USE OF UNTREATED AND ROASTED NAVY BEANS IN BREAD BAKING[1]

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ABSTRACT

The effect of using flour obtained from untreated and roasted navy beans on dough and baking properties was studied. Roasting navy beans caused an increase in water-retention capacity value and a decrease in protease and lipoxygenase activity of the flour. The farinogram absorption of blends prepared with wheat and navy bean flour was considerably higher with use of roasted navy beans. Bread containing roasted navy bean flour had a higher volume than did bread containing untreated flour at the same level of incorporation. In general, physical dough studies and conventional baking data indicate that if navy bean flour were to be used, roasting the navy beans before milling would be beneficial; the only bread quality factor that would be affected adversely would be crumb color.

Numerous studies are reported in the literature on the use of composite flour in bread baking. The Tropical Products Institute (1) recently published a bibliography on composite flour technology. Several recent studies have been published on use of legumes of the nonoil type in baking. McConnell et al (2) examined the effect of adding either faba bean flour or faba bean protein concentrate to bread. Better baking results were obtained with incorporation of the protein concentrate than with the flour itself. Patel and Johnson (3) investigated the effect on physical dough properties, bread quality, and amino acid composition of horsebean flour and protein isolate from horsebean in various amounts with wheat flour. Horsebean flour at all levels above 10% reduced mixing time and tolerance and produced inferior quality bread. Horsebean protein concentrate, however, even with protein equivalent to 20% horsebean flour, produced satisfactory physical dough properties and acceptable bread quality. Thompson et al (4) found that incorporation of mung bean flour at the 15% level with wheat flour should result in an approximately 10% increase in protein and an average 41–42% increase in lysine (before baking).

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Several researchers have indicated the importance of legumes as a source of protein. Several recent studies have been reported (5–9).

A recent report from our (10) laboratory discussed the rheologic and baking studies of legume-wheat flour blends. As a continuation of this study, the effect of roasting navy beans for use in composite flours was studied. The objective of the investigation was to study the use of flour, of varying extractions, obtained from untreated and roasted cracked and split navy beans. The cracked and split navy beans were chosen, since such beans would not have a regular commercial outlet except for animal feed.

MATERIALS AND METHODS

Samples

Navy Beans. Protein Products, Inc. (Olivia, MN) supplied untreated cracked and split navy beans and also cracked and split navy beans roasted by a flash-flame roaster.

Wheat Flour. The North Dakota State Mill and Elevator, Grand Forks, ND supplied a high-gluten, hard red spring (HRS) wheat flour of 13.8% protein (14% mb).

Milling Navy Beans

Before milling, the beans were washed with water to remove mud and dirt. After washing, the beans were allowed to air dry. The Allis-Chalmers and Buhler experimental mills were used for milling the beans. The samples were passed initially through the first-break rolls of the Allis-Chalmers mill, which primarily cracked the hull. The material was then passed through the Buhler laboratory experimental mill. Flour of four different extractions was obtained for both untreated and roasted navy beans.

Water-Retention Capacity

Water-retention capacity of navy bean flours of different extraction was determined on 5-g samples as described previously (10).

Starch Damage Content

Starch damage was determined according to AACC Method 76-30A (11).

Enzyme Activity

Protease and lipoxygenase activity in the untreated and roasted navy bean flours was determined according to the procedures of Hanford (12) and Lulai (13), respectively.

Preparation of Blends

A commercial high-gluten HRS wheat flour was used to prepare 5, 10, 15, and 20% blends with each of the different extraction rate untreated and roasted bean flours, giving a total of 32 samples.

Physical Dough Properties

The physical dough properties of the various wheat-navy bean flour blends were examined with the farinograph. The 50-g farinograph bowl and the constant flour weight procedure of AACC Method 54-21 (11) were used.

Baking Studies

Conventional Baking Method. The wheat-navy bean flour blends were baked according to the conventional straight dough procedure as well as with the continuous (mechanical development) baking method.

With the straight dough baking procedure, the various blends were baked in duplicate with and without incorporation of sodium stearoyl-2-lactylate (SSL). Farinogram absorption and mixing time were used as indicators of these two parameters for bread baking. Mixing was done in a National 100–200-g mixer (National Mfg. Co., Lincoln, NE). The baking formula used was as follows:

Flour	100 g (14% mb)
Salt	2%
Sugar	5%
Shortening	3%
Compressed yeast	3%
SSL	0.5% (when used)
Barley malt	0.05%
Potassium bromate	20 ppm
Water	Variable

For the 100% wheat flour bread (control), only 10 ppm of potassium bromate was used.

Continuous Bread Baking (Mechanical Development). Bread was produced by mechanical development from flour blends containing 5, 10, and 15% of untreated and roasted navy bean flour. For this experiment, bread was produced from blends containing 93 and 90% roasted and untreated navy bean flour, respectively.

A Wallace and Tiernan laboratory model continuous unit (Baker Process Co., Belleville, NJ) was used to make the continuous bread. The method employed was that of D'Appolonia (14). The baking formula, with percentage of ingredients based on flour weight, was as follows:

Flour	5,000 g
Sugar	8.0%
Salt	2.25%
Milk	2.0%
Shortening	3.25%
Yeast food	0.5%
Compressed yeast	2.75%
Barley malt	0.05%
Potassium bromate	60 ppm
Potassium iodate	12 ppm
Water	Variable

The baking absorption used was 3% higher than the respective farinograph absorption. The extruded doughs (540 g) were proofed under controlled temperature and relative humidity conditions for 55 min and baked for 20 min at 230° C to produce 1-lb loaves of bread.

Taste Panel Evaluation

For taste panel evaluation, 1-lb loaves of bread were produced using the straight dough baking procedure. For evaluation purposes, bread containing 10 and 15% navy bean flour was used. Navy bean flour used in the bread for the taste panel studies was of 99% extraction.

The triangle test was used, including two control samples (100% wheat flour bread) and navy bean flour-containing bread. The 20–25 member panel judged the bread for mastication (mouth-feel and chewing performance), taste, and aroma.

For mastication, the panel rated the bread in the triangle test as satisfactory, gummy and doughy, tough, or otherwise. The panel also rated the bread for taste and aroma as satisfactory, bland and tasteless, bitter, or otherwise.

Other Determinations

Moisture, ash, and protein contents were determined by standard AACC methods 44-15A, 08-01, and 46-11, respectively (11).

RESULTS AND DISCUSSION

Milling Data

Table I shows the yield, ash, and protein content of the break (B) and reduction (R) flour streams obtained from the Buhler mill for untreated and roasted navy beans. The yield was similar for untreated and roasted samples. The majority of

TABLE I
Yield, Ash, and Protein Content of Navy Bean Flour Streams

Stream	Untreated			Roasted		
	Yield (%)	Ash[a] (%)	Protein[a] (%)	Yield (%)	Ash[a] (%)	Protein[a] (%)
B-1	11.5	3.08	19.9	10.4	3.26	20.5
B-2	4.1	2.91	21.2	4.6	3.25	21.8
B-3	0.8	2.94	19.7	0.7	3.17	19.7
R-1	53.7	3.38	23.1	56.9	3.37	23.5
R-2	15.3	3.48	24.5	16.6	3.39	25.0
R-3	5.0	3.58	24.5	4.0	3.49	25.9
By-products	8.9	5.70	17.5	6.1	5.49	20.0

[a]Expressed on 14.0% mb.

TABLE II
Water Retention Capacity and Starch Damage Values of Navy Bean Flour

Flour	Bean Flour Extraction (%)	Water-Retention Capacity (%)	Starch Damage (%)
Untreated	54	107	4.2
	69	125	4.0
	90	122	3.9
	99	132	3.7
Roasted	57	152	4.5
	74	158	5.0
	93	159	4.9
	99	163	4.5

the product was obtained in the first and second reductions. The various streams were combined to give four different extractions: flour stream R-1, R-1 and R-2 combined, reduction and break flours combined, and the total ground bean. Bean flour extractions of 54, 69, 90, and 99% were obtained for the untreated navy beans and 57, 74, 93, and 99% for the roasted navy beans. The different extraction flours were used to prepare the blends. Ash content values are quite high when compared with wheat flour mill streams. This result has been reported previously. R flour streams were higher in protein and ash content than were B flour streams for both untreated and roasted navy beans. Little difference was noted in protein content between untreated and roasted navy beans for the corresponding flour stream.

Water-Binding Capacity and Starch Damage Values

Absorption is an important factor in bread baking. Wheat flour with a high absorption is desirable. Data in Table II shows the water-retention capacity and starch damage values of the untreated and roasted navy bean flours of different extraction rates. In general, as the extraction rate increased, the water-retention capacity value showed a slight increase. Particularly noteworthy is the effect of roasting on the water-retention capacity values. The increase in values over the untreated navy bean flour was pronounced.

The roasted navy bean flours showed slightly higher starch damage values than did the untreated material. This factor again could be of considerable importance in use of navy bean flour for bread baking. The higher starch damage values would explain in part the higher water-retention capacity values obtained with roasted bean flour.

Enzymatic Activity

Roasting had a definite effect on protease activity in navy bean flour (Table III). Loss in protease activity was progressive as bean flour extraction increased. At 99% extraction, reduction in protease activity was almost complete. The higher protease activity in untreated navy bean flour could have a detrimental effect on baking properties when used in blends with a wheat flour.

As was the case with protease activity, lipoxygenase activity essentially was lost completely as a result of the roasting process. The loss was the same regardless of the bean flour extraction. Lipoxygenase in bread baking is known to have a whitening effect on crumb color. With loss of the lipoxygenase activity, improvement or whitening of the crumb would be lost.

TABLE III
Relative Decrease in Protease and Lipoxygenase Activity Resulting From Roasting

Bean Flour Extraction		Decrease in Protease Activity (%)	Decrease in Lipoxygenase Activity (%)
Untreated (%)	Roasted (%)		
54	57	47.4	99.6
69	74	49.3	98.9
93	90	77.8	99.0
99	99	96.2	99.4

Physical Dough Properties

Farinograph data was similar regardless of the navy bean flour extraction level used to prepare the blends. Table IV shows data for the wheat-flour blends prepared using the 99% extraction bean flour, which is representative of data obtained using the other bean flour extractions.

Absorption increased slightly with incorporation of untreated navy bean flour compared with control HRS wheat flour. With use of roasted bean flour, however, a marked, progressive increase in absorption was noted as the level of navy bean flour in the blend was increased. The higher absorption values noted with roasted navy bean flour-containing blends would be in agreement with results obtained for water-binding capacity data (Table II).

A pronounced weakening of dough was noted as the level of untreated navy bean flour in the blend was increased. This result was not noted with roasted navy bean flour. Such a result could be attributed in part to the decrease in protease activity as a result of roasting.

Conventional Bread Baking

Regardless of the bean flour extraction used, baking data was similar. Table V shows baking absorption and mixing time for navy bean-wheat flour blends

TABLE IV
Farinograph Data on Untreated and Roasted Navy Bean-Wheat Flour Blends[a]

	Untreated			Roasted		
Blend (%)	Absorption[b] (%)	Dough Developing Time (min)	Stability (min)	Absorption[b] (%)	Dough Developing Time (min)	Stability (min)
Control	63.6	6.5	12.0			
5	64.9	7.0	8.5	64.9	7.5	9.0
10	65.9	6.5	6.5	67.5	6.0	8.0
15	66.4	6.5	4.5	69.0	6.0	8.5
20	66.4	6.5	3.5	70.8	5.5	8.0

[a]Untreated and roasted navy bean flour used represented 99% extraction.
[b]Expressed on 14.0% mb.

TABLE V
Baking Absorption and Mixing Time of Bread Containing Various Levels of Untreated and Roasted Navy Bean Flour[a]

	Untreated		Roasted	
Blend (%)	Absorption[b] (%)	Mixing Time (min)	Absorption[b] (%)	Mixing Time (min)
Control	62.4	3.50		
5	61.2	3.00	63.4	3.00
10	60.2	3.00	66.2	3.00
15	58.0	2.75	67.2	2.75
20	56.3	2.75	69.5	2.75

[a]Untreated and roasted navy bean flour used represented 99% extraction.
[b]Expressed on 14.0% mb.

using the 99% extraction bean flour. With use of untreated navy bean flour, absorption decreased as the level of bean flour in the blend was increased. The exact opposite, however, was noted with incorporation of roasted navy bean flour, in which case progressive increase in absorption was pronounced as the level of roasted bean flour was increased.

Doughs containing higher levels of untreated navy bean flour appeared sticky and wet during mixing; dough stuck to the sides of the mixing bowl, which necessitated stopping the mixer and scraping the bowl several times. This was not the case with doughs containing roasted navy bean flour.

Mixing time used was the same for doughs containing untreated and roasted navy bean flour at a particular blend level.

Baking data for bread containing untreated and roasted navy bean flour with and without incorporation of SSL are shown in Table VI. Loaf volumes (Table VI) for bread containing roasted bean flour were all higher than for bread containing untreated bean flour at the same level of incorporation. Use of SSL

TABLE VI
Baking Data of Conventional Bread Containing Untreated and Roasted Navy Bean Flour[a]

	Untreated							
	Loaf Volume		Crust Color[b]		Crumb Color[c]		Grain and Texture[b]	
Blend (%)	No SSL (cc)	0.5% SSL (cc)	No SSL	0.5% SSL	No SSL	0.5% SSL	No SSL	0.5% SSL
5	896	920	9.9	9.9	10.4	10.9	8.8	9.1
10	781	831	9.8	9.8	9.9	10.4	7.9	8.3
15	675	733	8.8	8.8	8.6	9.2	6.8	7.1
20	608	666	8.3	8.3	8.0	8.7	5.4	5.9
	Roasted							
	912	965	10.0	10.0	8.8	9.3	8.9	9.4
	866	887	10.0	10.0	8.3	8.8	8.6	8.9
	798	848	9.8	9.9	7.8	8.3	7.6	7.9
	768	775	9.5	9.6	6.7	6.9	6.7	6.8

[a]Results reported are an average of eight loaves based on duplicate bakes of four different milling extractions of navy beans.
[b]Values are based on score of 1–10, 10 being best score.
[c]Values are based on score of 1–11, 11 being best score.

TABLE VII
Taste Panel Evaluation (Triangle Test)

	Percentage of Panel Rating Bread Satisfactory			
	Untreated Navy Beans		Roasted Navy Beans	
Navy Bean Flour Incorporated[a] (%)	Mastication (%)	Taste and Aroma (%)	Mastication (%)	Taste and Aroma (%)
10	65	74	83	65
15	64	27	70	48

[a]Untreated and roasted navy bean flour used for baking for taste panel studies was of 99% extraction.

increased loaf volume in all cases. Average loaf volume (eight loaves) for 100% wheat flour bread (control) without and with incorporation of SSL was 932 cc and 986 cc, respectively. Crust color was also better with use of roasted bean flour than with untreated bean flour, particularly at higher levels of incorporation. At higher levels of incorporation of untreated navy bean flour, crust color showed excessive darkness, which was not as evident with roasted navy bean flour. Crust color score for 100% wheat bread with and without SSL was 10.0. As was true for volume and crust color, grain and texture were superior for bread containing roasted navy bean flour as opposed to bread containing untreated material. Bread containing higher levels of untreated navy bean flour generally produced a more compact, dense crumb structure than when roasted navy bean flour was used at the same percentage level. Incorporation of SSL in general improved grain and texture of bread. Average grain and texture score for the control without and with SSL was 9.0 and 9.4, respectively. Bread crumb color was the only quality factor that was better when untreated rather than roasted navy bean flour was used. Untreated navy bean flour apparently contained lipoxygenase enzyme, which resulted in a bleaching effect causing a whiter crumb color. This result has been reported previously (10). Roasting caused a destruction of this enzyme as shown in Table III. At the 5 and 10% level of incorporation of untreated navy bean flour, crumb color actually improved compared with the control bread. The average crumb color score for the control bread without and with SSL was 9.2 and 9.6, respectively. At higher levels of incorporation, scores for crumb color decreased but were still better than if roasted flour had been used. Use of SSL improved crumb color regardless of whether untreated or roasted navy bean flour was used.

Continuous Bread Baking (Mechanical Development)

Continuous bread containing 5% of untreated or roasted navy bean flour would be considered acceptable for internal or external appearance. Crust color, however, even at the 5% level, was considerably darker than with the control (100% wheat flour bread). As the level of navy bean flour was increased, the crust color became progressively darker and the grain became open and coarse. At the 15% level, the bread produced was entirely unacceptable. At the 15% level, the top crust had a sunken center and the grain was very open and coarse. No extreme differences were noted between breads made with untreated or roasted navy bean flour. With use of navy bean flour, an increase in underoxidation of bread was apparent as the level of navy bean flour was increased. Figure 1 shows the internal and external appearance of the continuous produced bread containing 5, 10, and 15% of untreated and roasted navy bean flour.

Taste Panel Evaluation

Data in Table VII show the percentage of the panel that rated the bread as being satisfactory for mastication and taste and aroma with incorporation of 10 and 15% of untreated or roasted navy bean flour.

Taste panel data tend to indicate a greater preference for bread containing roasted navy bean flour to that containing untreated navy bean flour. At the 15% level of incorporation of roasted navy bean flour, certain panel members detected a difference in taste, but it was not considered objectionable. With the 15% level of untreated navy bean flour, however, several panel members

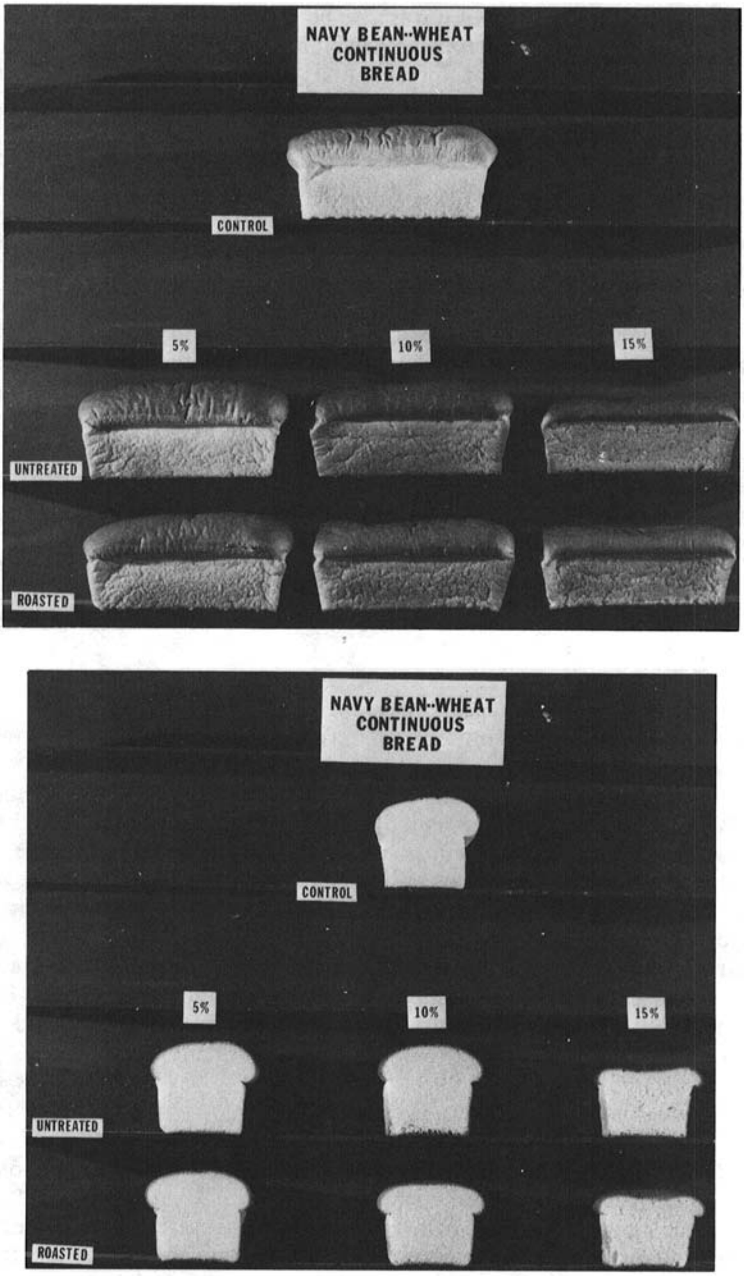

Fig. 1. Exterior and interior of continuous bread containing from 5 to 15% of roasted and untreated navy bean flour of 93 and 90% extraction, respectively.

commented that the bread had a beany taste and was objectionable.

Based on rheologic, baking, and taste panel studies, roasting navy beans appears to have a beneficial effect on use of the corresponding flour in bread baking. The only major disadvantage is that the whitening effect on crumb color noted with use of untreated bean flour would be lost during roasting.

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