Influence of Succinylated Whey Protein Concentrate on Farinograph Characteristics and Bread Quality

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ABSTRACT

When added to wheat flour, succinylated whey protein concentrates (SWC) decreased dough development time and stability compared with the addition of nonfat dry milk or whey concentrate. Lower volume, tenderness and acceptability, and lighter crust color of breads with SWC were also observed. Despite its high water-holding capacity, SWC did not effectively prevent the staling of bread. Addition of sodium stearoyl-2-lactylate did not significantly improve the effects of SWC. In general, succinylation did not improve the application of whey concentrate in breads.

Succinylation was applied to heat-denatured whey protein concentrate (WC) because of the need to obtain proteins of improved functional properties (Thompson and Reyes 1980). Succinylated whey protein concentrate (SWC) has increased solubility, viscosity, emulsifying properties, heat stability, and water- and fat-absorption capacities compared with WC. Its application has been studied with good results in coffee whitener, salad dressing, meat patties, and wieners (Thompson and Reniers 1982, Thompson et al 1982). The performance in bread of succinylated protein such as SWC has not been reported.

Since SWC has good water-holding capacity, supplementation of bread with SWC affords not only a means of increasing the protein content but probably also a means of retarding staling. Emulsifiers are known to improve the properties of high-protein breads (Tsen 1974). Therefore, it would be interesting to know if SWC, with its good emulsifying properties, is compatible with the wheat flour system. In this article, the effect on farinographic characteristics and bread quality of replacement by SWC of nonfat dry milk (NFDM) in bread formulation is described.

MATERIALS AND METHODS

SWC was prepared according to the previously described method (Thompson and Reniers 1982, Thompson and Reyes 1980, Thompson et al 1982). Commercial all-purpose wheat flour (Purity brand) and high heat NFDM were obtained from Maple Leaf Mills Ltd. and Dominion Dry Milk Co., respectively. Their compositions are given in Table I. The wheat flour was top patent (50%) from a blend of high-protein (13.6%), Western wheat with an extraction rate of 75%. It had 15 ppm $KBrO_4$ and enough malted barley flour to give a gassing power of 560 ± 15 mm per 6 hr. Farinographic characteristics of wheat flour and its 100:4 or 100:8 mixtures with NFDM, WC or SWC, with or without 0.5% sodium stearoyl-2-lactylate (SSL), were obtained by the constant flour weight method using 50-g samples (AACC 1969). Baking tests were performed on similar mixtures using the straight dough method (AACC 1969). The tests used 100 g of wheat flour, 4 g of NFDM, WC or SWC, 5 g of sugar, 3 g of yeast, 3 g of shortening, 1 g of salt, optimum hydration, and 1–2 min mixing in a Swanson mixer at room temperature.

Loaf volume and weight were determined 30 min after baking. Compressibility of the bread was determined after 24 and 48 hr of storage at room temperature in polyethylene bags by compressing 1-in. thick slices with the compression attachment of the Universal Testing Machine (Instron) to a constant compression of 0.25 in. at a crosshead speed of 2 in. per min. Elasticity was measured as percentage volume recovery of the compressed bread. Crumb color (Y_{CIE}) was determined by reflectance spectrophotometry (Clydesdale and Francis 1969). Appearance, texture, flavor, and overall acceptability was judged by a test panel using a 9-point hedonic scale (9 = like extremely, 1 = dislike extremely) (Larmond 1977).

Samples were prepared in two batches and analyzed at least in duplicate. Analysis of variance and Duncan's multiple range test (Steele and Torrie 1960) were used for interpretation of the bread specific loaf volume, compressibility, and acceptability data.

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RESULTS AND DISCUSSION

A farinograph study showed that the addition of increasing levels of WC and SWC to the wheat flour increased the water absorption, whereas the addition of NFDM had little effect (Table II). Higher absorption values for SWC than WC flour mixtures might be expected since SWC has a higher water-holding capacity than WC (Thompson and Reyes 1980).

TABLE I
Composition of Unmodified and Succinylated Whey Protein Concentrate, Nonfat Dry Milk, and Wheat Flour

	Whey Protein Concentrate		Nonfat Dry Milk	Wheat Flour
	Unmodified	Succinylated		
Moisture, %	5.4	1.7	3.0	12.0
Protein, %	67.7	74.9	35.9	11.7
Ash, %	5.2	5.7	8.0	0.4
Fat, %	···	···	0.8	0.7
Carbohydrates, %	21.7	17.3	52.3	75.2

Dough development time was only slightly affected by NFDM but was significantly decreased by the addition of WC and SWC. NFDM added dough stability to wheat flour, but WC and SWC decreased the stability, with SWC producing the weakest dough. Decreased dough development time and stability were also observed upon addition of protein isolates by others (Thompson 1977, Tsen and Hoover 1973). Interestingly, however, although increasing levels of NFDM and WC decreased the dough stability, SWC appeared to increase it at higher levels.

Addition of SSL did not greatly affect the water absorption or dough development time, except for a slight decrease in water absorption in the SWC-supplemented flour, and in dough development time in the all-wheat-flour control.

As might be expected from the farinograph characteristics (Table II), the protein additives did not improve the baking performance of wheat flour (Table III). SWC breads generally showed lower volume, tenderness, and acceptability compared to other breads. Similar observations were reported for other protein additives (Fogg and Tinklin 1972, Marnett et al 1973, Thompson 1977, Thompson et al 1976, Tsen and Hoover 1973). Taste panelists noted a heavy compact texture and a slight aftertaste in SWC bread. WC bread was rated better in acceptability than the SWC bread but lower than the NFDM and control breads. All breads were acceptable.

Crumb color of all the supplemented breads was slightly darker than that of the control, as might be expected with increased protein content in the flour mixture. Others (Ehle and Jansen 1965, Ranhotra et al 1975) also observed a similar darkening effect. The crust color of the SWC bread was, however, slightly lighter than the NFDM or WC breads, probably due to the lesser ability of the succinylated protein to undergo the Maillard reaction (Friedman 1978).

The elasticity of all breads was about the same. Compressibility results showed the control and NFDM breads to be softer than the WC and SWC breads. The SWC breads exhibited the lowest percentage increase in compressibility after 48 hr of storage, followed by the WC breads. However, the absolute increases in compressibility of the SWC and WC breads were higher than those of the control. Therefore, SWC did not effectively prevent staling, despite its very high water-holding capacity (Thompson and Reyes 1980).

Since the SWC decreased the dough stability as observed in the farinograph tests (Table II), the mixing time for dough development of the SWC flour in bread preparation was decreased from 2.0 to 1.5 or 1.0 min. This, nevertheless, did not result in big improvements of the bread properties (Table III).

Therefore, as judged from farinograph and baking tests, NFDM and WC perform better than SWC in breads when used at the 4% level. Although SWC bread was generally acceptable to the judges, its smaller volume and harder texture made it the least desirable of all the breads. SSL, an emulsifier known to improve the properties of soy protein fortified breads (Tsen 1974), did not significantly improve the properties of the SWC bread; in fact, it may have a negative effect. The heat stability, low gelling properties and high

TABLE II
Farinograph Characteristics of Mixtures of Wheat Flour (WF) and Nonfat Dry Milk (NFDM), Unmodified (WC) or Succinylated Whey Concentrate (SWC)

Flour	SSL[a] (%)	Water Absorption (%)	DDT[b] (min)	Stability (min)	TMD[c] (BU)[d]	Degree of Softening (BU)
WF						
100:0	0	64.2	5.0	21.5	25	15
	0.5	64.2	3.0	23.0	35	25
WF+NFDM						
100:4	0	64.6	5.0	33.0	20	20
	0.5	64.2	6.0	37.0	30	25
100:8	0	62.4	6.0	27.0	25	25
	0.5	62.6	6.0	33.0	25	25
WF + WC						
100:4	0	69.2	2.3	3.0	40	30
	0.5	72.2	2.0	2.0	115	90
100:8	0	72.7	2.0	2.0	105	70
	0.5	72.0	2.0	1.0	110	95
WF + SWC						
100:4	0	72.0	2.5	1.5	120	50
	0.5	71.4	2.2	1.5	160	70
100:8	0	74.0	3.5	2.0	100	40
	0.5	72.0	4.0	2.0	100	20

[a] Sodium stearoyl-2-lactylate.
[b] Dough development time.
[c] Twenty-minute drop.
[d] Brabender units.

TABLE III
Characteristics of Bread Containing Mixtures of Wheat Flour (WF) and Nonfat Dry Milk (NFDM), Unmodified (WC) or Succinylated Whey Concentrates (SWC)

Flour	SSL (%)	Specific Loaf Volume (ml/g[a])	Compressibility, kg[a]			Elasticity	Color Lightness Y_{CIE}	Acceptability[a,b]			
			24 Hr	48 Hr	Percent Increase			Appearance	Texture	Flavor	Overall
WF[c]	0	4.12^{u}	0.70^{z}	1.12^{z}	60.0^{x}	0.91	72.3	7.3^{x}	7.0^{xy}	7.0^{xy}	7.1^{x}
	0.5	4.00^{u}	0.71^{z}	1.18^{z}	66.2^{v}	0.91	74.1	7.1^{xy}	7.0^{xy}	7.0^{xy}	7.0^{x}
WF + NFDM[c]	0	3.46^{v}	0.91^{y}	1.58^{y}	73.6^{u}	0.90	74.1	7.6^{xy}	7.3^{xy}	6.8^{xy}	6.8^{x}
100:4	0.5	3.54^{v}	0.83^{yz}	1.41^{yz}	69.9^{uv}	0.90	66.6	7.7^{x}	7.5^{x}	7.2^{x}	7.0^{x}
WF + WC[c]	0	2.99^{x}	1.51^{x}	2.22^{x}	47.0^{y}	0.88	65.1	6.4^{xy}	6.7^{xy}	6.2^{xyz}	6.3^{xy}
100:4	0.5	3.07^{x}	1.18^{y}	1.72^{xy}	45.8^{y}	0.91	65.0	6.9^{xy}	6.7^{xy}	6.3^{xyz}	6.4^{xy}
WF + SWC[c]	0	2.28^{yz}	2.10^{v}	3.00^{v}	42.9^{y}	0.91	64.6	5.7^{xy}	5.8^{y}	5.5^{yz}	5.3^{y}
100:4	0.5	2.39^{y}	1.98^{v}	2.64^{v}	33.3^{z}	0.91	64.3	6.2^{xy}	6.1^{xy}	5.4^{z}	5.7^{xy}
WF + SWC[d]	0	2.40^{y}	1.76^{x}	...	...	0.88	64.0	...	...	...	...
100:4	0.5	2.28^{yz}	2.20^{v}	...	...	0.91	64.3	...	...	...	...
WF + SWC[e]	0	2.22^{yz}	2.24^{v}	...	...	0.87	63.9	...	...	...	...
100:4	0.5	2.16^{z}	2.45^{v}	...	...	0.91	64.0	...	...	...	...

[a] Means with different superscripts (u–z) within a column are significantly different ($P \leqslant 0.05$).
[b] 9 = like extremely, 1 = dislike extremely.
[c] 2 min of mixing.
[d] 1.5 min of mixing.
[e] 1 min of mixing.

water absorption and solubility of the SWC (Thompson and Reyes 1980) may have contributed to its poor behavior in the baked bread. Pomeranz and Finney (1973) reported that water-insoluble soy protein preparations were better additives than water-soluble proteins in breadmaking. Because of its water-absorption capacity, SWC probably competed for the available moisture, resulting in incomplete hydration of the gluten proteins (Fogg and Tinklin 1972). This hindered proper development of the gluten in breadmaking, producing an undesirable bread.

Although succinylation improved the utilization of WC and probably other protein sources in coffee whiteners, salad dressing (Thompson and Reniers 1982), and meat patties (Thompson et al 1982), it is a less desirable modification technique for WC to be used in breads. Test results also lead us to speculate that succinylation of wheat flour proteins, which has been tried by others (Grant 1973), could detrimentally affect the baking quality of the flour.

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