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Food Chemistry 99 (2006) 686–692
Food Chemistry
www.elsevier.com/locate/foodchem

Low carbohydrates bread: Formulation, processing and sensory quality ☆

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Received 2 May 2005; received in revised form 22 August 2005; accepted 22 August 2005

Abstract

A low carbohydrate bread formula was prepared using hard red spring wheat flour, soy protein and vital gluten. Soy protein was treated with ethanol and jet-cooked to remove the beany taste. Vital gluten and soy protein blends were prepared and added to the control flour in order to reduce the final starch content by 52%. The ratio of soy protein:vital gluten was adjusted, based on the Farinograph profile of the blend relative to the control flour. AACC Method 10-09, Straight dough, was used for the baking. The amounts of shortening and yeast were increased, to improve the dough consistency and to reduce beany taste, respectively. A blend of 70% gluten and 30% soy protein was added to replace 50% of the control flour. This blend gave a loaf value similar to the control. Overall, the loaf was softer, darker in colour and the grain was more open than the control. Another blend, with 50% soy nuggets and 50% vital gluten, was added to replace 50% of the control flour. This produced a loaf with 35% less volume, darker colour, and a grain similar to the control. The protein content of the final product was 56%, which is much higher than that reported in the literature. Bread with high protein content is more suitable for use in low carbohydrate diets than bread formulations currently used.

Keywords: Low carbohydrate; Vital gluten; Soy isolate; Baking; Firmness; Farinograph

1. Introduction

Low carbohydrate baked products are increasingly in demand by consumers for different reasons, such as nutrition, health, and weight control. Widespread literature exists on bread enrichment with oil seed flour and protein isolates. High quality yeast was found to be the most significant factor in reducing the beany taste of bread fortified with soy flour (Shogren, Mohamed, & Carriere, 2003). Khan and Lawhon (1980) reported the effects of protein isolates from soy, cotton seeds, and peanuts on bread baking. The highest amounts of protein isolate added to produce bread with acceptable volume were 4% for soy and 8% for cotton seed and peanut protein isolates. Sahni and Krishnamurthy (1975) reported optimum levels of ground nuts (10%) and soy flour (10%) that can be added to produce acceptable specialty Indian bread. It is well established in the literature that oil seed flours change wheat flour's mixing and other properties (Bacigalupo, Aguilar, Luna De La Fuente, & Valle Riestra, 1967; Bohn & Favor, 1945; Finney, Bode, Yamazki, Swickard, & Anderson, 1950; Ofelt, Smith, & Derges, 1954a, 1954b). Matthews, Sharpe, and Clark (1970) concluded that oil

☆ Names are necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of the product, and the use of the name by the USDA implies no approval of the product to the exclusion of others that may also be suitable.

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0308-8146/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodchem.2005.08.044

seed flour added to wheat flour increased the Farinograph water absorption, reduced dough tolerance, and produced bread with lower loaf volume. However, when 1% lecithin was added to wheat flour enriched with 6% soy isolate, the decrease in loaf volume was counteracted (Mizrahi, Zimmermann, Berk, & Cogan, 1967). The changes in the physicochemical properties of bread containing soy flour were reported by Shiraldi, Piazza, Brenna, and Vittadini (1996) who found a significant reduction of bread staling caused by soy flour. Dervas, Doxastakis, Hadjisavva, and Triandafilakis (1999), Doxastakis, Zafiriades, Irakli, and Tananaki (2002) and Buck, Walker, and Watson (1987) reported on the addition of up to 15% lupin flour or protein, triticale, corn protein or soy and their effects on rheological properties of wheat flour doughs.

Reports in the literature conclude that high protein breads contain up to 15–20% protein. The scope of this project was to develop bread formulas with protein contents higher than that reported in the literature, i.e. about 59% protein. The objectives of this work were also to address the mechanical rheological properties of the developed formulas, namely, Farinograph profile and water absorption.

2. Materials and methods

2.1. Materials

Bread flour containing 12% protein, as specified by the supplier (Dakota Miller's Choice HRS Wheat flour, Fargo, ND), gluten with 91% protein content, based on suppliers analysis (Vital Wheat gluten, Midwest Grain, Pekin, IL), and soy protein isolate (Soy Nuggets, The Solae Company, St. Louis, MO) were used for baking. Soy nuggets were milled in a grinding mill (Glen Mills, Clifton, NJ) and passed through an 80-mesh sieve. To reduce beany taste, soy protein was treated with ethanol:protein, 2:1 w/w. The suspension was stirred for 2 h, centrifuged, and air-dried before use. Two vital gluten/soy protein blends were prepared: (a) 70% gluten, 30% soy protein (70:30) and (b) 50% gluten, 50% soy protein (50:50). The flour/protein blends will be called PB1, 2, 3, and 4 as follows:

PB1 (70:30 gluten:soy) substituted 30% of wheat flour; PB2 (70:30 gluten:soy) replaced 50% of wheat flour; PB3 (50:50 gluten:soy) replaced 30% of wheat flour; PB4 (50:50 gluten:soy) replaced 50% of wheat flour. The control was 100% bread flour. Three replicate blends, for flour testing and baking, were prepared for each treatment and analyzed independently. The solutions used in this formula were: 500 ppm ascorbic acid, 0.3 g α-amylase (Doh-tone, American Ingredients Co., MO) in 100 ml water, and 8% sugar solution containing 1.5% NaCl. Based on the protein contents of wheat flour, wheat gluten, and soy protein, the protein content of the blends PB1 and PB2 were 38.5% while those of PB3 and PB4 were 56%.

2.2. Methods

2.2.1. Farinograph testing

The control flour and samples were tested by Farinograph according to AACC Approved Method No. 54-21. The dough water absorption, mixing tolerance index (MTI), and stability profiles were calculated.

2.2.2. Baking procedure

All dry ingredients were calculated as percent, based on the flour weight (500 g). Baking performance was analyzed, in triplicate, on pup and 1 lb loaves, using a modification of AACC Method 10-09. Briefly, the flour (500 g) was mixed with 1.5% instant dry yeast (Lallemand, Derry, NH), 6% Crisco vegetable shortening, 4% non-fat dry milk, 25 ml ascorbic acid solution (500 ppm), 5 ml α-amylase solution (0.003% Doh-tone) and 55 ml sugar/salt solution (8% sugar and 1.5% salt solution). The water absorptions, as determined by mixing and feeling the dough, were 69%, 99%, and 103% for the control and treatments PB1 and PB2, respectively, and 123% for treatments PB3 and PB4. Mixing times were 15 and 20 min for control and treatment samples, respectively. One pup (150 g dough) loaf and one pound loaf were obtained from the final dough. The pup loaf was used for loaf volume measurements, and the one pound loaf was used for the remaining tests. Punching and proofing times were: (a) 7.9 mm gap after 105 min; and (b) 7.9 and 4.8 mm gaps after 25 min. The sheeted dough was rolled to fit the pan after the last punch. The dough was proofed for another 30–80 min prior to baking. Loaves were baked at 425 °F for 24 and 45 min for pup and large loaves, respectively. Dough height, loaf weight and loaf volume were recorded.

The water absorptions were 67%, 80%, 83%, 99% and 101% for the control and treatments 1, 2, 3 and 4, respectively. Proper dough consistency was reached after 5–7 min. A pup loaf (20% of the dough) and a large loaf (80% of the dough) were obtained from the final dough, except for treatments 1 and 3, where 60% of the dough was used for the large loaves.

2.2.3. Bread firmness

Bread firmness were measured on freshly baked bread loves that were stored for 1 and 5 days at 25 °C using a TA-XT2i texture analyzer (Texture Technologies Corp., Scarsdale, NY) with a 6 mm cylinder probe with a 5 kg load cell. The samples were analyzed with a method based on AACC Method 74-09 modified as follows: a standard 25 mm probe with 5 kg load cell and three centre slices from the pup loaves (10 mm each) were used. The bread macro system available in the applications software of the texture analyzer was used without modifications.

2.2.4. Sensory evaluation

The sensory analysis was done using the spectrum descriptive analysis method. The test was performed by 21st Sensory, Inc. (Bartlesville, OK 74006). Twelve highly

trained panellists, led by a panel leader, were used in the evaluation. Samples were analyzed for flavour, texture, and appearance. Panellists measured five flavour and two texture attributes. Samples were coded with three-digit random numbers and presented in monadic and random order. They were evaluated using a 15-point intensity scale divided into 0.1 point increments, with zero indicating no measurable effect and 15 signifying an extremely strong effect. Bread was sliced utilizing a Rival Slicer (El Paso, TX 79906). Samples were kept in Ziploc® bags for freshness. The attribute definitions, food references, and preparation procedure are shown in Table 2.

2.3. Statistical analysis

A random complete block design (RCD) was used to compare panellists' flavour and textural attribute scores for 5 sample products (including the control). The blocking factor consisted of three separate batches of each product. Levene's homogeneity of variance test at $\alpha = 5\%$ was performed to determine if data transformation of the dependent attributes (beany, grain, yeasty, sweet, bitter, firmness, and denseness) were necessary since scores ranged from 0 to 15 with increments of 0.1.

A mixed effects model factorial analysis of variance (ANOVA) was performed to detect differences in taste panel flavour and textural attributes scores between products. The product formulation was considered to be the fixed effect in the model (Control, PB1, PB2 PB3, and PB4). The random effect consisted of 12 panellists and the block effect was Batch (1, 2 and 3). Differences in least square mean estimates of panelist taste and texture scoring were examined to find product differences. All analyses were performed using transformed data, where necessary, but raw data are presented for ease of interpretation. All analyses were carried out using PROC MIXED in SAS Version 8.2 for PC Windows.

3. Results and discussion

The bread formula used in this study contained two types of additional proteins: vital gluten and soy isolate. The scope of this work was to increase the bread protein content while maintaining good quality. The desired quality was accomplished by adding the type of protein that preserves the functional properties of wheat gluten, the most essential quality component of wheat flour (Finney, 1943; Finney & Barmore, 1948). Since soy isolate will dilute the visco-elastic properties of gluten and will reduce bread loaf volume, it was used as a blend with vital gluten. Similarly, adding wheat gluten alone will produce undesirable bread qualities. Brabender Farinograph testing was applied to determine the ratios of vital gluten to soy isolate needed for the blend (Sharadanant & Khan, 2003a, 2003b). The presence of excess proteins required changes in the bread formulation to avoid increase in the dough mixing time, thereby preserving the gluten structure needed for gas retention during baking. Use of higher amounts of yeast and ascorbic acid, relative to AACC Method 10-09, was shown to decrease beany taste, while a greater quantity of shortening was needed to facilitate better mixing properties and gluten film formation and spread (AACC, 10-09; Shogren et al., 2003).

Farinograph profiles shown in Fig. 1 represent the control flour and PB3 blend (70:30, flour:protein with 50% gluten and 50% soy). It is apparent from the profile that the control flour peaked to 500 BU in less than two min, while the PB3 blend needed around 5 min. The presence of the extra protein in the blend delayed gluten formation, thus increasing the mixing time. The effect of added protein on the flour water absorption (WA) is shown in Fig. 2 where the added protein increased the WA by up to 40%. The highest WA value was triggered by the occurrence of more protein in the blend containing more vital gluten, i.e. PB2. This indicates that wheat gluten functional properties are influenced by the degree of hydration. The WA increase caused by additional protein is consistent with reports in the literature (Mizrahi, Eitan, Moalem, Bárdos, & Ádány, 1965; Ruth, Every, Gerrard, Gilpin, & Ross, 1969).

Dough stability, as measured by the Farinograph, is a measure of the time needed for the curve to stay at or above the 500 BU. Most commercial bread flours have up to 10 min stability. The PB2 (less flour and more gluten)

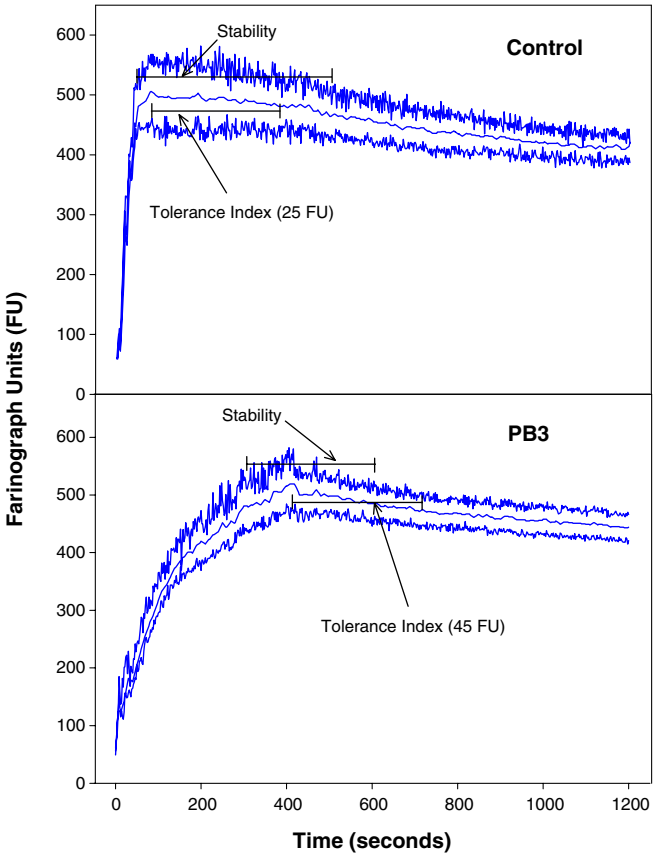

Fig. 1. Brabender profile of the control flour and 70% control flour blended with 30% protein blend (50:50, gluten:soy).

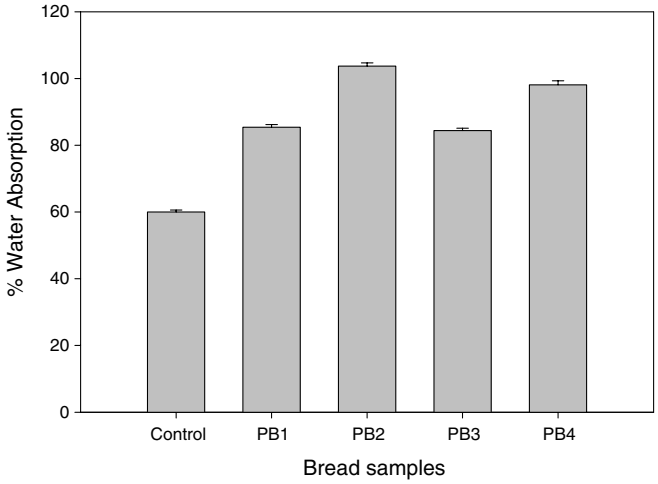

Fig. 2. Brabender water absorption of the control and different blends. The error bars represent the standard deviation. PB1 (70:30 gluten:soy) substituted 30% of wheat flour; PB2 (70:30 gluten:soy) replaced 50% of wheat flour; PB3 (50:50 gluten:soy) replaced 30% of wheat flour; PB4 (50:50 gluten:soy) replaced 50% of wheat flour.

blend showed a similar stability to the control but required higher WA (Fig. 3). This means that the presence of more gluten in the blend compensated for the presence of less control flour and maintained the dough physicochemical properties similar to the control. Samples PB1 and PB4, although containing different amounts of control flour, displayed similar stability due to the presence of vital gluten. The PB3 revealed the lowest stability time (5 min) of all samples evaluated, including the control. The composition of PB3 is closer to PB1 than all other samples because they contain the same amounts of control flour. However, PB3 contained less gluten in the protein blend and that caused it to remain for less time on the 500 BU line.

The mixing tolerance index (MTI) is the difference in Brabender Units between the top of the curve and the top of the curve measured 5 min after the peak is reached. Higher MTI values indicate weaker flour, i.e. flour with inferior bread-baking quality. Samples with more gluten showed overall lower MTI values (Fig. 4). The PB3 sample showed the lowest stability among all samples and the highest MTI value. Therefore, it would be the sample with the lowest baking quality. According to the profiles presented here, the PB4 sample would have the best baking quality of all because of its lowest MTI value.

The water absorption used for baking was different from that of the Farinograph, but the trend remained the same. The loaf height, volume (LV), weight, and density results are listed in Table 1. Samples with higher protein contents (PB2 and PB4 with 56% protein as is) required more water (123%) to form consistent dough, while the other treatments (PB1 and PB3, with 30% protein) entailed 99 and 103%, respectively. For example, it was necessary to add an average of 3% excess of water for every 1% protein blend added to the control flour. The loaf height, measured immediately out of the oven, showed no significant differences ($p < 0.2662$) between the control and the four treatments (Table 1). This indicates that the adjustments made to the ingredients were appropriate, but the LV values indicated significant differences ($p < 0.0001$) between the control and the treatments and within the treatments. Samples with overall higher gluten content revealed higher LVs (Table 1). The cause of significant difference in LV and not in loaf height is the difference in loaf shape; samples with higher non-gluten protein contents lost volume minutes after being removed from the oven and ended up with smaller LVs. The lower LV could be attributed to the lack of enough starch because gelatinized starch forms a gel upon cooling. The loaf weight data showed significant difference between

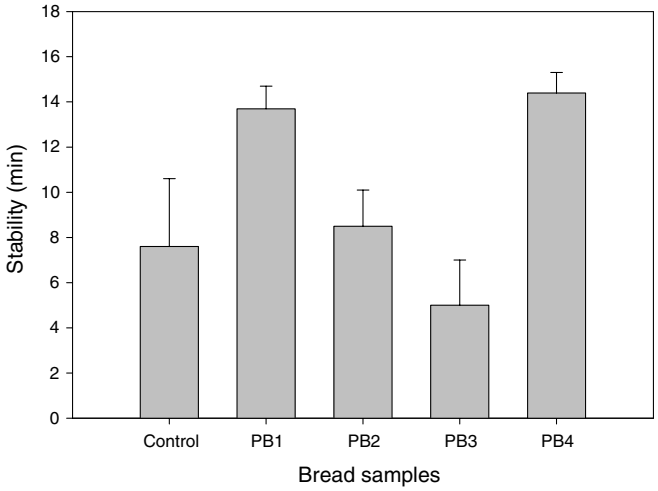

Fig. 3. Brabender stability of the control flour and different blends. The error bars represent the standard deviation. PB1 (70:30 gluten:soy) substituted 30% of wheat flour; PB2 (70:30 gluten:soy) replaced 50% of wheat flour; PB3 (50:50 gluten:soy) replaced 30% of wheat flour; PB4 (50:50 gluten:soy) replaced 50% of wheat flour.

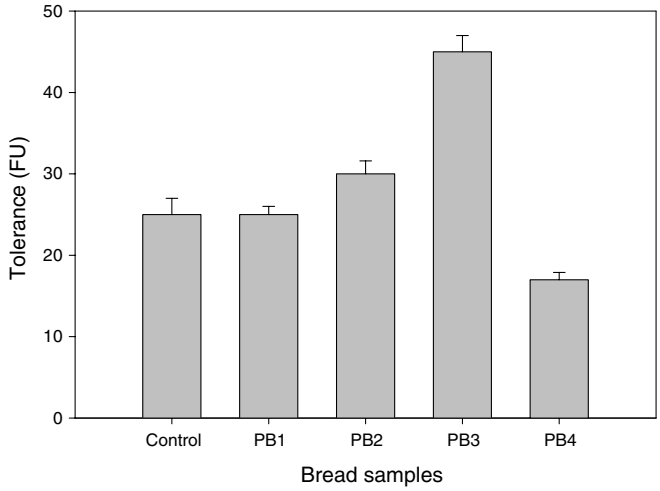

Fig. 4. Brabender tolerance of the control flour and different blends. The error bars represent the standard deviation. PB1 (70:30 gluten:soy) substituted 30% of wheat flour; PB2 (70:30 gluten:soy) replaced 50% of wheat flour; PB3 (50:50 gluten:soy) replaced for 30% of wheat flour; PB4 (50:50 gluten:soy) replaced 50% of wheat flour.

Table 1
Effect of protein level and type on loaf height, weight, volume, and density

Sample	Loaf height (cm)	Loaf volume (cm^3)	Loaf weight (g)	Density (g/cm^3)[D]
Control	88.2 ± 1.5nc[A]	1010 ± 48.3a[B]	148.4 ± 0.6c[C]	0.147b
PB 1[E]	73.2 ± 10.7nc	915.8 ± 64.9b	157.9 ± 1.7b	0.172b
PB 2	74.4 ± 1.8nc	804.3 ± 140.5bc	178.9 ± 3.8a	0.222a
PB 3	69.0 ± 3.7nc	731.7 ± 24.6c	163.6 ± 5.4b	0.224a
PB 4	86.8 ± 2.6nc	813.7 ± 37.1bc	182.1 ± 4.5a	0.224a

[A] Not significantly different. All values were not significantly different, $p < 0.2662$.
[B] Values within same column with same letters are not significantly different, $p < 0.0001$.
[C] Values within same column with the same letter are not significantly different, $p < 0.0001$.
[D] Loaf mass/volume values within same column with the same letter are not significantly different, $p < 0.0012$.
[E] PB1, 2, 3, and 4 = PB1 (70:30 gluten:soy) substituted 30% of wheat flour; PB2 (70:30 gluten:soy) replaced 50% of wheat flour; PB3 (50:50 gluten:soy) replaced 30% of wheat flour; PB4 (50:50 gluten:soy) replaced 50% of wheat flour.

samples according to their water absorption levels. Samples PB1 and PB3 exhibited similar loaf weights, while PB2 and PB4 were alike, with both groups being significantly higher than the control. Higher loaf weight resulted in higher loaf density, as indicated in Table 1. The control flour and sample PB1 showed no significant difference, but they displayed significantly lower densities than the remaining samples. Loaf density reported here is much lower than the density reported in our previous work (Shogren et al., 2003) because those researchers used whole wheat and soy flour rather than the wheat flour, vital gluten and soy isolate used in this work. Whole-wheat flour and soy flour hold more water because of their high fibre contents. Sahni, Krishnamurthy, and Girish (1975) reported a 43% reduction in LV when 10% ground nut protein isolate was added to wheat flour. The data reported here showed a 27% bread LV reduction resulting from adding protein blends in the worst case (i.e. PB3).

Sensory evaluation of the attributes scores and results are listed in Tables 2 and 3. Table 2 lists the attributes

Table 2
Sensory attributes definitions, references preparation and scale

Attribute definition	Reference[a]	Preparation procedure
Beany		
Flavours associated with cooked soybeans, sweet, starchy, legumy, and green/raw soybeans	Canned lima beans, bread 2.5, biscuit 3.5	Drained and washed with cold water. Bread and biscuits were prepared with 50% soy flour based on the flour
Grain		
Combined intensity of all grain flavors	Kelllogg's rice krispies 3.0, Wonder texas toast white bread and kretchmers wheat germ 3.5, rice chex 5.5, keebler 7-grain wheatable cracker 7.0, complete bran flakes 8.0	Thick slices bread. The remaining were used as is
Yeasty		
Aromatics associated with yeast and yeast fermentation. Example, Fleischmann's yeast	Wonder texas toast white bread 4.0, 2% Fleischmanns yeast solution 7.0	Microwave (at high) for 2 min before mixing
Sweet		
Basic taste caused by stimulation of receptor sites by compounds that include sucrose, aspartame, and saccharin. Example, Table sugar	5% sucrose solution 5.0	Dissolve sucrose in water
Bitter		
Basic taste caused by stimulation of receptor sites by alkaloid compounds such as caffeine and quinine. Example, black coffee	0.08% and 0.07% caffeine solution 5.0	Dissolve caffeine in water
Firmness		
Measure the force to bite through the sample with molars	Pound cake 2.0, Fig Newton 3.0, Cheeto puff 5.0, wonder original english muffin 5.5, great value queen olive 6.0	
Denseness		
Measure the compactness of cross section of sample while biting completely through with molars	Rice krispies 2.5, Ritz crackers 4.0, Wonder original english muffin 5.5	

[a] Scale, 0 = none, 15 = intense.

Table 3
Effect of protein blends on the sensory evaluation of bread

Attribute	Sample				
	Control	PB1[B]	PB2	PB3	PB4
Beany[A]	0.20 c	2.66 b	3.25 a	2.53 b	3.21 a
Grain	3.28 a	2.98 b	2.86 b	3.06 ab	2.94 b
Yeasty	3.55 a	2.63 b	2.63 b	2.68 b	2.58 b
Sweet	1.70 a	1.13 b	0.91 c	1.14 b	1.04 bc
Bitter	0.73 d	1.30 bc	1.56 a	1.21 c	1.52 ab
Denseness[A]	3.42 b	4.21 a	4.05 a	4.06 a	3.94 a

Statistical means followed by the same letter are not significantly different.
[A] Variables, yeasty and denseness were statistically transformed, respectively, by $YT = (Yeasty)^2$ and $DT = \log(Denseness - 2.9)$ while the remaining variables did not need transformations.
[B] PB1, 2, 3, and 4 = PB1 (70:30 gluten:soy) substituted 30% of wheat flour; PB2 (70:30 gluten:soy) replaced 50% of wheat flour; PB3 (50:50 gluten:soy) replaced for 30% of wheat flour; PB4 (50:50 gluten:soy) replaced 50% of wheat flour.

definition, references used to develop the score for each attribute, and the sample preparation. Table 3 showed the score collected for each sample, based on the system developed in Table 2. The scale used here was 0 for none and 15 for intense attribute. The beany taste of all samples was significantly higher than that of the control, especially for samples PB2 and PB4, due to their higher soy protein contents. As expected, the beany taste of these samples made with soy protein isolate was also higher than that of breads fortified with soy flour in an earlier study (Shogren et al., 2003). On the scale of 0–15, samples containing soy proteins scored between 2 and 3, which is tolerable because it is similar to lima beans taste, as indicated in Table 2. Grain flavour was significantly lower than the control, possibly due to the presence of beany flavour. The samples showed just slight differences in grain flavour. The yeast flavours for PB1 and PB4 were significantly lower than that of the control with no significant difference between samples. The sweetness values of all samples were lower than the control, possibly masked by the beany taste, which seems to dominate. Significantly, higher bitter taste of all samples was observed, which was possibly developed during overheating of the soy protein. The data recorded for density (Table 1) and denseness (Table 3) placed the control as significantly lower than the samples. This is consistent with the higher water absorption by the protein, as mentioned earlier. However, the calculated density showed no significant difference between the control and the PB1. This is consistent with the composition of PB1, which contained the least amount of added protein and contained more vital gluten.

Bread firmness can be one of the measures of the degree of staling, together with other attributes, such as taste. The time and temperature for testing bread firmness (1 and 5 days, 25 °C) was chosen to reflect average storage time and temperature at the supermarket. Samples with higher wheat flour and lower protein content showed higher firmness values (Fig. 5). This was expected, due to the higher starch and thus higher amylose content than in the samples with higher protein contents. It is widely accepted that bread staling is caused by amylose, and to a lesser extent,

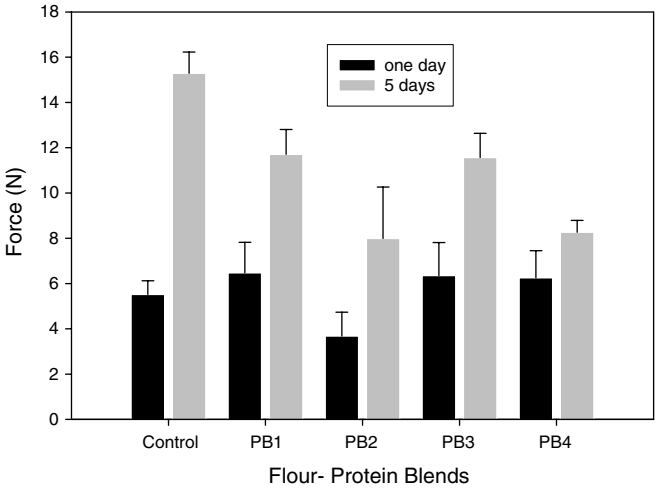

Fig. 5. Bread firmness of the control flour and different blends. The error bars represent the standard deviation. PB1 (70:30 gluten:soy) substituted 30% of wheat flour; PB2 (70:30 gluten:soy) replaced 50% of wheat flour; PB3 (50:50 gluten:soy) replaced 30% of wheat flour; PB4 (50:50 gluten:soy) replaced 50% of wheat flour.

amylopectin retrogradation. Willhoft (1971) suggested that the anti-staling effect of monoglycerides could result from an interaction with gluten, which has since been confirmed. Surfactants interact with proteins during dough mixing, then migrate toward the starch gel during baking to interact with amylose and prevent amylose retrogradation (Knightly, 1996, chap. 2). Since more shortening and more protein content were used in this formulation, it is expected to find lower firmness values for PB2 and PB4 (Fig. 5). The effect of higher protein content on bread firmness was more noticeable after 5 days of storage than one day, due to the low rate of amylose retrogradation on the first day. The high protein content altered the macromolecular content of the bread and thus the overall glass transition of the system. The change in the glass transition was directly related to the molecular relaxation of the bread, which in turn affected the staling process (Parker & Ring, 2001). Samples PB1 and PB3 showed similar firmness values, while PB2 and PB4 had comparable values. The higher firmness values

of PB1 and 3 are the result of higher amounts of wheat flour used, which in turn increases the amylose content.

4. Conclusion

By replacing 30% of the wheat flour, the final carbohydrate content (mostly starch) of the bread was reduced by 30%, because starch constitutes 70% of the flour. Conversely, the 50% wheat flour replacement decreased the carbohydrate content by 50%. Bread with lower carbohydrates showed lower firmness after five days of storage. Low carbohydrate (starch) content and high lysine are the most important characteristics of this product because they constitute two of the most pursued weight loss and nutritional consumer demands.

References

American Association of Cereal Chemists. (2000). *Approved methods of the AACC*, (10th ed.). Method 10-09.

Bacigalupo, A., Aguilar, T. S., Luna De La Fuente, R., & Valle Riestra, J. (1967). Bread enrichment with Protal–Peruvian cottonseed flour. *Cereal Science Today, 12*, 431–436.

Bohn, R. T., & Favor, H. H. (1945). Functional properties of soya flour as a bread ingredient. *Cereal Chemistry, 22*, 296.

Buck, J. S., Walker, C. E., & Watson, K. S. (1987). Incorporation of corn gluten meal and soy into various cereal-based foods and resulting product functional, sensory and protein quality. *Cereal Chemistry, 64*(4), 264–269.

Dervas, G., Doxastakis, G., Hadjisavva, Z., & Triandafilakis, N. (1999). Lupin flour addition to wheat flour doughs and effect on rheological properties. *Food Chemistry, 66*, 67–73.

Doxastakis, G., Zafiriades, I., Irakli, M., & Tananaki, C. (2002). Lupin, soy and triticale addition to wheat flour doughs and their effect on rheological properties. *Food Chemistry, 77*, 219–227.

Finney, K. F. (1943). Fractionating and reconstituting techniques as tools in wheat flour research. *Cereal Chemistry, 20*, 381–392.

Finney, K. F., & Barmore, M. A. (1948). Loaf volume and protein content of hard red winter and spring wheats. *Cereal Chemistry, 25*, 291–3002.

Finney, K. F., Bode, C. E., Yamazki, W. T., Swickard, M. T., & Anderson, R. B. (1950). Baking properties and palatability studies of soy flour in blends with hard winter wheat flours. *Cereal Chemistry, 27*, 312.

Khan, M. N., & Lawhon, J. T. (1980). Baking properties of oilseed protein and isolates produced with industrial membrane systems. *Cereal Chemistry, 57*(6), 433–436.

Knightly, W. H. (1996). In R. E. Hebeda & H. F. Zobel (Eds.), *Surfactants in baked goods freshness: Technology, evaluation and inhibition of staling* (pp. 30–47). New York: Marcel Dekker.

Matthews, R. H., Sharpe, E. J., & Clark, W. M. (1970). The use of some oilseed flours in bread. *Cereal Chemistry, 47*(2), 181–189.

Mizrahi, S., Zimmermann, G., Berk, Z., & Cogan, U. (1967). The use of isolated soybean proteins in bread. *Cereal Chemistry, 43*(2), 193–203.

Mizrahi, T., Eitan, M., Moalem, G., Bárdos, H., & Ádány, R. (1965). Moisture sorption isotherm characteristics of food products: a review. *Cereal Chemistry, 34*, 73–85.

Ofelt, C. W., Smith, A. K., & Derges, R. E. (1954a). Baking behavior and oxidation requirements of soy flour. I. Commercial full-fat soy flours. *Cereal Chemistry, 31*, 15.

Ofelt, C. W., Smith, A. K., & Derges, R. E. (1954b). Baking behavior and oxidation requirements of soy flour. II. Commercial defatted soy flours. *Cereal Chemistry, 31*, 23.

Parker, R., & Ring, S. (2001). In P. Chinachoti & Y. Vodovotz (Eds.), *Bread Staling: Macromolecules aspect of bread staling* (pp. 60–74). New York: CRC.

Ruth, B., Every, D., Gerrard, J. A., Gilpin, M. J., & Ross, M. (1969). Staling in starch bread: the effect of gluten additions on specific loaf volume and firming rate. *Starch/Stärke, 21*, 305–315.

Sahni, S. K., & Krishnamurthy, K. (1975). Development of high protein bread. Part II. Soya flour utilisation. *Journal of Food Science and Technology, 12*, 178–183.

Sahni, S. K., Krishnamurthy, K., & Girish, G. K. (1975). Development of high protein bread. Part I. Groundnut flour and ground nut protein isolate utilisation. *Journal of Food Science and Technology, 12*, 283–289.

Sharadanant, R., & Khan, K. (2003a). Effect of hydrophilic gums on the quality of frozen dough: bread characteristics. *Cereal Chemistry, 80*, 764–772.

Sharadanant, R., & Khan, K. (2003b). Effect of hydrophilic gums on the quality of frozen dough: bread characteristics. *Cereal Chemistry, 80*, 773–780.

Shiraldi, A., Piazza, L., Brenna, O., & Vittadini, E. (1996). Structure and properties of bread dough and crumb: calometric, rheological, and mechanical investigation on the effects produced by hydrocolloids, pentosans, and soluble proteins. *Journal of Thermal analysis, 47*, 1339–1360.

Shogren, R. L., Mohamed, A. A., & Carriere, C. J. (2003). Sensory analysis of whole wheat/soy flour breads. *Journal of Food Science, 68*, 2141–2145.

Willhoft, E. M. A. (1971). Bread staling I and II. *Journal of Science and Food Agriculture, 22*, 176–180.