Steamed Bread. IV. Negative Steamer-Spring of Strong Flours

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ABSTRACT

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The steamed-breadmaking characteristics of flours differing in inherent protein strength and content were studied, with a particular focus on the retention of volume during the steaming process. The response was coined *steamer-spring*, analogous to *oven-spring* in pan bread baking. A strong negative correlation ($r = -0.86$) was observed between proof height and height after steaming. The strong gluten flours (with large proof heights) collapsed in the steamer or immediately upon removal, whereas the soft wheat and weaker hard wheat flours maintained their proof height or yielded a significant steamer-spring. A negative correlation ($r = -0.76$) between protein content and steamed bread volume was observed among hard red spring wheats, whereas soft white, soft red, and club wheat flours were positively correlated with protein ($r = 0.78$, 0.86, and 0.60, respectively). Strong flours, particularly from high-protein hard wheats, are unsuitable for steamed bread. Soft wheat flours below 9.5% protein are undesirable for high-quality steamed bread. Flours that contain about 10–11% protein and are of medium to low strength are best suited for steamed bread.

The most critical stage in baking conventional pan bread is immediately after the fermented and proofed dough piece is placed in the hot oven (Pomeranz 1987, 1991). During that stage, loaf volume increases because of enhanced yeast activity and expansion of water, alcohol vapor, and gaseous materials, resulting in the so-called "oven-spring." In some cases oven-spring makes it possible to distinguish between satisfactory and unsatisfactory breadmaking flours. Some flours may perform quite well up to the baking stage yet fail in the oven. This fact has led to misinterpretation of some rheological tests that evaluate flours at room temperature and provide less than complete information about the breadmaking potential of tested flours. We have previously observed (Addo et al 1991) a negative correlation between the loaf volumes of pan bread and Chinese steamed bread and noted that some rheological parameters of dough that are positively correlated with pan bread volume are negatively correlated with Chinese steamed bread volume (Addo et al 1990). Whereas in most of the samples (mainly soft white wheat flours) bread volume increased during steaming, in some the volume collapsed and a "negative" "steamer-spring" response resulted. We were therefore interested in following this phenomenon further and in determining what is responsible for the variable steaming response among flours when Chinese steamed bread is produced.

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MATERIALS AND METHODS

Eight wheat flours were selected for the first phase of this study. The flours are listed and described with some baking characteristics in Table I. The Montana hard red winter (HRW) wheat flour was a commercial mill mix obtained from Centennial Mills (Archer Daniels Midland Co.), Spokane, WA, and was milled

TABLE I
Breadmaking Characteristics of Pan and Steamed Bread Before and After Steaming

				Steamed Bread						
									Volume[d]	
Flour	Wheat Class[a]	Flour Protein (N × 5.7) (%)	Pan Bread Volume (cm³)	Volume (cm³)	Score[b]	Proof Height (cm)	Bread Height (cm)	Difference in Height[c] (cm)	At Proof (cm³)	After Steaming (cm³)
Montana	HRW mix	13.3	950	500	1	4.4	2.5	−1.9	125	127
OR 487006	HRS	12.7	950	625	1	4.7	2.7	−2.0	126	123
Kodiak	HRS	12.7	1,150	550	1	4.5	2.2	−2.3	131	103
MPC-850712	HWS	12.8	850	600	1	4.8	2.7	−2.1	150	112
Bread standard	HRW	12.3	1,025	840	2	4.2	3.5	−0.7	112	183
Weston	HRW	12.3	950	978	3	3.8	3.9	0.1	109	211
Cookie standard	SWW/club	8.1	750	903	4	4.0	4.1	0.1	110	184
White Spear	Club mix	8.7	745	888	4	3.7	4.0	0.3	111	201

[a] HRW = hard red winter, HRS = hard red spring, HWS = hard white spring, SWW = soft white winter.
[b] On a scale of 1 = worst, 5 = best.
[c] Between proof and bread heights.
[d] Calculated from measurements of length times width times height of individual buns.

on a laboratory Buhler flour mill to a straight grade flour. Four additional hard wheats, OR 487006, Kodiak, MPC-850712, and Weston were from experimental plots grown at Moro, OR, in 1989 and were also milled to straight grade flours on a laboratory Buhler mill. The bread standard was a commercial bread flour obtained from Centennial Mills and was produced from a blend of HRW wheats. The cookie standard and White Spear flours were obtained from Fisher Flour Milling Co., Seattle, WA, and were produced from blends of soft white winter and club wheats for cookie flours. None of the flours was treated with chemicals or additives.

Flours used in the second phase, which was to confirm observations of differences between soft and hard wheat flours in steamed bread response to protein content, were made up of an additional 54 soft and 29 hard wheat flours. They were cultivars of wheats currently grown in the Pacific Northwest and were obtained from experimental nurseries at Lind and Pullman, WA, in 1988 and 1989. The soft wheat protein ranged from 6.3 to 15.6% and the hard wheat protein from 9.3 to 14.3%. Protein content was determined by AACC Method 44-15A (AACC 1983). Mixographs were determined by the 10-g method described by Finney and Shogren (1972).

The wheat flours were evaluated in breadmaking. The formula included 100 g of flour, water as needed, 1.5 g of sodium chloride, 1.8 g of instant active dry baker's yeast, 4 g of nonfat dry milk, 6 g of sugar, 0.5 g of 60°L malt syrup, 3 g of shortening, and 40 ppm ascorbic acid. The doughs were mixed to optimum as determined by an experienced experimental baker and on the basis of the mixograph data. A straight dough procedure with a 90-min fermentation time at 30°C was employed. Punching and panning were done mechanically. Proof time was 35 min at 30°C. Baking time was 24 min at 218°C. Loaf volume was determined immediately after baking by the dwarf rapeseed displacement method.

The flours were made into Chinese steamed bread, as described by Rubenthaler et al (1990). The basic method involved optimum mixing time and water absorption of 160 g of flour (14% mb), 1% instant active dry yeast, 8% sucrose, 2% shortening, and 1% salt (flour basis); fermenting for 3.5 hr; proofing for 58 min; and steaming, unless stated otherwise, for 10 min. The volume, texture, and overall score were determined as described by Rubenthaler et al (1990) and Faridi and Rubenthaler (1983). In addition to volume of the steamed bread, the width, length, and height of fermented and proofed doughs and the finished steamed bread were determined. Differences of 20 ml in volumes of steamed breads were significant at the 5% level. Texture was determined by the Fudometer (Rubenthaler et al 1990) on bread from which the top 1 cm was cut off; the lower the value, the softer the bread crumb. The bread was scored on a scale of 1 (worst) to 5 (best). The score was based on visual observation of the outside

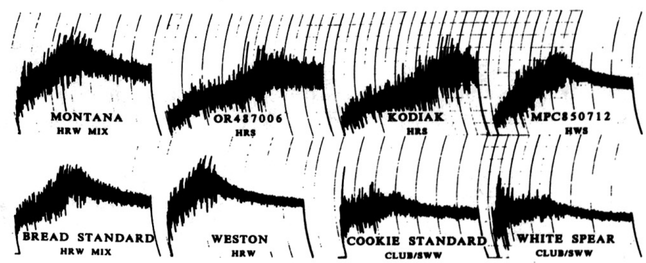

Fig. 1. Mixograms of eight flours (six hard and two soft) arranged in order of decreasing dough strength.

(symmetry, smoothness, and glossy or bright appearance) and the inside (fineness and uniformity of crumb grain) of the bread.

All baking tests and chemical determinations were made in at least duplicate, and the results are averages of those determinations. Standard deviations and other statistical analyses were obtained by a SAS statistical program for personal computers (SAS 1985a,b).

RESULTS AND DISCUSSION

The eight wheat flours selected for the first phase of this study differed considerably in physical, chemical and bread-baking characteristics (Table I). The Montana HRW mix was a typical blend used for the production of commercial pan bread flour. The flours from the two experimental wheats (OR 487006 and MPC-850712) and the cultivars Kodiak and Weston were similar in protein contents (12.3–12.8%) but differed significantly in dough mixing and inherent pan bread baking properties (2–6 min mixing time and 850–1,150 cm³ loaf volume).

The mixograms in Figure 1 demonstrate both strong and weak flours. The top four mixograms have relatively strong dough mixing properties, whereas the lower four, which include the commercial pan bread flour and the hard red winter cultivar Weston, are notably weaker. The flours are arranged from the top (left to right) in generally decreasing dough strength. Of the hard wheats, Kodiak has an exceptionally good loaf volume; the bread standard is excellent; the hard white spring wheat MPC-850712 is poor; and the other three, at 950 cm³, are good and quite acceptable for their protein content. In steamed-breadmaking, four of the six hard wheats totally failed on the basis of score and volume (Montana HRW mix, OR 487006, Kodiak, and MPC-857012); the bread standard was fair; and Weston was nearly as good as the two soft wheat flours (cookie standard and White Spear). Height before steaming (after proof) and height after steaming were highly and negatively correlated ($r = -0.86$; Fig. 2 and Table II). The differences in height before and after steaming were highly correlated with steamed bread volume (r = 0.95) but poorly correlated with pan bread volume (r = −0.58). The hard wheats had greater proof heights but yielded poor steamed bread volume. A collapse in the steamer was observed for hard wheats with the exception of Weston and to a lesser degree the bread standard. A similar strong negative correlation (r = −0.86) was found between the calculated volumes of the buns before and after steaming. No explanation can be offered for the positive response of Weston and the bread standard to steaming other than pointing to the fact that these two were the weakest among the hard wheat flours in dough mixing properties (Fig. 1).

Figure 3 shows the proofed dough (bun) immediately before steaming, the steamed bread, and the internal crumb grain of the cookie standard, Weston, and Montana mill mix wheats. The flours with strong gluten collapsed in the steamer or immediately upon removal, whereas the weaker hard wheats and the soft wheats maintained their proof height or yielded a significant steamer-spring.

Earlier modeling work using response surface methodology (Ylimaki et al 1988, Rubenthaler et al 1990) showed optimum steaming time to be about 10 min. Since the modeling was done with soft wheat flours, an additional study was made to determine whether further steaming is required to "set" stronger gluten flours. A series of steaming times from 8 to 16 min with three of the hard wheat flours and the two soft wheat flours indicated that a slight improvement could be obtained with an additional 2 min of steaming but that it did not significantly change the outcome (Fig. 4).

The plots in Figure 5 of the additional 20 hard red winter wheat flours and nine hard red spring wheat flours, which varied in protein content from 9.3 to 14.3%, show a decrease in steamed-bread volume as the protein level increased. This is particularly so with the stronger spring wheat cultivars, which exhibited a negative correlation coefficient (r = −0.77) with a standard error of estimate of 43 cm^3. Among the 20 HRW wheats, the correlation (r = −0.23) was poor, indicating that crude protein was not a single determining factor for steamed-breadmaking. All the breads handled and proofed normally, but in those that failed, the cause

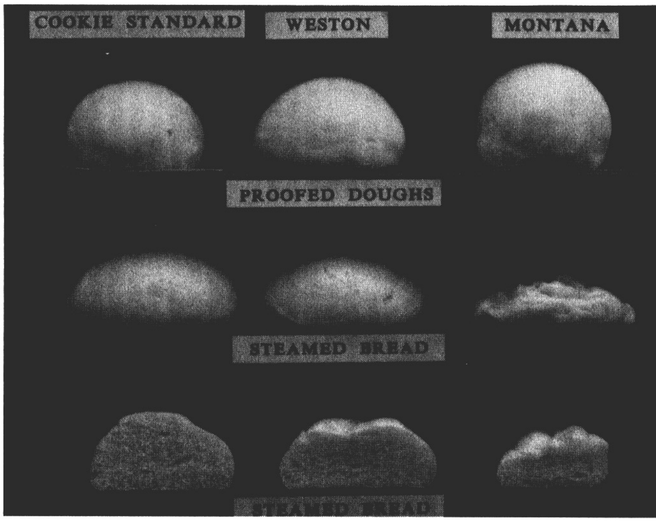

Fig. 3. Proofed bun (top), steamed bread (middle), and internal crumb grain (bottom) of the cookie standard (soft wheat), Weston (weaker hard wheat), and Montana mill mix (hard wheat) flours.

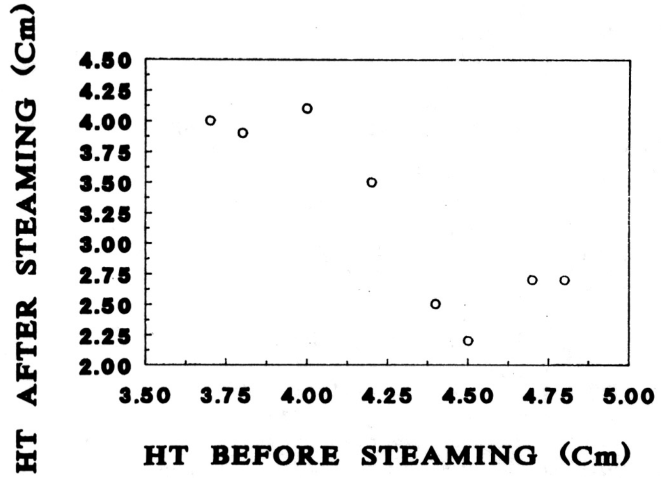

Fig. 2. Plot of bun height before steaming (end of proof) vs. bread height after steaming.

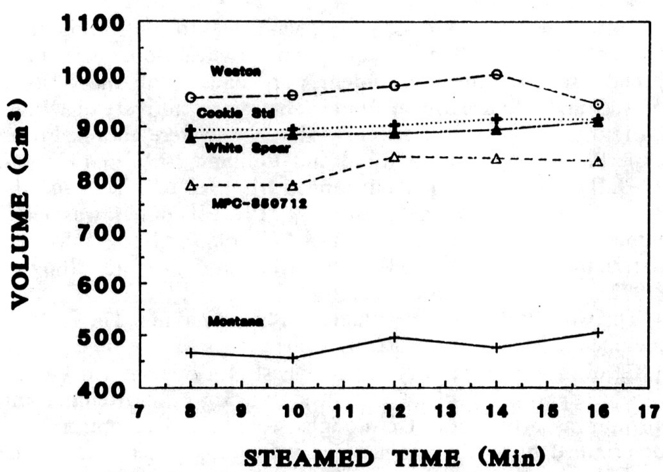

Fig. 4. Volume response to steaming times of 8–16 min of good and poor steamed-bread flours.

TABLE II
Correlation Coefficient Matrix of All Factors Listed in Table I

	Pan Bread Volume	Steamed Bread: Volume	Score	Proof Height	Bread Height	Height Difference[a]	Volume: At Proof	Volume: After Steaming
Flour protein	0.75	−0.64	−0.90	0.66	−0.77	−0.76	0.55	−0.60
Pan bread volume		−0.45	−0.68	0.40	−0.65	−0.58	0.21	−0.46
SB[b] volume			0.88	−0.84	0.96	0.95	−0.78	0.95
SB score				−0.90	0.95	0.96	−0.76	0.87
SB proof height					−0.86	−0.94	0.87	−0.92
SB height						0.98	−0.78	0.95
SB difference[a]							−0.84	0.97
SB proofed volume[c]								−0.86

[a]Between proof and bread heights.
[b]Steamed bread.
[c]Calculated from measurements of length times width times height of individual buns.

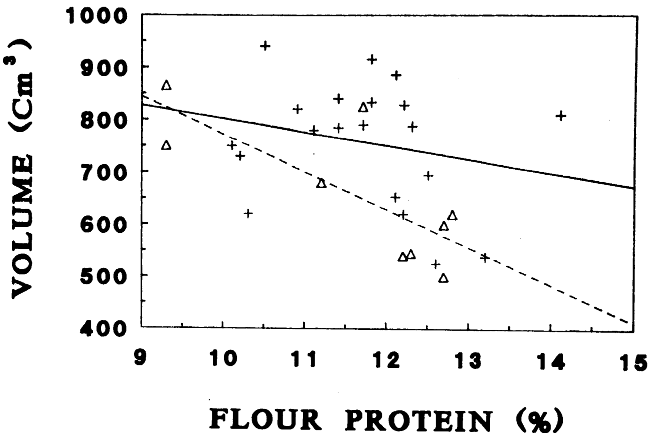

Fig. 5. Plots of protein of 20 hard red winter (+,—) and nine hard red spring (△,---) wheat flours vs. steamed-bread volume.

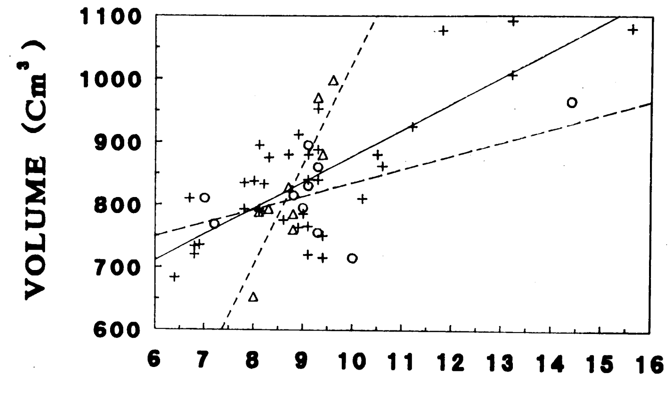

Fig. 6. Plots of protein of 35 soft white winter (+,—), 10 club (○,- -), and nine soft red winter (△,---) flours vs steamed bread volume.

presumably was a lack of steamer-spring.

A similar plot in Figure 6 for the 54 soft wheats shows a positive response in steamed-bread volume with protein content. The protein ranged from 6.3 to 15.6%, and the response appeared linear over this range. The correlation coefficients for the 35 soft white winter, 10 club, and nine soft red winter wheats were 0.79, 0.60, and 0.86, respectively. The standard deviations at the 0.05% level were 45, 60, and 92 cm^3, respectively. These results are in agreement with those reported by Faridi and Rubenthaler (1983) with soft white wheat cultivars.

Comparing the results in Table I and Figures 5 and 6, one can conclude that satisfactory steamed bread (in volume and overall quality score) can be produced in certain HRW wheats with lower and weaker protein. On the other hand, in selecting soft wheat flour for high quality steamed bread, care should be taken to select flours above 9.5% protein.

There appears to be an association between overall gluten or dough strength, as partially measured by physical dough development curves, and the observed negative and/or positive steamer-spring. Strong flours, and particularly higher-protein hard wheats, are unsuitable for steamed bread (Table I and Fig. 5). Such flours are satisfactory for pan bread production, but when used for steamed bread production, they seem to fail, apparently because they overextend during the proof stage and are taxed during the steaming stage. The semisoft texture and the lack of a solid crust may limit their capacity to retain the large volume attained at the end of the proof (see Table I), in which the proof heights of the unsatisfactory steamed breads are higher (4.4 cm or above) than the satisfactory steamed breads (4.2 or lower). While protein content and strength contribute to steamed-breadmaking potential, the role of starch (including the extent of its damage during milling and its gelatinization properties) cannot be excluded.

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