Steamed Bread. II. Role of Protein Content and Strength

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ABSTRACT

Twenty-nine hard wheat flours ranging in protein content from 9.3 to 14.4% and in specific pan bread volume (cm^3/1% protein) from 9.8 to 54.1 cm^3 and 34 soft wheat flours with protein content from 6.7 to 15.5% and specific pan bread volume from 14.9 to 74.1 cm^3 were compared in making pan bread and steamed bread under optimized conditions. Included in the evaluation were water absorption, mixing time, four alveograph parameters, and bread scores. Protein content was important in production of acceptable steamed bread (especially from low-protein soft wheat flours). High flour strength (as determined by physical dough tests) was desirable in production of pan bread (especially from high-protein hard wheat flours) and detrimental in production of steamed bread. A model using alveograph parameters and protein predicted 82.1% of the variability in pan bread volume potential of bread baked from hard wheat flours. Only 44.0% of the variability in steamed bread volume potential could be predicted from the protein content of soft wheat flours.

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The suitability of wheat flours in the production of Chinese steamed bread (CSB) has been the subject of few investigations. Part I of this series (Rubenthaler et al 1990) described the development of a straight dough formula and procedure for the production of CSB; it involved optimizing the procedure of Faridi and Rubenthaler (1983) for sponge and dough steamed bread. In that study, volume of steamed bread was highly correlated with flour protein. Preston et al (1986) developed a method that involved a fixed mixing time and water absorption level to examine the suitability of Canadian wheats of different extraction levels for steamed bread production and observed that patent flours of lower extraction were superior to standard-grade flours.

McMaster and Moss (1989) recently reported that low-ash, medium-low-strength wheat flour with an approximate protein content of 10% gave the most desirable CSB. In contrast, Lukow et al (1990) reported that current wheat-breeding objectives in the Western Plateau region of the People's Republic of China (PRC) include the development of cultivars with high protein content (about 13%) for satisfactory steamed bread. These investigators examined the milling, rheological, and other quality parameters of 10 spring wheat cultivars from the PRC and four spring wheat cultivars from western Canada (mean flour protein of 13.2%) and studied their relationship with pan bread and steamed bread properties. They reported that the overall performance and rating of the cultivars assessed by Canadian and Chinese standards were similar, indicating that the same factors determine the quality of pan bread and steamed bread. In general, they found protein content and gluten strength to be the most important factors determining steamed bread quality.

The objective of this study was to clarify the role of flour protein and rheological dough properties in steamed bread production. We report also on the extent to which those parameters can be used to predict the quality of pan bread and steamed bread from hard and soft wheat flours varying widely in protein content and strength.

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MATERIALS AND METHODS

Wheat and Flour Samples

Hard wheat flours. Eleven Midwest U.S. plant breeder's hard red winter wheat flours (five from the 1975 crop year and six from the 1979 crop year) and one regional baking standard (RBS-80) were obtained from the U.S. Department of Agriculture (USDA) Grain Marketing Research Laboratory in Manhattan, KS. Six hard red spring and 11 hard red winter wheats from the 1987 crop year grown in two locations (Pullman and Lind, WA), representing a selection of crosses varying widely in genetic background and covering a wide range in breadmaking potential, were obtained from the USDA Western Wheat Quality Laboratory in Pullman, WA. The wheats were milled on a Buhler experimental mill into straight-grade flours.

Soft wheat flours. Five soft red winter wheat flours were obtained from the USDA Agricultural Research Service Soft Wheat Quality Laboratory, Wooster, OH. Seven commercial soft wheat flours milled from wheats grown in the United States, France, and Australia were obtained from the Washington Wheat Commission through the USDA Western Wheat Quality Laboratory. These samples included U.S. soft white winter wheats of low, medium, and high protein contents; U.S. club; and U.S., French, and Australian soft red winter wheats. The samples were milled into straight-grade flours using the Miag Multomat mill.

Eleven soft white winter, eight club, and three soft white spring wheats from the 1987 crop year were obtained from the USDA Western Wheat Quality Laboratory. The wheats were milled on a Buhler mill into straight-grade flours.

Analytical Methods

Moisture, protein contents (N × 5.7), and ash of the flours were determined by AACC methods 46-12, 44-15A, and 08-01, respectively (AACC 1983).

Baking Procedures

Pan bread. The optimized procedure of Finney (1984) was used for the baking tests with 100 g of flour (14% mb). Optimum mixing time and water absorption were determined by mixograph analysis of the flours and by an experienced experimental baker. Specific loaf volume (cm^3/1% protein) was calculated as follows: (Loaf volume − 400)/% Protein.

Steamed bread. Baking procedure and bread score measurements for steamed bread were as described in Part I of this series (Rubenthaler et al 1990). The scoring system was 1 to 10: 1 denoted excellent and 10 denoted highly unsatisfactory crumb grain and texture.

Alveograph Testing

Alveograph tests were performed under conditions of constant dough water content and mixing times using the standard AACC method 54-30 (AACC 1983). For data recording and storage, the modified procedure of Addo et al (1990) was used. The following alveograph parameters were automatically recorded by a computer software program: the maximum overpressure needed to blow the dough bubble, *P*, which is an index of dough elasticity; the average abscissa at bubble rupture, *L*, an index of dough extensibility; the deformation energy, *W*, an index of dough strength; and the minimum point on the first derivative of the alveogram, *DM*, which is inversely related to the breadmaking quality of pan bread.

Statistical Analysis

Data were analyzed using the statistical analysis system as described by the SAS Institute (SAS 1985).

RESULTS AND DISCUSSION

Descriptive statistics for ash, protein, physical dough properties, and baking results for the hard and soft wheat flours are summarized in Table I. All results are expressed on a 14% moisture basis. Samples represented a wide range in all of the variable parameters tested. Protein content ranged from 9.3 to 14.4% with a mean of 11.96% for the hard wheat flours and from 6.7 to 15.5% with a mean of 9.23% for the soft wheat flours. Wide variations in breadmaking quality of the flour proteins are indicated by the wide ranges in specific loaf volumes. Similarly, rheological properties varied widely. Parameters that affected the volume of pan breads also affected their specific volumes and scores.

Simple linear correlation coefficients between protein or rheological parameters and baking data for regular pan bread (RPB) and CSB are presented in Table II. The relationship between protein and loaf volume of RPB and between the same factors of CSB are shown in Figures 1 and 2, respectively. Figure

TABLE I
Protein, Rheological, and Breadmaking Parameters of Wheat Flours

Wheat Flour	Variable	Minimum	Maximum	Mean	Standard Deviation
Hard ($n = 29$)	Protein (%, N × 5.7)	9.3	14.4	11.96	1.28
	Ash (%)	0.32	0.54	0.43	0.07
	Water absorption (%)	59.0	70.2	66.27	2.47
	Mixing time (min)	1.0	7.0	3.07	1.35
	Alveograph				
	P	64.0	164.0	94.24	23.55
	L	48.0	155.0	112.14	30.71
	W	82.0	556.0	319.90	11.63
	DM[a]	1.6	5.0	3.04	0.98
	Loaf volume, RPB[b] (cm^3)	520.0	1,065.0	846.03	136.27
	Specific volume (cm^3/1% protein)	9.8	54.1	37.71	11.35
	Score, RPB	2.0	9.0	4.90	2.41
	Loaf volume, CSB[c,d] (cm^3)	325.0	675.0	500.50	96.21
	Score, CSB	5.4	10.0	8.03	1.58
Soft ($n = 34$)	Protein (%, N × 5.7)	6.7	15.5	9.23	1.75
	Ash (%)	0.30	0.55	0.40	0.07
	Water absorption (%)	51.1	65.5	56.50	3.75
	Mixing time (min)	0.4	4.2	2.01	0.99
	Alveograph				
	P	17.0	158.0	48.00	28.78
	L	30.0	171.0	94.00	34.15
	W	16.0	369.0	116.00	76.17
	DM	1.0	5.2	2.20	5.00
	Loaf volume, RPB (cm^3)	515.0	1,000.0	679.62	96.04
	Specific volume (cm^3/1% protein)	14.9	74.1	30.90	11.78
	Score, RPB	2.0	9.0	7.50	1.97
	Loaf volume, CSB[d] (cm^3)	408.0	675.0	508.30	51.58
	Score, CSB	5.4	10.0	6.61	1.12

[a] An index based on the first derivative of the alveograph curve. See text for details.
[b] Regular pan bread.
[c] Chinese steamed bread.
[d] Loaf volume corrected to 100 g flour weight.

TABLE II
Correlations Among Protein, Rheological, and Breadmaking Parameters

Wheat Flour	Parameter	Regular Pan Bread Loaf Volume	Regular Pan Bread Specific Volume	Regular Pan Bread Score	Chinese Steamed Bread Loaf Volume	Chinese Steamed Bread Score
Hard ($n = 29$)	Protein (%, N × 5.7)	0.113	−0.212	−0.006	0.297	−0.182
	Water absorption (%)	0.520	0.410	−0.361	−0.201	0.271
	Mixing time (min)	0.548**	0.556**	−0.696***	−0.384*	0.563**
	Alveograph					
	P	0.012	0.002	−0.010	−0.107	0.119
	L	0.727***	0.704***	−0.610**	−0.295	0.277
	W	0.748***	0.690***	−0.694***	−0.472**	0.507**
	DM	−0.821***	−0.845***	0.784***	0.393*	−0.489**
Soft ($n = 34$)	Protein (%, N × 5.7)	−0.001	−0.321	0.161	0.663***	0.137
	Water absorption (%)	0.438**	0.374*	−0.382*	0.050	0.255
	Mixing time (min)	0.254	0.333	−0.313	−0.172	0.275
	Alveograph					
	P	0.082	0.019	0.058	−0.011	0.464
	L	0.541***	0.405*	−0.383*	0.330	−0.046
	W	0.375*	0.262	−0.181	0.064	0.498**
	DM	−0.177	−0.213	0.348*	0.026	0.308

***, **, and * = significant at $P < 0.001$, $P < 0.01$, and $P < 0.05$, respectively.

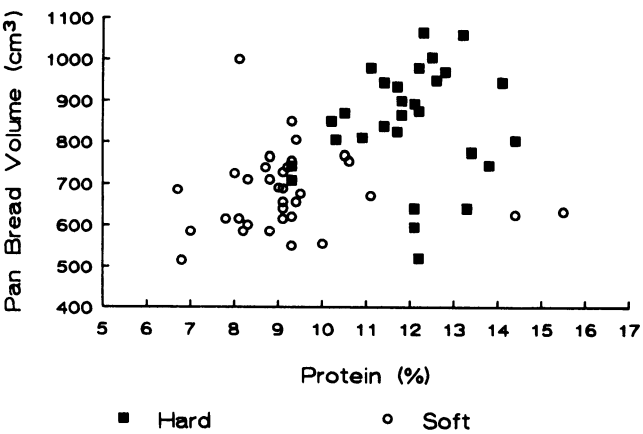

Fig. 1. Relationship between volume of regular pan bread and protein for hard and soft wheat flours.

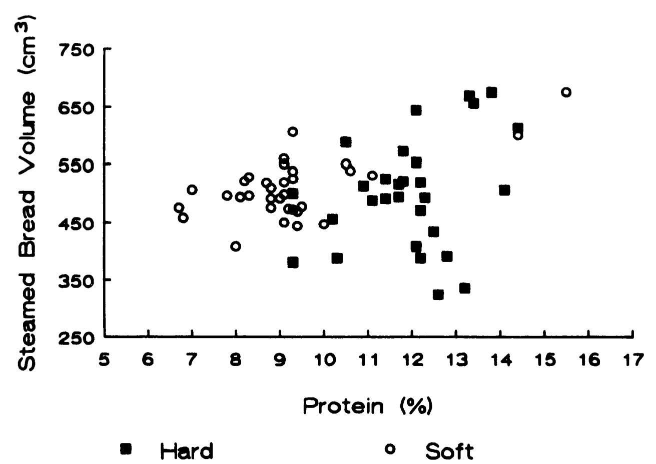

Fig. 2. Relationship between volume of Chinese steamed bread and protein for hard and soft wheat flours.

3 shows the relationship between RPB loaf volume and CSB loaf volume. Volumes of steamed bread baked from soft wheat flour (Fig. 2), but not from hard wheat flour, increased as protein contents increased. Volumes of pan bread and those of steamed bread showed no significant correlations (Fig. 3). Several correlations in Table II are of particular interest. Correlation coefficients between protein content and volume of pan bread were nonsignificant (0.113 and −0.001 for hard and soft wheat flours, respectively). This is the result of a wide range in protein quality as reflected by an almost eightfold range in specific loaf volume (9.8–74.1 $cm^3/1\%$ protein, Table I). The correlation coefficient between protein content and volume of steamed bread was highly significant for soft wheat flour ($r = 0.663$, $P < 0.001$) but not for hard wheat flour ($r = 0.297$, $P < 0.117$). The significance of protein content was much higher for the soft, low-protein (average 9.23%) flours than for the hard, high-protein (average 11.96%) flours. The mean volume of pan bread was 846.03 cm^3 for the hard wheat flours with a mean protein content of 11.96%, whereas the mean volume of pan bread was only 679.62 cm^3 for the soft wheat flours with a mean protein content of 9.23% (Table I). On the other hand, the mean volume of steamed bread baked from hard wheat flours (500.50 cm^3) was even slightly lower than the mean volume of steamed bread baked from soft wheat flours (508.30 cm^3). This is of special interest because volume of steamed bread is highly correlated with protein content of soft wheat flours (Table II). Water absorption and mixing time were positively correlated with loaf volume of pan bread and negatively correlated with volume of steamed bread baked from hard wheat flours. Similarly, there were positive correlations between alveograph

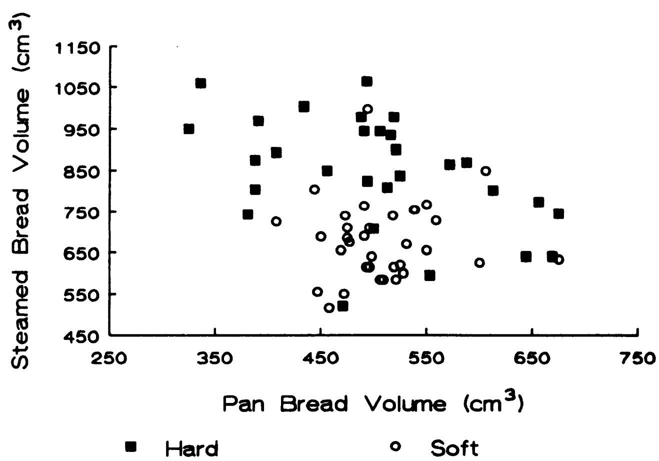

Fig. 3. Relationship between volume of pan bread and volume of steamed bread for hard and soft wheat flours.

W and *L* values and pan bread volume and no significant correlation or a negative correlation between *W* and *L* and steamed bread volume. The higher the alveograph *DM* value, the lower the flour strength (Addo et al 1990). *DM* values were negatively correlated with volume of pan bread and positively correlated or not correlated significantly with volume of steamed bread. The correlation coefficients between volume of pan bread and steamed bread were −0.451 ($P < 0.01$) and 0.064 (not signifi-

TABLE III
Stepwise Regression Procedure for the Dependent Variable Volume of Pan Bread

Wheat Flour	Variable Entered	Model R^2	F	Prob. $> F$
Hard ($n = 29$)[a]	Alveograph *DM*	0.674	55.85	0.0001
	Alveograph *W*	0.786	13.52	0.0011
	Protein	0.821	3.84	0.0362
Soft ($n = 34$)[b]	Alveograph *L*	0.293	13.26	0.0010
	Absorption	0.472	10.49	0.0029

[a]Prediction equation: Loaf volume = 752.84 + 0.54 (W) + 20.50 (protein) − 88.67 (DM).
[b]Prediction equation: Loaf volume = 14.55 + 1.75 (L) + 11.16 (absorption).

TABLE IV
Stepwise Regression Procedure for the Dependent Variable Volume of Steamed Bread

Wheat Flour	Variable Entered	Model R^2	F	Prob. $> F$
Hard ($n = 29$)[a]	Alveograph *W*	0.223	7.74	0.0097
Soft ($n = 34$)[b]	Protein	0.440	25.09	0.0001

[a]Prediction equation: Loaf volume = 26.69 − 0.72 (W).
[b]Prediction equation: Loaf volume = 524.19 + 31 (protein).

cant) for the hard and soft wheat flours, respectively. This indicates that different factors govern the qualities of pan bread and steamed bread. These results agree with those of Faridi and Rubenthaler (1983) and McMaster and Moss (1989), who indicated that flours for production of steamed bread should be of low to medium-low protein (about 10%) and of intermediate to low strength. The results disagree with those of Lukow et al (1990), who postulated that very high protein and high strength are desirable in production of both pan and steamed breads. Lukow et al (1990) used a relatively optimized system (water absorption, mixing time, sugar level) for baking pan bread and very stiff doughs and little sugar to produce steamed bread.

To account for the factors that govern loaf volume potential of pan bread and steamed bread and to develop equations to predict volumes on the basis of chemical and physical dough tests, models using multiple (stepwise) regression analyses were employed (Tables III and IV). The following seven variables were entered into those models: protein content, water absorption, mixing time, and alveograph parameters P, L, W, and DM. Alveograph parameters DM (negative) and W and protein content accounted for 82.1% of pan bread volume variability in hard wheat flours, and alveograph parameter L and water absorption accounted for 47.2% in soft wheat flours (Table III). Interestingly, those prediction models were more effective for hard wheat flours (the customary material for making pan bread) than for soft wheat flours.

In predicting volumes of steamed bread, alveograph parameter W (negative) accounted for 22.3% of variability in hard wheat flours, and protein content accounted for 44.0% in soft wheat flours (Table IV). Those prediction models were more effective for soft wheat flours (the customary material for steamed bread) than for hard wheat flours.

Still, the fact that even in soft wheat flours the use of seven parameters made possible the explanation of only 44% of the variability in production of steamed bread leaves most of the parameters governing the production of this type of bread elusive.

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