NOTE

Effect of Varying Flour Protein Content on Angel Food and High-Ratio White Layer Cake Size and Tenderness[1]

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ABSTRACT

The effect of artificially varying cake flour protein content on the size and tenderness of white layer cake and angel food cake was evaluated by varying cake flour protein content from approximately 7 to 16% by air-classification techniques and by adding gluten. Volume and tenderness of white layer cakes were not significantly affected by flour protein content. Height and tenderness of angel food cake decreased as flour protein content increased. However, relatively large (approximately 2%) increases in protein content were required to effect the change.

From crop year to crop year, the protein content of soft wheat may vary because of changes in location, climate, cultivars, and cultural practices. Although this variation may affect the quality of soft wheat products, the evaluation of these effects is complicated by many changes that also occur in the wheat kernel and flour when protein content is artificially adjusted for research purposes. Several workers have studied the influence of protein concentration (nitrogen) on wheat kernels and flour by using the techniques of nitrogen fertilization, chemical foliage sprays, seasonal changes, soil fertility, cultivar differences, or flour air-classification.

Wu and McDonald (1976) observed an increase in the amount of protein nitrogen, nonprotein nitrogen, crude protein, gluten, and soluble protein when wheat was fertilized at seeding time. The ratio of protein to nonprotein nitrogen remained constant. Donovan et al (1977) reported that high-protein kernels had lower kernel weight than did low-protein kernels. Only small differences in the concentration of starch per kernel were observed. A low-protein cultivar had more nonprotein and nonstarch carbohydrate material, which was partially attributed to its lower nitrogen content per kernel.

Strbac et al (1974) observed an increase in gliadin content in higher-protein wheat kernels and a difference in the electrophoretic patterns of gliadins from high- and low-protein kernels. This suggests differences in protein quality and quantity. Farrand and Hinton (1974) dissected wheat kernels and observed that although the protein content of the endosperm decreased toward the center of the kernel, the higher-protein variety was always higher in protein at each of the concentric locations evaluated. Total wheat ash (El Gindy et al 1957) and flour ash (Watson et al 1976) are highly positively correlated with protein content.

Kernel protein and moisture contents were observed by Farrand (1974) to affect flour milling extraction. However, El Gindy et al (1957) observed little influence of kernel protein content on flour milling behavior or flour yield.

Unpublished data from this laboratory suggest that the effect of kernel protein content on soft wheat milling behavior is probably influenced by variety. The resulting effect of protein content on cake flour particle size has not been quantified, but it is also probably affected; this is a subject of current research.

If kernel protein content does affect flour particle size, cake volume may be influenced (Chaudhary et al 1981, Yamazaki and Donelson 1972, Miller et al 1967). A smaller flour particle size also increases the amount of chlorine necessary to achieve a desired pH (Wilson et al 1964), resulting in greater protein solubility (Kissell 1971) and the many other changes that occur when flour is chlorinated (Gough et al 1978).

In this study, fertilizers and foliage sprays were not used to alter kernel protein content. Cake flour protein levels were adjusted downward by air-classification and upward by adding soft wheat gluten and the fines fraction from air-classification. The influence of altered cake flour protein content on the size and texture (tenderness) of white layer and angel food cakes was evaluated.

MATERIALS AND METHODS

Flour and Flour Treatments

A 50% patent soft red winter wheat cake flour (A) was Allis-Chalmers-milled in our laboratory from a blend of many cultivars, and another patent cake flour (B) was obtained from a commercial source. Both flours were chlorinated to pH 4.8 (Kissell and Marshall 1972), and part of each flour was air-classified, producing coarse (95%) and fine (5%) fractions. Soft wheat gluten was prepared by wet fractionation of a hexane-extracted nonchlorinated flour (Yamazaki et al 1977). Lyophilized gluten was ground in a small impact mill (CRC) and passed through a

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screen of 100-μm openings. Flour lipids were not added back to the gluten.

Cakes

White layer cakes (AACC 1979) were baked from flours A and B. Treatments consisted of 1) replacing 6 and 9 g of flour with gluten, 2) replacing 50 g of flour with the appropriate air-classified fine flour fraction, and 3) replacing 50 g of flour with the appropriate straight air-classified coarse flour fraction. Protein contents (AACC 1979) of flours used in these cakes are presented in Table I.

Angel food cakes (AACC 1979) consisted of 1) replacing 5 g of flour with gluten, 2) replacing 9 and 7 g of flours A and B, respectively, with gluten, 3) replacing 25 and 20 g of flours A and B, respectively, with the corresponding air-classified fine fraction, and 4) replacing 25 and 20 g of flours A and B, respectively, with the corresponding air-classified coarse fraction. Protein contents (AACC 1979) of flours used in these cakes are presented in Table II.

Cake Tenderness Measurements

White layer cakes were cooled 1½ hr in the cake pan, depanned, and cake volume was determined by rapeseed displacement. Cakes were then sealed in plastic bags at room temperature for 3 hr, at which time tenderness/compression measurements were taken. Angel food cakes were cooled 40 min in the pan, depanned, and cake height was determined as described in AACC method 10-15 (AACC 1979). Cakes were then sealed in plastic bags at room temperature for 3 hr, at which time tenderness/compression measurements were taken.

Tenderness/compression measurements were taken with a Struct-O-Graph (C. W. Brabender, South Hackensack, NJ) fitted with a 500-cmg spring and a 50-mm disk, and a 250-cmg spring and 40-mm disk for the layer and angel food cakes, respectively. The movable platen was operated at a speed of 140 mm/min and 132 mm/min for layer and angel food cake, respectively, and the chart speed was geared to slowest speed. Layer cakes were quartered, and the top of each piece was removed with an electric knife 2 cm from the bottom. The remaining 2-cm-thick quarters were individually compressed. Angel food cakes were sliced 4 cm thick with parallel sides. Four slices of each cake were compressed individually. Tenderness is expressed as chart distance (in centimeters) required for compression to increase to a resistance of 450 or 225 cmg for layer and angel food cake, respectively. All data are the means of duplicate replications and were analyzed by analysis of variance.

RESULTS AND DISCUSSION

Protein contents of flour A ranged from 7.9 to 14.5% for treatments used in white layer cakes (Table I) and from 7.1 to 12.5% for treatments used in angel food cakes (Table II). Protein contents of flour B ranged from 8.1 to 16.3% for treatments used in white layer cakes and 8.2 to 12.7% for treatments used in angel food cakes. Analysis of variance did not show a significant effect of flour protein content on either white layer cake volume or tenderness. Because much flour protein and white layer cake volume data are also available from the soft wheat cultivar evaluation program of our laboratory, this finding was checked against cakes baked from flours of composited Uniform Nursery Series wheats grown at approximately 29 locations in the eastern United States. For the five crop years from 1977 through 1981, the correlation coefficient between cake flour protein content and AACC white layer cake volume was only -0.12 ($n = 477$, $P = 0.05$) for all cultivars. This comparison, however, is complicated by many factors, especially cultivar differences. Protein content *within* eight cultivars (cultivar composites) for these years was also not significantly correlated with white layer cake volume. Although crop year effects can be quite large and the reasons for protein fluctuations in these eight cultivars are unknown, these large population data do confirm the findings of our controlled study.

In contrast to the response of white layer cake, a significant relationship was found among flour protein content and angel food cake height (F-ratio = 17.7, $P = 0.1$ and F-ratio = 8.4, $P = 0.05$ for flours A and B, respectively). A significant difference

TABLE I
Treatment Origin and White Layer Cake Flour Protein Content of Flours A and B

Flour	Flour Protein Treatment	Flour Protein Content (%)
A	Coarse fraction	7.9
	Control	8.2
	+6 g Gluten	11.3
	+9 g Gluten	12.9
	+50 g Fine fraction	14.5
B	Coarse fraction	8.1
	Control	9.2
	+6 g Gluten	12.3
	+9 g Fine fraction	13.8
	+50 g Fine fraction	16.3

TABLE II
Treatment Origin and Angel Food Cake Flour Protein Content of Flours A and B

Flour	Flour Protein Treatment	Flour Protein Content (%)
A	Coarse fraction	7.1
	Control	8.2
	+5 g Gluten	10.6
	+9 g Gluten	11.2
	+25 g Fine fraction	12.5
B	Coarse fraction	8.2
	Control	9.4
	+5 g Gluten	11.8
	+20 g Fine fraction	12.1
	+7 g Gluten	12.7

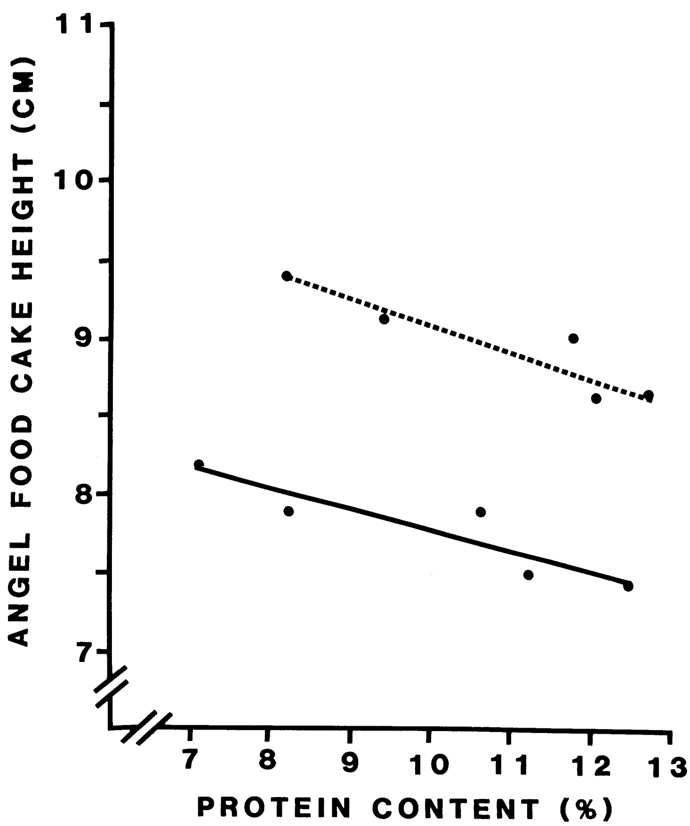

Fig. 1. Relationship of cake flour protein content and angel food cake height. Flour A = solid line, flour B = dotted line. Cake height LSD = 0.37 cm.

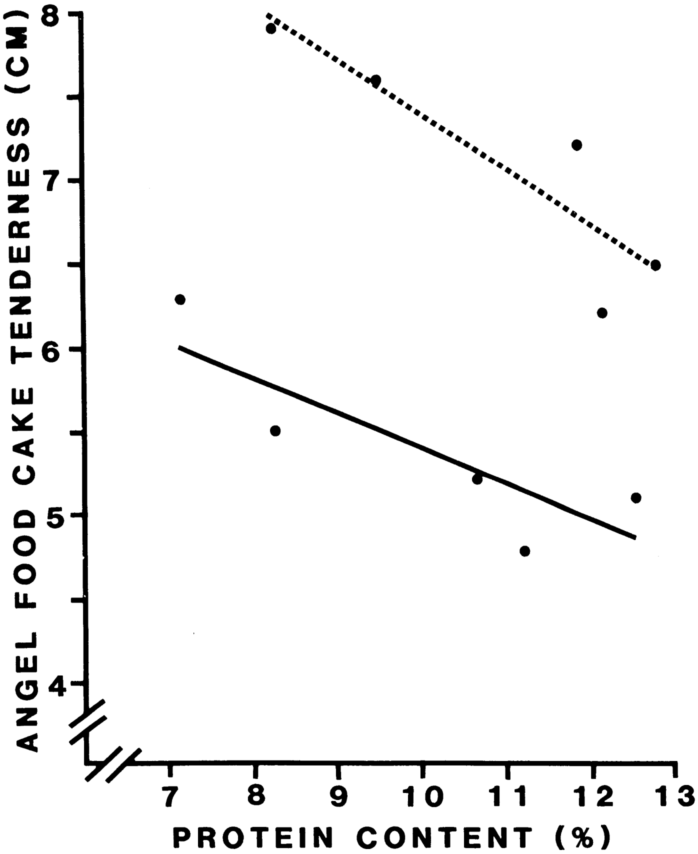

Fig. 2. Relationship of cake flour protein content and angel food cake tenderness. Flour A = solid line, flour B = dotted line. Cake tenderness LSD = 0.52 chart cm.

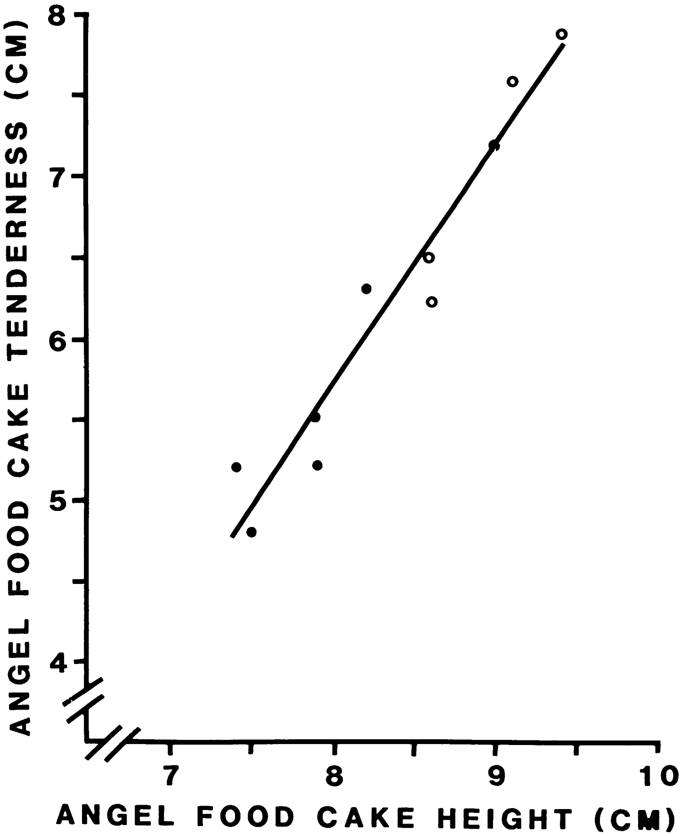

Fig. 3. Relationship of angel food cake height and angel food cake tenderness. Flour A = filled circles, flour B = open circles.

in angel food cake height required changes in protein content of 2.7 and 2.3% for flours A and B, respectively (Fig. 1). Because flours A and B produced two distinct data sets, flour quality factors other than protein content also contributed to differences in angel food cake height. Flour protein content also significantly affected angel food cake tenderness (F-ratio = 27.1, $P = 0.01$ and F-ratio = 18.4, $P = 0.01$ for flours A and B, respectively) (Fig. 2). A significant difference in angel food cake tenderness required a change in flour protein content of 1.8 and 1.6% for flours A and B, respectively.

Flours A and B did not have the same angel food cake tenderness at any protein content, and the slopes in Figure 2 show that the lines are essentially parallel. Thus, another factor was affecting cake tenderness measurements of both flours. Figure 3 shows that angel food cake tenderness was a function of cake height. A 0.34-cm change in cake height caused a small but significant ($P = 0.05$) change in cake tenderness. This statistically measurable change in tenderness can probably not be detected subjectively.

These data from two flours and from two artificial methods of flour protein variation show that cake flour protein content in the approximate range of 7–16% did not significantly influence white layer cake volume or tenderness, but that angel food cake height and tenderness responded to protein content of cake flour. However, protein content must be changed by approximately 2% before significant objective changes occur in angel food cake height or tenderness. Yearly fluctuations in protein content of soft wheat milling stock may normally be less than 1%, and a baker may generally specify only a 0.5% range in flour protein content from a miller. Thus, the necessary 2% fluctuation would not normally be encountered.

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