Effect of Hydrogen-Peroxide Treatment of Skim Milks for Sponge Bread Baking

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Since the time of the pioneer work of Greenbank *et al.* (1), the U.S. Department of Agriculture has maintained continued interest in the utilization of milk in bread-baking. Curtailment of its use in baking by problems arising from changes in dough production techniques has led us to study more intensively the influence of milks on doughs and to consider chemical methods for modification of milk to render it more suitable for bakery use.

Nonfat dry milk (NFDM) increases the oxidation requirements —normally supplied by potassium bromate—for doughs used in conventional baking (2). Milk requires extra amounts of both potassium bromate and potassium iodate (3) in the continuous bread-baking process. Milks for bread-baking require high-heat-treatments in excess of 74°C., holding for 30 min. (4). They are characterized by low Harland and Ashworth (H&A) (5) values, reflecting the denaturing effects of heat on serum proteins, and also show increased absorption which is due to casein destabilization (4).

Paulsen (6) reports that the bread-baking properties of soy flour can be improved by treatment with $CaCl_2$ and H_2O_2. The use of H_2O_2 to process milks for cheese has been covered by patent (7) and by publications (8,9). Patel *et al.* (10) reported that addition of 0.05 or 0.10% H_2O_2 to milk heated at 88°C. for 30 min. improved grain, texture, and, to some extent, volumes of continuous breads made with 6% NFDM in the control of absorption, oxidation level, and mixing speed.

The purpose of our paper is to report on some sponge bread-baking properties of NFDM made from fluid skim milk heated with different levels of H_2O_2. The NFDM's were also characterized by viscosity, H&A values, farinograph studies, and moisture and solubility indices.

Materials

Flours. A commercial HRW wheat flour of 12.2% protein that was bleached and malted, and a commercial HRS (wheat flour) of 12.7% protein that was bromated, bleached, and malted were used.

Nonfat Dry Milks. These were prepared from raw fresh skim milks. The fluid milks were rapidly heated to the desired temperature, H_2O_2 was added where desired, and milks were held for 30 min., then cooled to 32°–38°C. Enough catalase was added to H_2O_2-treated milks to destroy H_2O_2 within 10 to 15 min. as judged by the method of Tepley (8). The milks were then flash-heated to 60°C. in the Mallory heater and condensed to 40% total solids *in vacuo* with two passes in a Wiegand-Harris falling film evaporator[1], leaving at about 50°C. They were then spray-dried in a Gray-Jensen dryer at about 140°C. inlet temperature, 105°C. exhaust temperature. Concentrates were heated by stirring in 10-gal. cans set in a steam-hotwater bath for 15 min. after coming up to 80°C.

Skim Milks. Raw skim milks (310 g.), 1 day old, were brought to temperature by immersion of flasks in a constant-temperature water bath. H_2O_2 was then added, the contents being held for various times at different conditions. When H&A determinations (12) were made, the milks were chilled to 32°C. before addition of catalase to destroy excess H_2O_2. Analytical grade 31.0% H_2O_2 was used and was added on a v./v. basis without dilution.

Catalase. A commercial preparation of enzyme was used containing 100 Keil units/cc. Enzyme was added at a dosage of 3 Keil units/lb. of fluid milk containing 0.25% H_2O_2.

Methods

Baking. Sponge-and-dough method as outlined in Cereal Laboratory Methods (13) was used. The formula is given in Table I. With 6% NFDM, the farinograph absorption of flour + 4% water was used as a measure of dough absorption. An optimum mixing plus extended mixing time were used in characterizing doughs. Bread volume was taken 1 hr. after cooling and corrected to 1-lb. loaf weights. Breads were stored overnight in a closed cabinet and then scored.

Breads were scored 20 points for volume, 15 each for symmetry and crumb color, 10 for crust color, and 20 each for texture and grain. Standard slices assigned numbers were used to judge grain.

In each experiment, quadruplicate doughs were mixed in random order on four separate days, yielding a total of eight loaves. Data were then statistically treated (14). Mixing times reported are for second speed.

[1]Mention of brand or firm names does not constitute an endorsement by the Department of Agriculture over others of a similar nature not mentioned.

Table I. Sponge Dough Formula

	Sponge %	*Dough* %
Flour	65	35
Water	61 HRW 63.5 HRS	vari.
Sugar	......	7.5
NFDM	......	6 or 3
Shortening	......	3
Yeast	2.25	......
$CaH_4(PO_4)_2 \cdot H_2O$	0.37 (6% NFDM) 0.185 (3% NFDM)	
Salt	......	2.25
Diamalt	0.5	......
Arkady[a]	0.5	......
Dough temp.	76 ± 1°F.	80°–81°F.
Set	4 hr. 86°F., 85% r.h.	40 min. floor time 86°F.; 12 min. int. proof; 60–65 min. proof 96°F. at 95% r.h.

[a] Yielding 15 p.p.m. $KBrO_3$.

Table II. Effect of Level of Added H_2O_2 on Its Consumption in Fluid Skim Milk Held at 63°C. for 30 Minutes

Added %	*Consumed* %
0.015	0.008
.031	.013
.062	.020
.125	.028
.250	.029
.330	.026
0.440	0.028

Table III. Effect of Holding Time and Concentrations of Hydrogen Peroxide on Harland Ashworth Values of Skim Milk Held at 63°C.

Con. of H_2O_2 (Fluid Milk) %	*Holding Time* min.	*WPN* mg/g.	*H_2O_2 Consumed* %
0	30	6.35	......
0.25	1	6.55	0.011
0.25	10	6.35	0.023
0.25	20	5.00	......
0.25	30	4.15	0.025
0.25	60	3.90	0.029
0.50	30	3.48	......
1.00	30	3.48	......

Low speed for 1 min. was used to incorporate ingredients.

Farinograph. A model PL-2H Farinograph running at 63 r.p.m. was equipped with a 300-g. bowl. In the 300-g. constant flour weight procedure (13), curves were centered on the 500 B.U. line when water, flour, 6% NFDM, and 2% salt were mixed. NFDM absorptions were determined by the method of Hoffman *et al.* (15) with a 40% initial absorption for NFDM.

Determination of H_2O_2 in Fluid Milk. Excess unreacted H_2O_2 was determined by an adaptation of the method used to quantitatively determine bromates in flour (13). In this procedure, 50 ml. of freshly treated and cooled milk was added to 150 ml. water, followed by 25 ml. of 0.36*N* $ZnSO_4$ and 25 ml. of 0.18*N* NaOH. After filtration, the H_2O_2 remaining was titrated iodometrically with 0.02 to 0.10*N* sodium thiosulfate. A dilution of H_2O_2 heated in phosphate buffer of 0.1 ionic strength and pH 6.6 was used to determine the total amount of H_2O_2 added. Heating at 63°C. in buffer had no effect on the H_2O_2 titer. For comparative purposes, milk was assumed to have a specific gravity of 1.035.

Viscosity of 40% Concentrates. NFDM (160 g.) was added to 240 ml. of water, stirred by hand, and then stirred with a motor-driven paddle for 10 min. After this had set 2 hr. at 25°C., viscosities were taken on the Brookfield viscometer.

Moisture and Solubility Indices. Determinations were made according to Standard Methods of Analysis of the American Dry Milk Institute (16).

Compressibility. Compressibility was determined with the Baker Compressimeter on six uniform cut slices from the centers of loaves. The bread was stored in polyethylene bags at room temperature and cut uniformly immediately before analysis. Results are expressed as g. of load to depress a slice of bread 3 mm. with the fulcrum in No. 1 position.

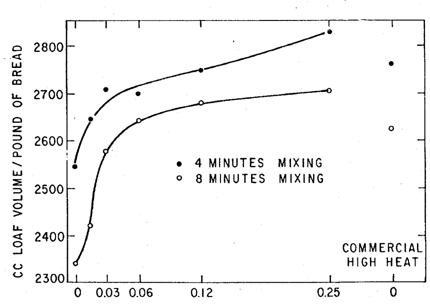

Fig. 1. Effect of 6% NFDM made from fluid skim milk heated with H_2O_2 at 63°C. for 30 min. on loaf volumes of sponge breads made with HRW wheat flour (63.5% absorption).

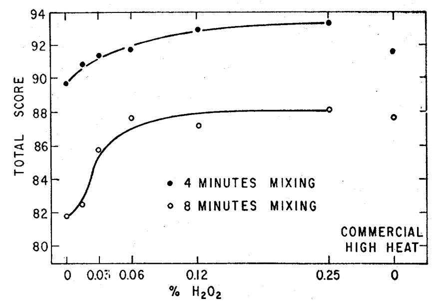

Fig. 2. Effect of 6% NFDM made from fluid skim milk heated with H_2O_2 at 63°C. for 30 min. on total scores of sponge breads made with HRW wheat flour (63.5% absorption).

Results

Figure 1 shows the effect of H_2O_2 concentration in the fluid skim milk held at 63°C. for 30 min. on loaf volume of HRW wheat bread containing 6% NFDM. A commercial high-heat milk was also evaluated. Optimum and extended mixing times were used. The data show that the volumes increase progressively with increasing concentrations of H_2O_2 used in the fluid milk. The volume of bread made from milk treated with 0.25% exceeds that of the high-heat control. All treatments of milk tended to progressively improve the handling qualities of the doughs, those of the high level of H_2O_2 very closely approaching those of the high-heat control milk.

Collaborative "pup" bakes with 4% NFDM also showed that the NFDM with 0.25% H_2O_2 yielded the highest volume but was slightly stickier than high-heat controls.

Figure 2 shows data similar to those of Fig. 1, except that total scores are evaluated. Again the total score of NFDM made with 0.25% H_2O_2 exceeds that of the commercial high-heat control.

Increasing amounts of H_2O_2 added to fluid skim milk held at 63°C. for 30 min. are consumed until the 0.125% level is reached, and then the amount consumed is relatively constant (Table II). Contribution of the catalase in milk at this temperature was almost negligible.

Table III shows the effect of holding time on H&A values of milks held at 63°C. At the 0.25% level of H_2O_2, the H&A values decrease up to 60 min. of holding time. Higher levels of H_2O_2 yield slightly lower H&A values. The table also shows that increasing the time of holding at 63°C. increases the consumption of H_2O_2.

At 63°C. holding for 30 min., increasing levels of H_2O_2 progressively decrease H&A values and increase absorption to heating levels intermediate between 63° and 85°C. (Table IV). Viscosities of 40% concentrates increase up to the 0.06% H_2O_2 level. H&A values of milk preheated with H_2O_2 at 85°C. are slightly higher than the 85°C. control, and viscosities are considerably higher.

Heating fluid skim milk at 63°C. with incerasing levels of H_2O_2 progressively strengthens the farinograph stability of doughs made with HRW wheat flour, 6% NFDM, and 2% salt up to that of the high-heat controls (Table V). Heating milk with 0.25% H_2O_2 at 33°C. pro-

Table IV. Analysis of Milks Treated with Hydrogen Peroxide

Sample	Fluid Milk (30 min.)	H_2O_2 in Fl. Milk	Dry Powder: Moisture	Dry Powder: S.I.[a]	Viscosity of 40% Conc.	WPN (H & A)	Farinograph Test 50 Flour/50 NFDM: Devel. Time	Farinograph Test 50 Flour/50 NFDM: Abs.
	°C	%	%		cp.	mg./g.	min.	%
CSH[b]	....	....	2.8	....	170	1.25	12.5	57.0
P	85	none	4.4	0.4	188	1.00	16.5	51.0
K	85	0.250	6.4[c]	0.5	345	1.70	7.5	52.0
AD	85	0.062	4.8	1.0	1,260	1.80	12.5	52.0
Q	63	0.250	4.8	0.5	160	3.50	21.0	45.8
U	63	0.125	4.4	0.5	172	3.80	39.5	42.6
X	63	0.062	3.2	1.8	180	5.30	34.0	42.8
Y	63	0.031	2.6	1.0	135	6.50	59	40.0
Z	63	0.015	3.6	1.2	80	7.65	66	40.0
O	63	none	3.6	0.2	65	6.50	......	39.2
W	33	0.25	5.2	2.0	150	5.65	......	37.0

[a] Solubility Index.
[b] Commercial super-heat.
[c] High moisture was due to drying a concentrate of 44% total solids.

Table V. Farinograph Data on Nonfat Dry Skim Milks Treated with Various Levels of H_2O_2: HRW Wheat Flour + 6% NFDM + 2% NaCl

Sample	Fluid Milk (30 min.)	H_2O_2 in Fluid Milk	Absorption	A[a]	B[a]	C[a]	MTI[a]
	°C	%	%	min.	min.		
CSH[b]	....	none	62.7	6.5	15.5	28.5	10
P	85	none	62.7	7.5	19.0	26.5	20
K	85	0.25	62.7	7.0	18.0	27.0	10
Q	63	0.25	62.7	7.5	18.0	28.0	5–10
U	63	0.125	62.7	7.5	15.0	25.5	5
X	63	0.062	62.7	7.5	14.5	21.5	20
Y	63	0.03	63.3	8.5	15.5	18.5	15
Z	63	0.015	63.3	9.0	14.5	13.0	30
O	63	none	62.7	8.5	12.5	8.0	65
W	33	0.25	62.7	7.0	13.5	12.0	60

[a] A, arrival time; B, peak time; C, stability; MTI, Mixing Tolerance Index.
[b] Commercial super-heat.

Table VI. Effect of Various Heat-Treatments and Levels of H_2O_2 Added to Fluid Skim Milk on Baking Quality of Doughs with 6% NFDM

Sample	H_2O_2	Fluid Skim Heated 30 min.	Mix Time 4 Minutes: Loaf Volume	Mix Time 4 Minutes: Total Score	Mix Time 8 Minutes: Loaf Volume	Mix Time 8 Minutes: Total Score	Std. Dev. by Ranges: Loaf Volume	Std. Dev. by Ranges: Total Score
	%	°C	cc.		cc.		cc.	
HRW flour, 63.5% abs.								
Comm'l high-heat control	....	....	2,789	91.12	2,600	85.56	±89	±1.70
Q	0.25	63	2,862	91.50	2,617	86.19	....	....
X	0.062	63	2,756	* 90.37	2,582	85.50	....	....
W	0.25	33	* 2,662	89.12	* 2,339	* 82.25	....	....
High-heat control[a]	....	....	2,685 *	90.94	2,607	88.25	±73	±1.25
Q[a]	0.25	63	2,799	92.75	2,660	88.68	....	....
K[a]	0.25	85	2,769	92.38	2,600	88.48	....	....
High-heat control	....	....	2,734	91.75	2,650	89.19	±81.5	±1.79
AC	0	85	2,759	92.50	2,659	89.25	....	....
AD	0.062	85	2,787	91.88	2,647	88.06	....	....
K	0.25	85	2,853	93.12	2,765	90.06	....	....
HRS flour, 68% abs.								
High-heat control	....	....	2,599	91.50	2,567	88.81	±79	±1.90
Q	0.25	63	2,602	90.93	2,662	89.31	....	....
X	0.06	63	2,536	90.31	2,631	89.06	....	....
Low-heat control	0	63	* 2,426	88.62	* 2,442	* 86.19	....	....

* Significantly different at 5% level.
[a] For 6-minute mix: loaf volume (cc.) and total score respectively:

High-heat control	2,610 *	90.00
Q	2,768 *	91.18
K	2,674	90.38

Table VII. Effect of Concentration of Milk Held at 63°C. for 30 Minutes with 0.25% H_2O_2 on Harland & Ashworth Values of the Milk (Milks All Diluted to 10% T.S. Before Testing

	Whey Protein Nitrogen	
Conc. of Milk	*Control*	*0.25% H_2O_2*
%	*mg./g.*	*mg./g.*
10	6.15	3.90
20	6.50	4.40
30	6.65	5.80
40	6.70	6.75

Table VIII. Effect of Heating a 40% Concentrate of Skim Milk at 80°C. for 15 Minutes with H_2O_2 on Sponge Bread Baking Quality (6% NFDM Used with HRW Wheat Flour at 63.5% Absorption; Fluid Milks Pasturized at 77°C. for 20 Sec.)

	Mixing Time			
	4 Minutes		*8 Minutes*	
Sample	*Loaf Volume*	*Total Score*	*Loaf Volume*	*Total Score*
	cc.		*cc.*	
Comm'l superheated NFDM	2,594	88.13	—2,625	87.56
			*	*
Lab.-heated control	2,547	87.69	2,462	85 56
			*	
Lab.-heated with 0.25% H_2O_2	2,478	86.88	—2,484	85.50
Std Dev. by ranges	±76 cc.	±1.45		

Table IX. Effect of H_2O_2-Treated Milks on Baking Quality of HRW Flour at 60.5% Absorption (3% NFDM Used)

Sample	*Level of H_2O_2 in Fluid Milk at 63°C., 30 min.*	*Mixing Time*			
		4 Minutes		*8 Minutes*	
		Loaf Volume	*Total Score*	*Loaf Volume*	*Total Score*
	%	*cc.*		*cc.*	
Comm'l high-heat	....	2,897	95.25	2,882	—92.31
		*			
Q	0.25	—3,059	96.50	—2,966	—93.12
X	0.06	2,921	94.94	2,953	—93.19
		*		* *	
Low-heat control	none	—2,766	93.25	—2,769	* 90.0
Std. Dev. by ranges	± 106 cc.	± 1.81			

duces a weak curve, only slightly stronger than that from the 63°C.-heated control, showing the effect of temperature on the H_2O_2 reaction. Absorptions for the milks are similar. Curves with milk heated at 85°C. and with 0.25% H_2O_2 are very similar to those with the high-heat controls.

Table VI combines the results of several studies, showing the effect of various levels of heat-treatment and H_2O_2 levels of the fluid skim milk on the baking qualities of doughs containing these NFDM's at the 6% level. The table shows that treating fluid skim milk at 33°C. with 0.25% H_2O_2 yields bread of significantly inferior baking quality compared to similar treatments at 63°C. Thus, some heat is necessary to improve the baking quality of H_2O_2-treated milks. The weak farinograph curves for sample W in Table V also substantiate these data.

Table VI also shows that skim milk heated with 0.25% H_2O_2 at 85°C. for 30 min. yields breads equal or superior to high-heat-treated controls and nearly comparable to breads from skim milks treated with 0.25% H_2O_2 at 63°C. for 30 min. In this study the loaf volume of skim milk treated with 0.25% H_2O_2 at 63°C. and 4 and 6 min. of mixing time significantly exceeds that of the high-heat control.

Table VI shows further that H_2O_2 added to fluid skim milks at 63°C. for 30 min. is only of value to HRS wheat flours at extended mixing times but not at a significant level compared to the high-heat control. Here the low-heat control NFDM yields bread of significantly poorer baking quality. The average gain scores of H_2O_2-treated milks rated equal to or very slightly lower than those of the controls, but were not significantly different in any one series of bakes. The grain scores of all breads using 4 min. of mixing time were significantly higher than those of 8 min. on extended mixing times.

Increasing concentrations of milk solids up to 40% interferes with denaturing effect of 0.25% H_2O_2 at 63°C. (Table VII). Thus, treatment of concentrates in lieu of fluid skim milk at 63° C. would probably not affect baking quality. For these studies raw milk was concentrated to 40% total solids, diluted for reaction, and all diluted back to 10% total solids to run the H&A test.

In a further effort to utilize smaller amounts of H_2O_2 to treat skim milk, a 40% concentrate was heated with 0.25% H_2O_2 at 80°C. for 15 min. before it was dried. Catalase was not added here, because foaming produced when catalase was added to the concentrate made it impossible to pump. This treatment failed to improve the baking quality of the concentrate (Table VIII). In this particular bake a 55-min. proof time with HRW wheat flour was used.

The use of 3% level of NFDM made from fluid milk heated at 63°C. for 30 min. with 0.25% H_2O_2 produces breads with higher volumes and total scores compared to high-heat NFDM as well as the low-heat control NFDM (Table IX). NFDM treated with 0.25% H_2O_2 at 4-min. mixing time gives bread of significantly higher volume than that of the high-heat-treated NFDM as well as the low-heat powder.

Milk treated with 0.25% H_2O_2 in fluid state at 63°C. yields a bread of significantly higher volume and total score with no $KBrO_3$ compared to the high-heat control (Table X). H_2O_2-treated milk does not require bromate to achieve optimum baking quality. Even though the results with different bromate levels are not quite statistically different in the column for high-heat-treated milk, bromate appears necessary for optimum volume and total score. The average volumes and total scores of the breads made with H_2O_2-treated milk very significantly exceed those of the high-heat control milk.

Table XI shows the effect of numerous testings of NFDM on loaf volume and total scores at both 6 and 3% NFDM levels when skim milk was heated at 85°C. with either 0.05 or 0.06% H_2O_2. These data show that the H_2O_2-treated NFDM's generally yield breads of slightly higher volumes and total scores than the control NFDM. In most instances within each test, differences were not statistically significant, but the mass of data of different flours and levels of NFDM indicate that the H_2O_2-treated samples perform better than the controls. For each of the 42 evaluations of NFDM under different conditions with six different NFDM's, the data are computed from an average of eight loaves or four doughs.

Although the loaf volume and total scores for tests 5 and 6 are very close, the H_2O_2-treated NFDM's required slightly less average time to proof to height. For tests 7 and 8 with HRS wheat flours, higher average volumes and total scores of the H_2O_2-treated samples were obtained even by proofing to height in a slightly shorter time than that of the control milks. Textures and crumb color scores of the two milks averaged much the same. On the average H_2O_2-treated milks had slightly better symmetry and very slightly poorer grain scores.

Table X. Effect of $KBrO_3$ Levels on Baking Quality of HRW Wheat Flour Containing 6% NFDM from Fluid Skim Milk Held at 63°C. for 30 Minutes with 0.25% H_2O_2, vs. High-Heat NFDM (4 Minutes Mixing Time at 63.5% Absorption)

	Loaf Volume		*Total Score*	
$KBrO_3$	*High-Heated NFDM*	*H_2O_2 NFDM*	*High-Heated NFDM*	*H_2O_2 NFDM*
p.p.m.	*cc.*	*cc.*		
0[a]	2,808*	3,029	92.50*	95.08
15	2,938	3,070	93.83	95.76
30	2,917	3,033	93.50	94.18
45	2,925	3,012	94.21	94.25
(Av)	2,897**	3,036	93.51**	94.82
Std. Dev by ranges	± 88 cc.	± 1.25		

[a] Bromate-free Arkady used.

Miscellaneous Data

The H_2O_2 treatment of skim milk at 63°C. for 30 min. does not change the pH of reconstituted NFDM. Very similar sensory panel scores were obtained on breads made with 6% control high-heat skim milk and with 0.05 and 0.20% H_2O_2 high-heat skim milks. On the 9-point hedonic scale, the control rated 7.19, *vs.* 6.87 for bread with 0.05% H_2O_2-treated NFDM, and 7.00 for the bread with 0.2% H_2O_2-treated NFDM.

Addition of up to 4 Keil units of catalase to 700-g. doughs was without significant effect on baking quality of low-heat and high-heat NFDM. This rules out any effects of catalase added to milks on baking quality.

Table XII gives the compressibility scores of bread made with 0.05% H_2O_2-treated skim milk preheated to 85°C. for 30 min. at 3 and 6% NFDM levels. The compressibility scores of these breads up to 4 days old are not significantly different from those of bread made with high-heat NFDM.

Table XII. Compressibility Scores of HRW Wheat Bread Made with 0.05% H_2O_2-Treated Skim Milks and 3 and 6% NFDM[a]

	Control: Superheated NFDM		*H_2O_2-Treated*	
Storage	*3%*	*6%*	*3% NFDM*	*6% NFDM*
days				
1	8.9	7.9	8.6	8.0
2	13.0	12.0	13.5	11.8
3	15 1	15.5	15.1	15.0
4	20.2	17.5	19.2	16.9

[a] Compressibility is g. load to depress six center slices 3.0 mm.

Discussion

Of late, interest has increased with respect to studies on interactions of H_2O_2 with milk systems. Treatment of skim milk at 49.9°C. with 0.5 and 1.0% H_2O_2 decreased H&A values and increased nonprotein nitrogen values sequentially up to 24 hr. of holding time (17). On the other hand, treatment of raw skim milk with up to 0.25% H_2O_2 for 10 min. at 21°C. and then heating at 89°C. for 30 min. increased H&A values (decreased denaturation) (18). This was explained by noting that at high temperatures H_2O_2 prevented denaturation of bovine serum albumin and complexing of beta-lactoglobulin with kappa-casein (17,19). These studies might question the importance of the complexing of kappa-casein and beta-lactoglobulin as being responsible for good bread-baking properties (11). It is also suggested that a casein component could be solubilized by H_2O_2 that is not precipitated by saturated salt solution employed in the H&A test (18). Also, it is interesting that at 30°C. at pH 6.5, the solubility of kappa-casein treated with H_2O_2 at 55°C. is slightly increased in the presence of 50 *mM* calcium (20). However, a 0.2% level of H_2O_2 changed the polarographic characteristics of whey protein but not the casein (21).

The results of these studies clearly support the fact that the full bread-baking potential of NFDM is not being achieved by high heat alone. The 0.25% level of H_2O_2 added to milk at either 63° or 85°C. for 30 min. will consistently produce breads of superior volume and total score compared to high-heat-treated milks. Also, the use of the Harland and Ashworth value for H_2O_2-treated milks is not very meaningful as we customarily interpret it for baking quality. In this study, however, high heat is necessary along with H_2O_2 to achieve the full absorptive effects of NFDM as determined by both farinograph absorption and handling qualities of the doughs.

Repeated evaluations of baking potential of both 3 and 6% levels of NFDM to which 0.05 or 0.06% H_2O_2 was added in processing showed that for the most part small increases in baking quality compared to high-heat control NFDM were obtained when the H_2O_2 treated milks were held at 85°C. for 30 min.

Since milk cheddar and swiss cheeses is permitted to be processed with up to 0.05% H_2O_2 in the United States, there appears to be no reason why milk intended for bread could not be treated with this level of H_2O_2.

Table XI. Comparison of Breads Made from NFDM Produced by Treating Skim Milk with 0.05% or 0.06% H_2O_2 at 85°C. for 30 Minutes (Treated), vs. Control High-Heat NFDM

Test No.[a] and Flour	No. of Milks: Control High-heat NFDM	No. of Milks: Treated H_2O_2 NFDM	Proof Conditions	NFDM %	Mixing Time min.	Loaf Volume: Control NFDM cc.	Loaf Volume: Treated NFDM cc.	Proof Time: Control min.	Proof Time: Treated min.	Total Score: Control	Total Score: Treated
1 – HRW I	1	1	Time	6	4	2,759	2,787	65	65	92.16	91.40L
					8	2,659	2,647L[b]	65	65	89.01	88 28L
2 – HRW II	1	1	Time	6	4	2,706	2,806	60	60	91.39	92.63
					8	2,643	2,753	60	60	88.00	89.20
3 – HRW II	1	1	Time	6	4	2,584	2,771	60	60	89.87	91.88
					8	2,531	2,669	60	60	87.01	87.69
4 – HRS I	3	3	Time	6	5	2,827	2,864	60	60	91.20	92.09
5 – HRW II	3	3	Height	6	4	2,705	2,719	58	57L	90.83	90.96
6 – HRW II	3	3	Height	3	4	2,754	2,738L	57	55L	91.14	91.10L
7 – HRS II	3	3	Height	6	7	2,652	2,731	59	57L	89.74	90.02
8 – HRS II	3	3	Height	3	4	2,758	2,780	52	51	91.34	91.97
9 – HRW III	1	1	Time	6	4	2,688	2,747	60	60	91.03	91.48
10 – HRW III	1	1	Time	3	4	2,794	2,863	60	60	92.25	92.88

[a] Test conditions were as follows:
[b] L = less than control.

Nos. 7, 8: 500 g. dough scaled; others 525 g. dough.
Nos. 1, 2, 3: milk treated with 0.06% H_2O_2.
Nos. 9, 10: milk treated with 0.05% H_2O_2.
Nos. 4, 5, 6, 7, 8: two milks 0.05% H_2O_2 and one milk 0.06% H_2O_2. One commercial control and two lab controls.

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