Sugar-Snap Cookies Prepared with Wheat-Navy Bean-Sesame Seed Flour Blends[1]

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ABSTRACT

Sugar-snap cookies were prepared with 20 and 30% navy bean-sesame seed flours substituted for wheat flour. Navy bean-sesame combinations were: 20:0, 15:5, 10:10, 5:15, 0:20 for 20% substitutions, and 30:0, 20:10, 15:15, 10:20, and 0:20 (w/w) for 30% substitutions. Cookie spread and top grain scores were reduced as the percentage of navy bean and/or sesame flour increased. Cookies with 20 and 30% of sesame flour alone were tough, and more force was needed to compress and break them. The force required to break and shear the cookies decreased with increasing levels of navy bean flour. Cookies containing up to and including 20% navy bean flour were scored above 4 on a 7-point scale by most sensory panelists. Panelists gave low scores to the flavor of cookies containing more than 10% sesame flour. Cookies with 20% substitution had better baking properties and organoleptic characteristics than did those with 30% substitution.

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Cookies usually have a low protein efficiency ratio. Protein-fortified cookies can carry nutrients in concentrated forms and can complement other foods that are low in some essential amino acids and that have low protein efficiency ratios. To improve nutritional value, cookies can be prepared from wheat flours supplemented with nonwheat flours. High-protein cookies would be particularly useful for child-feeding programs, and can be prepared from such composite flours as wheat flour fortified with soy flour , Tsen et al 1973, Tsen 1974), cottonseed (Fogg and Tinklin 1972, Bacigalupo 1969), peanut (Subrahmanyan 1958), or corn germ flour (Blessin et al 1972).

Physical characteristics, organoleptic properties, and nutritional quality of cookies are expected to vary widely with different composite flours and with percentages of additive used. The objective of this study was to investigate the effect of navy bean and sesame flours on chemical composition, baking properties, and organoleptic characteristics of cookies.

MATERIALS AND METHODS

Flour Preparation

Navy beans (*Phaseolus vulgaris*) and dehulled sesame seeds were obtained from food stores at Michigan State University. Bean flour was prepared by the drum dry method (Bakker-Arkema et al 1967). Beans were soaked in water at 98.9° C for 45 min, placed in a wire basket, and retorted in steam at 104.4° C for 30 min. After the beans were macerated by a Malheim Electro-Cut™ vegetable cutter and slicer, they were dried by drum drier. Finally, they were ground by comminuting mill model D, using a .027 screen, and thoroughly mixed to obtain a homogenous product. Sesame seed flour was prepared by extracting the oil with hexane (Boloorforooshan and Markakis 1979). The dehulled seeds were ground into flour by an Osterizer blender in a double volume of commercial hexane. After 5 min of blending, the slurry was filtered under vacuum in a

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Buchner funnel. This extraction was repeated four times. After the last extraction, the flour was left as a thin layer in a ventilated hood for 24 hr at room temperature for complete removal of solvent. This flour was ground in a cyclone mill (Udy Corporation, Boulder, CO) to give a finer and more uniform particle size. A 70% patent cookie flour milled from a soft red winter wheat was obtained from Mennel Mills of Fostoria, OH.

Cookie Formulation

Micro-method III of Finney et al (1950) was further modified to include soy lecithin, based on the recommendations of Kissel and Yamazaki (1975). Six cookies were prepared per bake.

The formula for making sugar-snap cookies is shown in Table I. Four replications of each variable were prepared to be evaluated by both objective and subjective measurements. The variables included control cookies and those which were substituted with both 20 and 30% navy bean and/or sesame flours. For 20% substitution, the ratios of navy bean to sesame were 20:0, 15:5, 10:10, 5:15, and 0:20 (wt basis). In the case of 30% substitution, these ratios were 30:0, 20:10, 15:15, 10:20, and 0:30 (wt basis).

Cookie Evaluation

Grain-surface characteristics. Using a series of cookies from the USDA Soft Wheat Quality Laboratory in Wooster, OH, as a reference standard, the top grain of a selected cookie representing each bake was scored. A compact cookie with no surface breaks was assigned a score of 0, whereas a score of 9 was assigned for a well-broken top containing numerous small "islands" characteristic of an optimal sugar-snap cookie (Finney et al 1950).

Spread factor is the ratio of cookie width to the height for each bake (W/T). Spread factors were calculated according to AACC method 10-50D (AACC 1983).

A Kramer Shear Press equipped with a TR-3 recorder and the standard shear compression cell was used to evaluate tenderness of the cookies. The tenderness value was expressed as pounds of force per gram.

Breaking strength (lb/cm^2) of each cookie was determined using the single blade attachment of the Kramer Shear Press.

Cookies were judged for surface appearance, interior appearance, tenderness, mouthfeel, and flavor by six trained taste panelists. A copy of the scorecard is given in Fig. 1.

Chemical Analyses

Nitrogen was measured according to the AACC (1983) micro-Kjeldahl method 46.13. Protein was calculated as N × 5.7 for wheat flour and N × 6.25 for navy bean and sesame flours. Moisture, ash, and total lipid (acid hydrolysis) were determined according to AAOC methods 14.002, 14.006, and 14.019, respectively (1980).

TABLE I
Formulation of Sugar-Snap Cookies

Ingredients	Percentages of Wheat Flour Substituted with Navy Bean and Sesame		
	0 (control)	20	30
Cream mix (g)[a]	112.8	112.8	112.8
Soy lecithin (g)	2.2956	2.2956	2.2956
Solution A (ml)[b]	12.0	12.0	12.0
Solution B (ml)[c]	9.0	9.0	9.0
Flour (g)	114.78	91.82	80.35
Navy bean and/or sesame flour (g)	...	22.95[d]	34.43[e]
Deionized H_2O (ml)	6	6	6

[a] Cream mix was made up of 594.0 g of sugar, 297.0 g of shortening, 9.9 g of sodium bicarbonate, and 29.7 g of nonfat dry milk solids.
[b] Prepared by dissolving 39.9 g of sodium bicarbonate in 500 ml of deionized water.
[c] Prepared by dissolving 33.8825 g of ammonium chloride and 29.6175 g of sodium chloride in 500 ml of deionized water.
[d] These included the following ratios of navy bean to sesame flour: 20:0, 15:5, 10:10, 5:15, and 0:20 (w/w).
[e] These included the following ratios of navy bean to sesame flour: 30:0, 20:10, 15:15, 10:20, and 0:30 (w/w).

Data Analyses

Data were analyzed for variance using the STAT package with the Michigan State University Cyber, model 750 Computer. When significant differences were found between the two extreme means, Duncan's multiple range test (Duncan 1957) was used to determine difference among means.

RESULTS AND DISCUSSION

Flour Composition

The soft wheat, navy bean, and sesame flours were analyzed for moisture, protein, fat, and ash (Table II), carbohydrate was obtained by difference.

The soft wheat flour had the highest levels of moisture and carbohydrates and the lowest levels of fat, protein, and ash. Protein content of navy bean flour was twice that of soft wheat flour but less than half the protein content of sesame flour.

Baking Study

Cookies prepared with navy bean flours, especially those with 20% navy bean substitution had dough-handling properties much

TABLE II
Compositions of Wheat, Navy Bean, and Sesame Flours (n = 3)

	Wheat Flour	Navy Bean Flour	Sesame Flour
Moisture (%)	10.5	6.9	9.1
Total lipid (%)	1.5	3.1	3.6
Total protein (%)[a]	10.8	23.0	52.6
Ash (%)	0.4	3.3	7.4
Carbohydrate (%)[b]	76.8	63.7	27.3

[a] For wheat flour, N × 5.7; navy bean and sesame flour, N × 6.25.
[b] Obtained by difference.

SUGAR-SNAP COOKIE SCORE CARD

Name_____ Date_____ Sample #_____

	Points	Score
A. SURFACE APPEARANCE		
1. Shape		
a) Uniform sphere; evenly rounded	7	
b) Less circular shape; inconsistent	4	
c) Sunken center; outer ridge	1	
2. Surface Color		_____
a) Excellent	7	
b) Fair	4	
c) Poor	1	
3. Surface Characteristics		_____
a) Excellent	7	
b) Fair	4	
c) Poor	1	
		_____
B. INTERIOR APPEARANCE		
1. Distribution of Cells		
a) Uniform; visible sheeting, thin crust	7	
b) Heterogenous distribution, moderately thick crust	4	
c) Cake-like; no discernible cells, thick crust	1	
DESCRIBE WHAT YOU SEE: _____		_____
2. Shape & Size of Cells		
a) Excellent	7	
b) Fair	4	
c) Poor	1	
CIRCLE ONE OF THE FOLLOWING:		_____
Geometrical shape: spherical, oval, elongated collapsed		
Size: Small Medium Large		
3. Interior Color		
a) Excellent	7	
b) Fair	4	
c) Poor	1	
		_____
C. EATING CHARACTERISTICS		
1. Texture		
a) Crisp; requires considerable force to bite through	7	
b) Slightly chewy; requires moderate force to bite through	4	
c) Chewy: requires little force to bite through	1	
2. Mouthfeel		_____
a) Acceptable	7	
b) Moderately acceptable	4	
c) Unacceptable	1	
CIRCLE ONE OF THE FOLLOWING: crunchy, gritty adhesive, harsh, gummy, smooth, powdery, OTHER: _____		_____
3. Flavor		
a) Acceptable	7	
b) Moderately acceptable	4	
c) Unacceptable (pronounced off-flavors present)	1	
		_____
If the cookie is scored 3 or below for flavor, circle one of the following: chalky, greasy, metallic, rancid, OTHER: _____		

COMMENTS:

Fig. 1. Scorecard used for sensory evaluation of sugar-snap cookies.

like those of the flour controls. However, as the proportion of sesame flour increased, the doughs became sticky and difficult to handle.

Spread ratio and top grain of substituted cookies are given in Table III for 20 and 30% substitution. As the substitution level increased, width of cookies decreased, thickness increased, and, as a result, spread ratio (W/T) was significantly higher for the control than for the substituted cookies. Cookies with 20 and 30% sesame flour had significantly lower spread ratios than did those baked from other combinations. There was no significant difference among the other combinations of navy bean, sesame, and wheat flours. Cookies substituted with 30% navy bean, sesame and/or sesame flour had significantly ($P < 0.05$) lower spread ratios than did those with 20%.

Tsen et al (1973) fortified wheat flour with up to 50% soy flour and found that fortifying wheat flour with soy flours and soy protein isolate drastically reduced cookie width and increased thickness. Both effects were enhanced progressively as fortification increased.

Control cookies had significantly higher top grain scores than did those with different combinations of sesame and navy bean flours (Table III). As the amount of sesame flour in the blend was increased, top grain scores decreased. Cookies with 20 and 30% sesame flour had lowest top grain scores. There was no significant difference between 20 and 30% substitution level.

The mechanism by which cookie spread is reduced by certain wheat flour supplements is not understood completely. Kissel and Yamazaki (1975) enriched cookie flours with wheat gluten and soy flour derivatives. They reported that nonwheat proteins used in cookie formulas exhibit greater water retention than does wheat flour, and thus possess a greater capacity for competing for the limited free water in cookie dough. Consequently, typical spread and top grain characteristics of cookies containing these types of proteins fail to develop during baking. Yamazaki et al (1977) also found that cookie spread was depressed by increasing the relative quantity of hydrophilic additives in cookie dough. The use of dough conditioners delays the gelatinization of flour starch, delaying the increase in dough viscosity and allowing cookies to spread more before becoming firm or set. Kissel et al (1971) found that an increase in flour lipids increased cookie spread.

Means for breaking strength and shear compression are presented in Table III. Breaking strength was used as a measure of crispness, and shear compression as an indication of tenderness. The force required to break and shear the cookie decreased with increasing level of navy bean substitution, indicating a less crisp and more tender cookie as the level of navy bean flour increased. Cookies with 20 and 30% navy bean flour were significantly harder and less crisp than those with 20 and 30% sesame flour. Cookies with 10 and 30% sesame were tough and difficult to break, so the higher value for breaking strength in these cookies does not mean that they were more crisp.

Tsen et al (1975) reported that incorporation of a protein-rich flour or additive in a composite flour generally necessitates more water to obtain a machinable cookie dough, and cookies prepared from a high-absorption dough tend to be extremely hard. Kim (1972) suggested mixing the protein-rich flour or additive with a part of the shortening before adding it to the previously mixed dough. The protein additive is thus coated with shortening, which reduces its water absorption.

Sensory Evaluation

Results of sensory evaluation are shown in Tables IV and V. Acceptability of cookies with up to 20% navy bean flour and with up to 15% sesame flour was quite similar to those with all wheat flour. Cookies containing these flours spread uniformly during baking and developed a typical top grain. This was reflected in sensory quality scores for appearance as no significant differences were noted among the control and these test samples. Cookies with 30% navy bean flour and those with 30% sesame flour had significantly lower scores for surface character and shape. Competition of navy bean and sesame proteins for moisture may

TABLE III
Objective Measurements[a] of Wheat Flour Substituted with Navy Bean and/or Sesame Flours

W:B:S[b] (%)	Spread Ratio	Shear Compression (lb/g)	Breaking Strength (lb/cm²)	Top Grain
		20% Substitution		
100:0:0	13.8 a ±0.5	12.0 b ±0.9	3.2 a ±1.0	9.0 a ±0.0
80:20:0	11.1 bc ±0.4	8.6 d ±0.3	2.0 c ±0.3	7.0 bc ±1.4
80:15:5	11.3 b ±0.3	10.4 c ±0.5	2.3 bc ±0.5	6.3 bc ±1.0
80:10:10	11.4 b ±0.1	11.7 b ±0.3	2.5 abc ±0.6	5.3 c ±1.5
80:5:15	10.7 cd ±0.3	11.8 b ±0.2	3.0 ab ±1.0	3.8 d ±0.5
80:0:20	10.3 d ±0.6	12.7 a ±0.5	2.5 abc ±0.7	3.3 d ±1.0
		30% Substitution		
100:0:0	13.8 a ±0.5	12.0 b ±0.9	3.2 a ±1.0	9.0 a ±0.0
70:30:0	9.7 b ±0.2	7.2 d ±0.1	1.6 b ±0.5	7.0 b ±0.0
70:20:10	10.0 b ±0.2	9.3 c ±0.3	2.4 ab ±0.4	6.2 c ±1.1
70:15:15	10.1 b ±0.3	11.5 b ±0.4	2.7 a ±0.6	5.0 d ±0.0
70:10:20	10.0 b ±0.3	12.4 ab ±0.8	2.4 ab ±0.8	5.0 d ±0.0
70:0:30	8.6 c ±0.2	13.2 a ±1.1	3.3 a ±0.5	1.0 e ±0.0

[a] Mean of four replications; means followed by the same letters are not significantly different at $P < 0.05$ (Duncan 1957).
[b] W = wheat flour, B = navy bean flour, S = sesame flour.

TABLE IV
Surface Appearance[a,b] and Interior Appearance[a,b] of Cookies Baked from Wheat Flour Substituted with Navy Bean and/or Sesame Flour

W:B:S[c] (%)	Surface Appearance: Shape	Surface Appearance: Surface Color	Surface Appearance: Surface Character	Interior Appearance: Dist. of Cells	Interior Appearance: Size of Cells	Interior Appearance: Interior Color
			20% Substitution			
100:0:0	6.3 a ±0.5	6.3 a ±0.2	5.6 ab ±0.9	6.0 a ±0.3	6.3 a ±0.4	6.6 a ±0.2
80:20:0	5.5 b ±0.7	6.2 a ±0.4	5.1 b ±0.6	5.1 bc ±0.4	5.1 b ±0.4	6.0 b ±0.5
80:15:5	6.4 a ±0.4	6.2 a ±0.3	5.9 a ±0.5	5.5 ab ±0.6	5.5 b ±0.8	6.0 b ±0.3
80:10:10	6.4 a ±0.3	6.2 a ±0.4	5.9 a ±0.5	5.2 bc ±0.4	5.3 b ±0.3	5.9 a ±0.5
80:5:15	6.1 a ±0.4	6.0 ab ±0.4	5.4 ab ±0.4	5.5 ab ±0.4	5.3 b ±0.7	5.7 b ±0.4
80:0:20	5.8 ab ±0.3	5.6 b ±0.2	4.6 c ±0.2	4.8 c ±0.5	5.1 b ±0.5	5.6 b ±0.2
			30% Substitution			
100:0:0	6.3 a ±0.5	6.3 a ±0.3	5.6 a ±0.9	6.0 a ±0.3	6.3 a ±0.5	6.6 a ±0.2
70:30:0	5.1 c ±0.4	5.8 ab ±0.6	4.3 b ±0.8	5.1 b ±0.4	5.3 b ±0.4	6.0 bc ±0.4
70:20:10	5.9 ab ±0.5	5.7 ab ±0.6	5.2 a ±0.6	5.5 ab ±0.8	5.4 b ±0.5	6.1 b ±0.1
70:15:15	5.8 abc ±0.3	5.9 ab ±0.3	5.3 a ±0.8	5.1 b ±0.3	5.3 b ±0.3	6.0 bc ±0.2
70:10:20	6.3 a ±0.3	5.9 ab ±0.4	5.3 a ±0.8	5.0 ab ±0.2	5.2 b ±0.4	5.8 c ±0.3
70:0:30	5.2 bc ±0.5	4.8 b ±0.5	2.6 c ±0.5	4.3 c ±0.4	4.4 c ±0.6	5.4 b ±0.4

[a] Means of four replications; means followed by the same letter are not significantly different at $P < 0.05$ (Duncan 1957).
[b] Total score of 7, with 7 representing the most desirable.
[c] W = wheat flour, B = navy bean flour, S = sesame flour.

TABLE V
Sensory Eating Characteristics[a,b] of Cookies Baked from Wheat Flour Substituted with Navy Bean and/or Sesame Flours

W:B:S[c] (%)	Tenderness	Mouthfeel	Flavor
	20% Substitution		
100:0:0	6.2 c ±0.7	6.2 a ±0.5	6.5 a ±0.2
80:20:0	6.2 c ±0.4	6.3 a ±0.5	5.2 b ±0.4
80:15:5	6.3 bc ±0.5	6.1 a ±0.7	5.4 b ±0.6
80:10:10	6.8 a ±0.2	5.7 b ±0.5	5.8 ab ±0.3
80:5:15	6.5 abc ±0.4	5.4 c ±0.4	4.1 c ±0.7
80:0:20	6.6 ab ±0.3	4.9 d ±0.5	3.4 c ±0.6
	30% Substitution		
100:0:0	6.2 a ±0.7	6.2 a ±0.5	6.5 a ±0.2
70:30:0	6.2 a ±0.6	5.9 abc ±0.3	4.0 bc ±0.5
70:20:10	6.6 a ±0.5	6.1 ab ±0.3	4.8 b ±1.0
70:15:15	6.7 a ±0.3	5.5 bc ±0.4	3.9 bc ±0.4
70:10:20	6.8 a ±0.1	5.4 c ±0.7	3.6 c ±0.8
70:0:30	6.7 a ±0.5	3.9 d ±0.2	2.6 d ±0.4

[a] Based on four replications; means followed by the same letter are not significantly different at $P<0.5$ (Duncan 1957).
[b] Total score of 7, with 7 representing the most desirable.
[c] W = wheat flour, B = navy bean flour, S = sesame flour.

have been a factor in poor surface appearance of cookies made with these two plant proteins. Control cookies were significantly more acceptable in interior appearance than were those containing navy bean and sesame flours. As the percentage of sesame flour increased, scores for flavor and mouthfeel decreased (Table V). Taste panelists detected an undesirable bitter taste at high levels of sesame flour (15, 20, and 30%), and they described the cookies as gummy, chalky, and harsh. The panelists also could detect a beany flavor when 20 or 30% navy bean flour was substituted for wheat flour in cookies. McWatters (1978) suggested that one means of reducing raw, beany flavor in legume flours that are to be used in baked products is to expose the material to moist heat.

CONCLUSIONS

Chemical and organoleptic results show that navy bean flour can be a good supplement for wheat flour for sugar-snap type cookies. Cookies containing up to and including 20% navy bean flour were scored above 4 on a 7-point scale by most panelists. Cookies containing more than 10% sesame were scored low by the panelists. Some panel members detected a bitter aftertaste in cookies with more than 10% sesame flour. Cookies containing both 10% navy bean and 10% sesame flours were also scored as acceptable by these panelists.

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