Effects of Heat Treatment and Level of Navy Bean Hulls in Sugar-Snap Cookies[1]

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ABSTRACT

The effects of levels of navy bean hull incorporation and of navy bean heat treatment on the physical and sensory qualities of sugar-snap cookies were investigated. Levels of 0–30% substitution of navy bean hulls were substituted for flour. The hulls were either not roasted or subjected to one of two roasting temperatures: 160 or 240° C. The major differences attributed to roasting were cookie color, moisture, and flavor. Flavor and physical characteristics, including top grain and spread, were adversely affected as the level of substitution increased. Approximately 0.2, 0.7, 1.2, and 1.7 g of dietary fiber was available per cookie with 0, 10, 20, and 30% navy bean hull substitution, respectively.

Epidemiological evidence linking low-fiber diets to noninfectious diseases such as colonic cancer and diverticular disease (Burkitt 1971) has prompted numerous studies utilizing various types and sources of dietary fiber in food products. Cereal brans have been successfully incorporated into baked products such as breads, cakes, and cookies as a means of increasing fiber consumption. Shafer and Zabik (1978) evaluated cakes containing 30% wheat, corn, soy, or oat bran and found that substitution with soy and oat bran resulted in cakes with poor flavor; however, cakes containing wheat and corn bran were acceptable. Vratanina and Zabik (1978) concluded that sugar-snap cookies could be prepared with as much as 20% of the flour substituted with wheat bran before flavor was adversely affected. Rajchel et al (1975) reported that wheat bran could also be successfully incorporated into flavored cakes without affecting the quality of the products.

Although various investigations have been made into the use of cereal brans as dietary fiber sources, little has been reported on the utilization of noncereal dietary fiber sources. Collins and Post (1981) found peanut hull flour to have potential use as a dietary fiber.

Navy beans were separated into three fractions, hulls and high-starch and high-protein fractions, which can be used as food ingredients (Aguilera et al 1982). The purpose of our study was twofold. Milled navy bean hulls, reported to contain 31–50% enzyme neutral detergent fiber by Aguilera et al (1982), were evaluated as a potential source of dietary fiber in sugar-snap cookies by incorporation at levels of 0, 10, 20, and 30%. Additionally, the beans were subjected to three roasting

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temperatures (none, 160, and 240°C) before dehulling and milling to determine the effect of heat on hull functionality.

MATERIALS AND METHODS

Navy Bean Hull Flour

Texas A&M University supplied the milled navy bean hulls used in this study. Navy beans were subjected to two roasting temperatures, 160 or 240°C, for 2 min in a particle-to-particle heat exchanger before dehulling by aspiration (Aguilera et al 1982). The product temperatures at the end of the roasting were 100 and 125°C, respectively. Milled navy bean hulls were also provided from beans receiving no heat treatment. Preliminary baking results using four replications indicated that particle size significantly affected various physical and sensory cookie characteristics;[4] therefore, all hulls were milled to a uniform particle size of approximately 150 μ, using a Udy Cyclone Sample Mill, model MS.

Cookie Preparation

Sugar-snap cookies were prepared by the micro III method of Finney et al (1950) as modified by Vratanina and Zabik (1978). Vanilla (4 ml) was added to improve flavor. Both the control and the 10%-navy bean hull formulas contained 2 ml of deionized water per 115 g of flour or flour-navy bean bran, whereas water levels were increased to 4 and 8 ml for hull levels of 20 and 30%, respectively.

The remaining ingredients were obtained in common lots from the Michigan State University Food Stores. Four replications of each variable were prepared, and their baking order was randomized before the beginning of the experiment. Humidities were recorded daily before baking using a Weathermeasure Meteorgraph, model M3701-E. No baking or evaluations of the cookies were conducted if the relative humidity was 60%.

After baking, cookies were cooled and stored in zip-type polyethylene bags at −24°C until needed for subsequent evaluation.

Objective Measurements

Top grain, spread, color (Hunter color difference meter), breaking strength (Allo Kramer shear press), and shear compression (Allo Kramer shear press) of cookies were determined as outlined by Vratanina and Zabik (1978). Moisture contents were determined in both cookie dough and baked cookies using AACC procedure 44-40 (AACC 1962).

[4] C. DeFouw and M. E. Zabik. Unpublished data.

TABLE I
Objective Measures[a] of Sugar-Snap Cookies with 10, 20, and 30% Navy Bean Hulls Substituted for Flour

Treatment (%)	Physical Characteristics				
	Top Grain	Spread Factor (W/T)[b]	Color Values[c] L	$+a_L$	$+b_L$
Control	8.8 ± 0.5 a	12.42 ± 0.25 a	62.2 ± 0.5 a	+5.7 ± 0.2 bcd	+23.9 ± 0.2 a
Raw Hulls					
10	8.3 ± 0.5 ab	11.30 ± 0.29 bc	53.7 ± 1.1 b	+6.1 ± 0.5 bc	+21.4 ± 0.2 b
20	7.5 ± 1.3 abc	10.35 ± 0.31 dc	50.4 ± 0.8 c	+5.5 ± 0.4 bcd	+19.7 ± 0.1 c
30	6.3 ± 1.0 bc	9.71 ± 0.17 ef	49.3 ± 0.4 c	+4.6 ± 0.1 bcd	+18.7 ± 0.2 cd
Moderate Roasting[d]					
10	8.5 ± 0.6 a	11.42 ± 0.32 b	56.0 ± 1.0 b	+2.8 ± 0.9 d	+19.3 ± 0.5 c
20	6.8 ± 0.5 abc	10.61 ± 0.07 cd	50.3 ± 0.9 c	+3.2 ± 0.5 cd	+17.7 ± 0.2 d
30	6.3 ± 1.3 bc	9.35 ± 0.60 f	48.2 ± 0.7 c	+2.8 ± 0.5 d	+16.0 ± 0.4 e
High-Temperature Roasting[e]					
10	8.8 ± 0.5 a	10.76 ± 0.28 bcd	63.4 ± 1.1 a	+9.5 ± 1.5 a	+24.9 ± 0.6 a
20	7.5 ± 0.6 abc	9.60 ± 0.46 ef	61.8 ± 2.5 a	+9.6 ± 2.5 a	+24.3 ± 0.4 a
30	6.0 ± 1.4 c	9.10 ± 0.15 f	61.7 ± 1.9 a	+6.9 ± 2.5 ab	+22.6 ± 1.2 b

[a] Means and standard deviations of means are based on four replications. Means followed by the same letter are not significantly different ($P < 0.05$).
[b] W/T = width/thickness of cookies.
[c] L = lightness; $+a_L$ = redness; $+b_L$ = yellowness.
[d] Moderate roasting was done at 160°C.
[e] High-temperature roasting was done at 240°C.

TABLE II
Objective Measures[a] of Sugar-Snap Cookies with 10, 20, and 30% Navy Bean Hulls Substituted for Flour

Treatment (%)	Physical Characteristics			
	Moisture (%) Raw	Moisture (%) Baked	Breaking Strength (lb/cm^2)	Shear Compression (lb/g)
Control	13.68 ± 0.34 e	3.10 ± 0.24 bc	4.11 ± 0.20 a	20.46 ± 1.98 a
Raw Hulls				
10	14.23 ± 0.37 de	2.96 ± 0.21 c	3.18 ± 0.51 a	16.49 ± 1.34 b
20	15.16 ± 0.33 c	3.24 ± 0.35 bc	2.99 ± 0.16 a	15.07 ± 0.79 b
30	16.38 ± 0.23 b	4.05 ± 0.40 abc	3.05 ± 0.92 a	14.82 ± 0.67 b
Moderate Roasting[b]				
10	15.32 ± 0.09 c	3.56 ± 0.39 bc	3.44 ± 0.62 a	17.02 ± 1.35 b
20	16.25 ± 0.20 b	4.09 ± 0.25 ab	3.42 ± 0.32 a	16.21 ± 0.76 b
30	16.97 ± 0.17 a	4.76 ± 0.52 a	3.70 ± 0.60 a	15.67 ± 2.13 b
High-Temperature Roasting[c]				
10	13.94 ± 0.08 e	2.99 ± 0.21 c	4.62 ± 1.20 a	15.33 ± 1.35 b
20	14.53 ± 0.22 d	2.99 ± 0.69 c	3.81 ± 0.61 a	14.71 ± 0.86 b
30	15.56 ± 0.17 c	3.17 ± 0.82 bc	3.81 ± 1.17 a	15.69 ± 0.61 b

[a] Means and standard deviations of means based on four replications. Means followed by the same letter are not significantly different ($P < 0.05$).
[b] Moderate roasting was done at 160°C.
[c] High-temperature roasting was done at 240°C.

Sensory Measurements

Surface appearance, interior appearance, and eating characteristics were evaluated using a 7-point scale described by Vratanina and Zabik (1978). Because too many variables were involved to permit evaluation of all the cookies from one replication at one time, the trained panel of six members evaluated five cookies chosen by random numbers in individual booths, each lighted with a daylight fluorescent tube, on each panel day. The control cookie was also assigned a random number and evaluated, using the 7-point descriptive scale for each sensory characteristic.

Analyses of Data

The data were analyzed for variance, and Tukey's multiple comparison test was used (Gill 1978) to identify significantly different ($P<0.05$) means. Differences resulting from substitution level and from degree of heat treatment of the hulls were noted.

RESULTS AND DISCUSSION

Spread Factor and Top Grain

Spread factor and top grain (Table I) were affected more by level of hull substitution than by degree of heat treatment of the hull. Whereas only the 30% substitution level differed significantly from the control for top grain scores, all substitution levels differed significantly from the control for spread. Vratanina and Zabik (1978) also reported that increased levels of wheat bran substitution caused similar results and attributed this to competition of the hemicelluloses and pectin in bran for available water within the cookie-dough system.

Color

Color data in Table I show that no significant differences were found in lightness values between the control cookie and cookies containing hulls roasted at 240°C. Cookies made with either the unroasted hulls or with the hulls roasted at 160°C were significantly darker and less yellow than the control or cookies made with the hulls roasted at 240°C. As the percent of hull substitution increased for all treatments, lightness and yellowness values decreased. The low color values associated with cookies prepared with moderately roasted hulls were expected because these hulls were darker and more gray than the other hulls. Cookies prepared with the moderately roasted hulls had a slight gray tinge, which Shafer and Zabik (1978) also reported in cakes prepared with soy hulls.

Moisture

Because of the increased water-holding capacity of the navy bean hull flour, water levels were increased in the cookie formulation to compensate for increasing substitution levels. Table II contains moisture data for both the dough and the baked cookies. Cookies containing moderately roasted (160°C) hulls tended to have higher moisture contents than did cookies prepared with similar levels of unroasted hulls or with hulls roasted at high temperature (240°C); however, these results were not significant.

Breaking Strength and Shear Compression

Although no significant differences were found between the breaking strength required for the control cookie and for cookies containing navy bean hull flour, the incorporation of hull flour significantly affected shear compression (Table II). All cookies that contained navy bean hulls required significantly less force to shear than did the control, and as the level of substitution increased, shear values decreased. As the level of hull incorporation increased, moisture content increased, resulting in loss of characteristic texture and increased softness. Gorczyca and Zabik (1979) also found this to be true for sugar-snap cookies prepared with increasing levels of cellulose.

Sensory Evaluation

Table III summarizes results from sensory evaluations of cookies prepared with increasing levels of navy bean hulls. Of the surface qualities evaluated, color was most significantly affected by hull incorporation. Whereas all levels of unroasted and moderately

TABLE III

Sensory Evaluation[a] of Sugar-Snap Cookies with 10, 20, and 30% with Navy Bean Hulls Substituted for Flour

Treatment (%)	Surface Appearance			Interior Appearance			Eating Characteristics		
	Shape	Color	Characteristics	Distribution of Cells	Size and Shape of Cells	Color	Texture	Mouthfeel	Flavor
Control	6.60 ± 0.08 a	6.55 ± 0.21 a	6.08 ± 0.25 a	6.10 ± 0.42 a	5.95 ± 0.40 a	6.43 ± 0.31 a	6.50 ± 0.18 a	6.63 ± 0.05 a	6.55 ± 0.31 a
Raw Hulls									
10	6.48 ± 0.24 ab	5.48 ± 0.26 bc	5.38 ± 0.47 abc	5.53 ± 0.74 ab	5.30 ± 0.91 ab	4.98 ± 0.35 bcd	6.15 ± 0.44 ab	5.80 ± 0.39 ab	5.03 ± 0.64 b
20	6.10 ± 0.27 ab	4.75 ± 0.21 cd	5.08 ± 0.29 abc	5.25 ± 0.50 ab	5.08 ± 0.74 ab	3.93 ± 0.65 def	5.45 ± 0.26 abc	5.13 ± 0.39 bc	3.28 ± 0.43 cd
30	5.95 ± 0.33 ab	4.25 ± 0.38 de	4.85 ± 0.44 bc	4.53 ± 0.97 ab	4.58 ± 0.81 ab	3.68 ± 0.25 ef	4.90 ± 0.82 c	4.83 ± 0.39 bc	2.60 ± 0.34 cd
Moderate Roasting[b]									
10	6.20 ± 0.36 ab	5.33 ± 0.25 bc	5.20 ± 0.65 abc	5.03 ± 0.67 ab	4.55 ± 0.42 ab	4.20 ± 0.47 cde	5.63 ± 0.30 abc	5.83 ± 0.25 ab	5.10 ± 0.24 b
20	5.85 ± 0.33 ab	3.78 ± 0.21 ef	4.60 ± 0.24 bc	4.45 ± 1.11 b	3.88 ± 1.18 b	3.05 ± 0.69 fg	5.73 ± 0.30 abc	5.00 ± 0.63 bc	2.85 ± 0.62 cd
30	5.78 ± 0.37 b	3.20 ± 0.79 f	4.35 ± 0.33 c	4.03 ± 0.21 b	3.75 ± 0.42 b	2.48 ± 0.24 g	5.25 ± 0.73 bc	4.25 ± 0.64 c	2.20 ± 0.70 d
High-Temperature Roasting[c]									
10	6.03 ± 0.46 ab	6.08 ± 0.22 ab	6.05 ± 0.37 a	5.50 ± 0.71 ab	5.38 ± 0.43 ab	5.65 ± 0.17 ab	5.30 ± 0.35 abc	6.25 ± 0.06 a	5.83 ± 0.50 ab
20	6.08 ± 0.22 ab	5.65 ± 0.49 abc	5.60 ± 0.46 ab	5.48 ± 0.54 a	5.35 ± 0.31 ab	5.23 ± 0.41 bc	5.45 ± 0.58 abc	5.78 ± 0.37 ab	5.15 ± 0.67 b
30	5.68 ± 0.50 b	5.05 ± 0.52 cd	5.08 ± 0.81 abc	5.13 ± 0.35 ab	5.30 ± 0.57 ab	4.65 ± 0.59 bcde	5.63 ± 0.62 abc	5.03 ± 0.59 bc	3.65 ± 0.44 c

[a] Means and standard deviations of means based on four replications. Means followed by the same letter are not significantly different ($P<0.05$). Highest possible score = 7.
[b] Moderate roasting was done at 160°C.
[c] High-temperature roasting was done at 240°C.

roasted hulls were scored significantly lower than the control, only the 30% level of hulls roasted at high temperature was scored significantly lower than the control. Surface characteristics were not significantly different for the control and for cookies having any level of high-temperature hull incorporation; however, the 30% substitution of unroasted hulls and 20 and 30% substitutions of moderately roasted hulls were scored significantly lower than the control.

Taste panelists indicated that the cookies prepared with 20 and 30% levels of moderately roasted hulls were significantly less acceptable than the control for distribution, size, and shape of interior cells. No significant differences existed, however, in cell distribution or shape and size among any of the cookies containing any level or type of hull.

As the level of hull substitutions increased, the interior color became less acceptable. Only the 10% level of hulls roasted at high temperature was not significantly different than the control cookie. Cookies containing hulls roasted at 160°C were scored lowest for color by panelists. This was probably due to the slight gray color imparted by the moderately roasted hulls.

Texture was not significantly affected by less than 30% substitution with unroasted or moderately roasted hulls. Taste panelists indicated no significant differences in texture resulting from degree of hull heat treatment. Mouthfeel was scored as most acceptable in the control and in cookies containing 10% hull substitution. No significant differences were found in mouthfeel resulting from heat treatment of the hulls. The only cookie for which flavor was not significantly less acceptable than the control was that prepared with 10% hulls roasted at high temperature. Aguilera et al (1982) reported that high-temperature roasting successfully inactivated the antinutritional factors and thus would probably also inactivate lipoxygenase. D'Appolonia (1978) reported that taste panels preferred bread with heat-roasted navy bean flour to that with unheated navy bean flour and that roasting the navy beans reduced the lipoxygenase activity by 99%. Cookies containing 20 and 30% hulls roasted at high temperatures were rated significantly higher by taste panel members than similar levels of unroasted or moderately roasted hulls. Panelists described the flavor of cookies containing higher levels of hulls as being beanlike or bitter. Vratanina and Zabik (1978) also reported that, as substitution levels of wheat bran in sugar-snap cookies increased, flavor acceptability decreased.

Using the enzyme neutral detergent values for the navy bean hulls roasted at the high temperature reported by Aguilera and co-workers (1982), the dietary fiber in the cookies containing 10–30% bean hulls was calculated. Approximately 0.7, 1.2, and 1.7 g of dietary fiber are available per cookie prepared with 10, 20, and 30% navy bean hulls, respectively, as reported by Vratanina and Zabik (1978) for similar levels of wheat bran in sugar-snap cookies. The all-wheat control cookie had approximately 0.2 g of dietary fiber; thus, substitution of navy bean hulls for flour substantially increased their contribution to dietary fiber in the diet.

SUMMARY

The major differences attributed to roasting were cookie color, moisture, and flavor. Surface characteristics, such as top grain, spread, and flavor, tended to be affected by level of substitution. Taste panelists preferred cookies prepared with the hulls roasted at high temperature to cookies prepared with either unroasted or moderately roasted hulls. Navy bean hull flour was shown to be an acceptable source of dietary fiber in sugar-snap cookies and compares favorably to wheat bran. Because cookies made with unroasted hulls were rated better overall than those made with moderately roasted hulls, the time and energy required for roasting appear to be nonproductive. Cookies prepared with hulls roasted at the high temperature were rated closest to the control. This indicates that further studies should be undertaken to determine the roasting temperature that provides the best functional characteristics with the least energy expenditure.

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