NOTE

Navy Bean Flour Substitution in a Master Mix Used for Muffins and Cookies[1]

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ABSTRACT

A master mix was developed with levels of 0, 25, and 35% whole, dehulled navy bean flour substituted for all-purpose wheat flour. Effects of navy bean flour substitution on the physical and sensory qualities of pumpkin spice muffins and oatmeal drop cookies were investigated. A high-quality muffin was produced with no significant differences ($P<0.05$) between controls and 25 and 35% substitution levels in all parameters investigated. Whole, dehulled navy bean flour substitution in oatmeal cookies did not significantly ($P<0.05$) affect objective tenderness, spread, color or sensory color, appearance, and flavor, but did significantly ($P<0.05$) affect sensory texture and general acceptability. Incorporation of navy bean flour into a master mix is a feasible way to produce quality products with increased protein and mineral contents.

Dry bean flour contains substantial amounts of protein, calcium, iron, magnesium, phosphorus, and potassium (Tecklenburg et al 1984). Dry edible beans can be an alternative source of nonanimal protein for both developed and subsistent populations. Recent studies have shown that bean flour can be successfully incorporated into baked products (Deshpande et al 1982, Dryer et al 1982, Silaula 1985). Spink and co-workers (1984) also demonstrated that bean substituted cake doughnuts were well-liked by an economically and ethnically diverse consumer population. Over 50% of navy beans produced in the United States are grown in Michigan, where navy beans contribute greatly to the state's economy. Finding alternative uses for legume products could expand overall use of navy beans (Lee et al 1983).

The popularity of formulated convenience foods suggests the possibility of developing and marketing a master mix that utilizes whole dehulled navy bean flour as a means of complementing wheat flour amino acids (Deshpande et al 1983). A master mix that incorporates bean and wheat flour, as well as fat and leavening agents, could be an effective mode of producing high-quality, high-protein home baked goods. The market for such a product could include government feeding programs, vegetarians, and other people who have a limited intake of complete protein or who wish to supplement their protein and mineral intake.

The objective of this investigation was to successfully develop master mixes with 25 and 35% navy bean flour substitution and to incorporate these into an oatmeal cookie and pumpkin spice muffin in order to determine which level of bean flour substitution yields the highest quality product.

MATERIALS AND METHODS

Materials

Whole, dehulled navy bean flour was obtained in a common lot from Texas A&M University. The navy bean flour was prepared according to the method outlined by Aguilera et al (1982). The flour contained approximately 25.9% protein, 5.3% ash, and 7.6% enzyme neutral detergent fiber on a dry weight basis (Uebersax and Zabik 1986). All-purpose wheat flour and all other nonperishable ingredients were procured in single lots from Michigan State University Food Stores, East Lansing. Eggs, milk, and margarine were obtained weekly from retail sources.

Master Mix

The formula and method of preparation for the master mix is given in Table I. All master mixes were stored in airtight polypropylene containers at room temperature (20° C) until used (less than two weeks).

Muffin Preparation

The formula for the pumpkin spice muffins (Table II) was adapted from Dryer et al (1982). Twelve muffins were prepared per bake for each of the four replications. Brown sugar and spices were blended with the prepared master mix using the paddle attachment of the KitchenAid K-5A mixer for 1 min at speed 1 (144 rpm). Milk, eggs, pumpkin, and vanilla were combined and mixed for 1 min at speed 1. The liquid mixture was added to the dry ingredients and mixed by hand (25 strokes). Scoops of batter

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weighing 75 g were placed in greased aluminum muffin tins. The muffins were baked in a rotary hearth oven at 204° C for 25 min. Muffins were cooled 5 min at room temperature in the muffin pan and then removed and cooled another 30 min on wire racks at room temperature before being individually wrapped in clear polyethylene film and aluminum foil. The muffins were held frozen at −22.2° C until time of sensory and objective evaluations (less than two weeks).

Oatmeal Cookie Preparation

The oatmeal cookie formula (Table II) was adapted from a domestic recipe (Anonymous 1976). Two dozen cookies were prepared per bake for each of four replications. Shortening, brown sugar, sucrose, egg, vanilla, and water were blended for 1.5 min at speed 4 (272 rpm) using the paddle attachment of the KitchenAid K-5A mixer. All dry ingredients were mixed together by hand until well blended. The creamed mixture was then thoroughly combined with the dry mixture. Scoops of dough weighing 17 g were baked in a rotary hearth oven at 177° C for 15 min. In order to raise the humidity in the oven, cookies were baked after muffins. Following baking, the cookies were removed immediately from the baking sheets and cooled at room temperature for 5 min on a wire rack before being wrapped in pairs with clear polyethylene film and aluminum foil. All cookies were stored in airtight polypropylene containers and held frozen at −22.2° C until the time of evaluation (less than two weeks).

Evaluations

All frozen samples were thawed at room temperature before performing organoleptic and objective evaluations. Cookies were evaluated as outlined by Vratanina and Zabik (1978) for surface color, spread (method 10-50D; AACC 1983), and tenderness. Characteristics evaluated by a five-member trained sensory panel included color, appearance, texture, flavor, and general acceptability. Panelists rated cookies on a descriptive five-point scale with five being most desirable. All taste panels were conducted in individual booths with fluorescent daylight lighting. Objective tenderness of cookies and muffins was evaluated using the standard shear compression cell of the Food Technology Corporation model TR5 Texturerecorder equipped with a 3,000-lb transducer.

Muffin compressibility was determined employing the plunger attachment (5.5 cm diameter) of the Texturerecorder. Volume was determined by rape seed displacement (National loaf volumeter) using three muffins to obtain an average value. Crumb color values were determined using the Hunter Lab color difference meter (model D25-2) with the standard yellow color tile C2-6007 (L = +78.4, a_L = −1.9, b_L = +25.0). Muffins were also evaluated by a five-member trained organoleptic panel for surface appearance, interior color, texture, flavor, moisture, and tenderness on a seven-point descriptive scale with seven being most desirable.

A one-way analysis of variance (Gill 1981) was first performed on the mean scores of the subjective and objective measurements for oatmeal cookies and pumpkin spice muffins. Those sources of variation shown to be significant by analysis of variance were further tested using Bonferroni's t statistic as described by Gill (1981).

TABLE I
Master Mix Formula and Preparation

Ingredient	Weight (g)	Method of Preparation
All-purpose wheat flour/ navy bean flour[a]	900	
Sucrose	45	Sift dry ingredients together
Sodium aluminum sulfate baking powder[b]	27	
Salt	13.5	
Hydrogenated vegetable shortening[c]	279	Blend shortening with 1/3 dry ingredient at slow speed 1 min. Add remaining dry ingredients and continue blending 3 min.

[a] Wheat flour and navy bean flour weights were 900 and 0 g, 675 and 225 g, and 585 and 315 g, respectively.
[b] Calumet, General Foods Corp., White Plains, NY.
[c] Crisco, Proctor & Gamble Co., Cincinnati, OH.

RESULTS AND DISCUSSION

Muffins

Analyses of variance of pumpkin spice muffins revealed no significant differences among any level of bean flour substitution for all objective tests. Bean-substituted muffins were comparable to controls in all respects. Both Dryer (1982) and Aguilera et al (1981) showed decreased b_L and L values with higher levels of navy bean flour substitution in quick breads. Aguilera and co-workers (1982) attributed the lowered L values to the increased presence of reducing sugars in navy bean flour versus wheat flour, causing increased Maillard browning.

Sensory characteristics, as scored by surface appearance, interior color, texture, moisture, tenderness, and flavor, also showed no significant differences among controls and muffins prepared with navy bean-flour substituted master mix. This indicates a close similarity between the control and test muffins, which in this study was a desirable outcome. Tenderness scores for all substitution levels ranged from 6.3 to 6.4 on a seven-point scale indicating little resistance to tearing and biting. Flavor scores ranged from 5.7 to 5.9, indicating a sweet muffin with no off-flavor. Surface appearance scores ranged from 5.1 to 5.9, showing orange-

TABLE II
Pumpkin Spice Muffin and Oatmeal Cookie Formulas

Ingredient	Pumpkin Spice Muffins (g)	Oatmeal Cookie (g)
Master mix	238.5	80.8
Light brown sugar	256.5	120.0
Sucrose		53.7
Canned pumpkin[a]	246.0	
Quick oats[b]		132.5
Margarine		67.2
Whole milk	121.0	
Water		29.5
Egg	100.0	28.0
Vanilla	2.5	2.5
Sodium aluminum sulfate baking powder[c]		2.3
Salt		2.2
Cinnamon	1.0	1.5
Cloves	0.5	1.1

[a] Libby's, Libby, McNeill & Libby, Inc., Chicago, IL.
[b] Quaker, Quaker Oats Co., Chicago, IL.
[c] Calumet, General Foods Corp., White Plains, NY.

TABLE III
Sensory Evaluation of Oatmeal Drop Cookies Prepared with Master Mix of 0, 25, and 35% Navy Bean Flour Substitution[a]

Substitution Level in Master Mix (%)	Color	Appearance	Texture	Flavor	General Acceptability
0	4.5±0.1 x	4.4±0.5 x	4.4±0.2 x	4.7±0.4 x	4.4±0.2 x
25	4.2±0.5 x	4.2±0.2 x	4.0±0.4 x	4.1±0.3 x	3.9±0.4 xy
35	4.1±0.4 x	4.3±0.3 x	3.0±0.8 y	3.6±0.9 x	3.5±0.5 y

[a] Means and standard deviations based on four replications, five judges per replication. Range = 1–5, 5 = most desirable. Means followed by the same letter are not significantly different using Bonferroni's t test at $P<0.05$ (Gill 1981).

brown muffins with slightly uneven surface texture. In a similar study on pumpkin bread, substitution for wheat flour with navy bean flour improved the general acceptability over controls (Aguilera et al 1981).

Oatmeal Cookies

Comparison by analysis of variance of oatmeal cookies revealed no significant differences in any of the objective parameters measured, i.e., tenderness, spread, and color. Hoojjat and Zabik (1984) found increased tenderness with higher levels of navy bean flour in sugar-snap cookies. Increasing cookie tenderness with increasing bean flour is probably caused by a weakened or diluted gluten matrix, resulting from the protein composition of navy bean flour. Navy bean protein is predominantly composed of globular proteins (not gluten-forming) as opposed to the structural proteins (glutenin and gliadin) of wheat flour that the bean flour replaces.

Organoleptic results for the oatmeal cookies are reported in Table III. Analyses of variance revealed no significant differences for color, appearance, or flavor, although differences were observed for sensory texture and general acceptability. Cookie texture of variables containing the 35% substitution level was found to be significantly different ($P < 0.05$) from both the control and the 25% substitution level, with bean-containing cookies scoring as slightly less desirable than the control. Some panelists commented that cookies prepared with the 35% level of bean flour substitution were slightly too soft. Hoojjat and Zabik (1984) reported decreased surface character and shape with navy bean flour substitution in sugar-snap cookies. Appearance scores in this study ranged from 4.2 to 4.4 on a five-point scale. The oatmeal cookie scores indicated a fairly circular shape and pebbled surface, implying oatmeal cookies may be more amenable to bean flour substitution than sugar-snap cookies. A significant difference ($P < 0.05$) was observed between the general acceptability scores of controls and cookies prepared with the master mix containing 35% bean flour substitution. General acceptability scores ranged from 3.5 to 4.4 on a five-point scale. The control and 25% substituted cookies were rated "like very much." Although significantly different from the control, the 35% navy bean cookies were still acceptable, scoring between "neither like nor dislike" to "like moderately well."

Master mixes prepared with 25 and 35% navy bean flour substitution performed well in both pumpkin spice muffins and oatmeal drop cookies. Products made from these master mixes compared very favorably to products prepared using the control master mix. No significant differences ($P < 0.05$) were observed for any parameters measured other than sensory texture and general acceptability at the 35% level for the oatmeal cookies. This demonstrates that bean flour incorporation into baked products by way of a master mix could be an alternate and nutritionally beneficial use of navy beans.

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