfleiderer twin-screw extruder model ZSK-30 (Ramsey, NJ). The dry feed was metered into the dry feed hopper of the extruder with a K-tron T-35 volumetric feeder and a series 6300 controller (K-tron Corp., Glassboro, NJ) at a dry feed rate of 200 g/min. This extruder utilizes two corotating and intermeshing screws. The screw configuration is presented in Table I. The barrel temperatures in the last three sections were set at 150°C, whereas the first two sections were set at 40 and 90°C, respectively. Sodium phosphate buffer (1%, w/v, pH 11) was pumped (Masterflex variable speed metering pump, model no. 7520-20, Cole Farmer Instrument Co., Chicago, IL) into the first section to provide a moisture content of 50% on a dry weight basis. Previous investigations showed (Artz et al 1990) that the greatest extrusion modification within the range of parameters evaluated (90-150°C and pH 3-11) occurs at 150°C and pH 11 and thus, these conditions were selected for fiber modification. The screw speed was 200 rpm. A dual orifice die (9 mm i.d.) was used.

The extrudate was dried at 66°C in a forced-air convection oven for 24 hr. The dried extrudate was coarsely ground in a Burr mill (Bauer Brothers, Springfield, OH), finely ground in a hammer mill pulverizer (Webber Brothers, Chicago, IL) and sifted through a 2-mm sieve. The mill was allowed to cool to room temperature between samples. Each sample of dried, ground extrudate was stored in an air-tight glass jar at room temperature.

Cookie Preparation

Sugar snap cookies were prepared following the Micro Method III described by Finney et al (1950). The dough was rolled to a thickness of 7 mm and cut to a diameter of 7 cm. After baking, the cookies were cooled for 30 min on a wire rack, then stored

TABLE I
Screw Configuration

Section No.	Screw Element Type (X/Z)[a]	No. of Screw Elements
1	S[b]/10	1
	20/10	1
	42/21	5
	42/42	3
	28/28	2
2	28/28	10
3	28/28	2
	20/20	5
4	20/20	6
	KB/45°/5/28[c]	2
5	20/20	5
	KB/45°5/14[c]	2
	20/20	4
	14/14	1
	20/20	1

[a] X/Z: X = distance (mm) to make a complete revolution; Z = length of screw element (mm). Total length = 1,161 mm.
[b] S indicates the initial or starting element.
[c] KB/A°/Y/Z: KB = kneading block; A° = angle of flight; Y = number of discs; Z = length of screw elements (mm).

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frozen at −29°C until sensory analysis. Frozen storage did not exceed 10 days. The cookies were transferred to cold storage (3°C) the day before sensory evaluation, and then allowed to warm to room temperature the day of the taste panel analysis.

Analyses

All samples were analyzed in triplicate. Moisture content was determined by drying the ground samples in a vacuum oven at 70°C for 24 hr and was calculated on a dry weight basis. Cookie diameter was measured and reported according to the method of Finney et al (1950).

The shear force was determined with a FTC texture testing system, model T-2100-C, equipped with a standard shear compression cell model CS-1 (Food Technology Corp., Rockville, MD). To determine the shear force, one half of a single cookie was weighed and placed in the cell for measurement. Results were expressed as newtons of force needed to shear 1 g of sample.

Color comparisons were made with a Hunter color difference meter (Hunter Lab model D25 A-9 Tristimulus colorimeter, Reston, VA). The samples were placed, whole, in a petri dish, and the Hunter color values were measured. Three samples were analyzed for each treatment, and each sample was analyzed in triplicate.

The triangle test with untrained taste panelists (18) was used to detect differences between samples and to determine preferences (Larmond 1977). If a difference was discerned, the preference for either the odd or paired sample for each set of samples was indicated by the panelist.

RESULTS AND DISCUSSION

Three cookie batches were processed: 1) 15%, w/w, extruded fiber, 2) 15%, w/w, nonextruded fiber, and 3) a control without added fiber. A significant difference in cookie moisture was found among all samples (Table II). Both cookies containing fiber were less moist than the control. Extrusion of the fiber resulted in a cookie containing less moisture than the cookie containing nonextruded fiber. Previous investigations (Artz et al 1990) indicated that extrusion does not significantly modify the fiber, either in terms of increased solubility or decreased crystallinity as indicated by any changes in the X-ray diffraction profiles. Evidently, extrusion does not result in a substantial change in fiber components on a molecular level. A slight increase in particle porosity as a result of extrusion-induced changes may explain the higher moisture content of the cookie. Extrusion may also enhance interactions between the particle surface and cookie macromolecular components such as starch and protein, which may increase the cookie's resistance to shear.

Unlike the results reported here, Vratanina and Zabik (1978) found an increase in the moisture content after baking with an addition of 20% bran. Jeltema et al (1983) compared cookies with various added fiber types, including corn, wheat, navy bean, oat, and soy. They also found an increase in moisture in the fiber-containing cookies compared with the control. This apparent contradiction was probably due to the fact that both Jeltema et al (1983) and Vratanina and Zabik (1978) added over 1.5 times as much moisture to the cookie doughs with added fiber as was added to the cookie dough without added fiber. No significant difference in shear force was found between the control and the cookies containing extruded fiber (Table III). The cookies with the lowest shear force values also had the lowest moisture, which suggests that low moisture content might increase cookie brittleness. Vratanina and Zabik (1978) produced cookies with reduced shear values and breaking strength as a result of wheat bran addition. They found that with the addition of 20% or more of either white or red wheat bran fiber to the cookies, a significant decrease in the shear values occurred, similar to the results reported for the nonextruded corn bran sample.

Addition of 15% corn fiber did not significantly affect the cookie spread (Table II). Chen et al (1988) did not find a significant difference in cookie spread between the control and cookies containing either 4, 8, and 12% oat bran or 4 and 8% wheat bran. The cookies containing either 4, 8, or 12% apple pomace had significantly smaller diameters than the control. Jeltema et al (1983) evaluated the effect of five bran types on cookie diameter and found a significant reduction with addition of 20% of either corn, oat, wheat, or soy fiber, but not with 20% navy bean bran. It may be possible that that unless the added fiber has swollen due to moisture absorption, there is no effect on cookie diameter (perhaps due to an increase in the dough viscosity). The fact that both apple pomace (Chen et al 1988) and added moisture (Jeltema et al 1983) reduce cookie diameter suggests this possibility.

The control samples were slightly lighter in color than either cookie sample containing added fiber (Table III) ($P < 0.05$). The intensity of the brown color was greater in the samples containing fiber, which was indicated by the lower L color value. The differences in the a and b values are probably due to increased browning, rather than a change of green to red or blue to yellow, because a and b are functions of L. The nonextruded fiber imparted the darkest brown color to the cookies. Jeltema et al (1983) found that the addition of 20% corn fiber to sugar snap cookies darkened the color.

Panelists were able to discern whether or not the cookies contained fiber (Table IV). However, they were unable to discern differences between the cookies based on fiber type. Panelists indicated a preference for the control over either of the fiber-containing cookies. Although significant differences were found in the moisture content and shear force values between the two fiber-containing cookie samples, these differences did not affect sensory scores.

CONCLUSIONS

The results suggest that corn fiber can be incorporated into sugar snap cookies at moderate concentrations and that extrusion

TABLE II
Selected Physical Characteristics of Sugar Snap Cookies

Cookie Sample	Moisture (%)	Shear Force[b] (N/g)	Cookie Wt[c] (g)	Cookie Diameter (cm)
15% extruded fiber	6.21 b	217 a	11.2 ± 0.5	6.95 a
15% nonextruded fiber	5.77 c	144 b	9.7 ± 1.5	6.99 a
Nonfiber control	6.50 a	207 a	12.3 ± 1.2	7.06 a

[a] Samples followed by different letters are statistically different ($P < 0.05$).
[b] Newtons per gram.
[c] Average weight ± standard deviation for the samples used for shear force analysis.

TABLE III
Tristimulus Color Values of Sugar Snap Cookies

Cookie Sample	Hunter Color Values[a,b] L	a	b
Extruded	62.1 b	0.3	15.4
Nonextruded	61.3 b	0.8	16.9
Nonfiber control	64.1 a	−0.9	13.1

[a] L = lightness values, 100 = white, 0 = black; $+a$ = red, $-a$ = green; $+b$ = yellow, $-b$ = blue.
[b] Samples followed by different letters are statistically different ($P < 0.05$).

TABLE IV
Summary of Triangular Taste Test Responses for Three Sugar Snap Cookies

Treatment ($n = 18$)	Response: Correct	Response: Incorrect	Significance Level ($P < 0.05$)
Extruded vs. nonextruded	7	11	no
Control vs. extruded	12	6	yes
Control vs. nonextruded	10	8	yes

of the fiber added to the cookie produced a product with a residual moisture content, color, and hardness based on shear force closer to that of the control. However, results indicate that taste panelists could still detect differences, and a preference for the control was suggested by the limited population studied. This indicates that a 15% incorporation level for both extruded and nonextruded corn is too much. The potential for altering fiber functionality by extrusion to facilitate fiber incorporation at lower levels should be explored to achieve a product similar to that of the control.

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