A Note on Some Protein, Ash, Viscosity, and Damaged-Starch Relationships in the Sedimentation Test[1]

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An investigation was made of the protein displacement, relative viscosity and ash components of the supernatant lactic acid, and the role of damaged starch in the sedimentation test.

Protein Displacement

A number of Buhler-milled wheat varieties were subjected to the standard macro Zeleny sedimentation test (1), and a macro version of the Modified Micro sedimentation test (2). This macro version differed only in the use of a 3.2-g. sample weight, and 75-ml. total volume of reagents. The tests were replicated a number of times to obtain sufficient material for all of the measurements reported. The contents of the sedimentation cylinders were transferred to centrifuge cups and centrifuged to recover the supernatant liquid and the residues. Protein on both fractions and on the parent flour was determined by the Kjeldahl procedure.

Relative Viscosity

Relative viscosity of aliquots of supernatant liquid from the macro version of the Modified Micro sedimentation tests was measured by a method reported by Udy (3).

Ash

Aliquots of supernatant lactic acid from standard Zeleny tests and from the second dispersion of the macro version of the Modified Micro tests were evaporated to dryness, ashed, and weighed.

Damaged Starch

The basic procedure developed by Donelson and Yamazaki (4) was applied to 28 Buhler-milled flours, representing 14 varieties, each at a high and a low protein level. Sedimentation values were measured by the Modified Micro method, and protein content was determined by the Kjeldahl method.

RESULTS AND DISCUSSION

Lactic acid is known to be an effective agent for extracting gluten from flour. The magnitude of the protein displacement of four varieties is shown in Table I. Between 57 and 74% of the original flour protein is dispersed in the lactic acid, and thus is not part of the swollen material. The second mixing period of the Modified Micro test extracts approximately another 5% of the original protein. It is rather surprising that less than half of the protein is involved in the swelling phenomenon.

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TABLE I. PROTEIN BALANCE SHEET

Sedimentation Test	Variety	Flour Protein %	Proportion of Flour Protein Recovered: In Residue %	In Supernatant %	Total %
Standard Zeleny	Wasatch	9.0	35.6	60.1	95.7
	Marfed	15.1	40.1	57.8	97.9
	Omar	8.6	31.7	67.1	98.8
	Columbia	14.8	37.2	61.3	98.5
Modified micro, macro version	Wasatch	9.0	29.6	66.8	96.4
	Marfed	15.1	34.7	62.7	97.4
	Omar	8.6	26.8	73.7	100.5
	Columbia	14.8	32.6	64.7	97.3

The possibility was considered that soluble, colloidal, and dispersible flour components might produce variations in the viscosity of the lactic acid solution in which they are mixed. The data in Table II, however, indicate that flour components do not produce any appreciable difference in the viscosity of the supernatant lactic acid.

TABLE II. RELATIVE VISCOSITY OF THE SUPERNATANT LIQUID FROM THE SECOND DISPERSION OF THE MACRO VERSION OF THE MODIFIED MICRO SEDIMENTATION TEST

Variety	Protein %	Modified Micro Sedimentation Value cm.	Relative Viscosity η_r[a]
Columbia	12.9	9.3	1.08
Itana	10.5	9.7	1.07
Wasatch	8.3	3.5	1.06
Marfed	13.0	12.7	1.08
Brevor	8.3	3.5	1.06
Omar	7.9	1.2	1.06

[a] η_r The ratio of the flow time of the supernatant liquid to the flow time of the solvent at 30.00°C. ± 0.01°C.

It is to be expected that the ionic environment and ash components of the lactic acid in the standard Zeleny test would be considerably different from that of the lactic acid in the second dispersion in the Modified Micro test. Table III indicates the extent of the difference. This difference indicates that removal of some of the soluble ash components is chiefly responsible for the improved performance of the Modified Micro sedimentation test on our early-generation material.

It is well known that flour from hard wheats contains more damaged starch than flour from soft wheats, and that damaged starch will swell extensively in cold water. Little is known of its role in the sedimentation test; however, Schlesinger (5) reported that the effect on sedimentation values of increased starch damage by ball-milling of previously tested flours was negligible. Table IV shows the inverse relationship that is usually found between protein and damaged starch contents. Invariably the low-protein sample of each variety has the lowest sedimentation value. Considering the damaged starch contents, however, the low-protein sample of each variety,

TABLE III. ASH IN THE SUPERNATANT LACTIC ACID FROM THE STANDARD ZELENY TEST AND FROM THE SECOND DISPERSION OF THE MACRO VERSION OF THE MODIFIED MICRO SEDIMENTATION TEST

		Ash in Supernatant from 3.2 g. Flour	
Variety	Protein in Parent Flour %	Standard Zeleny Test mg.	Macro Version of Modified Micro Test mg.
Henry	14.9	8.5	1.9
Columbia	16.1	7.0	1.9
Rio	11.9	7.4	2.3
Marfed	13.0	8.6	2.1
Federation	12.8	8.3	2.0
Brevor	6.0	8.2	1.4
Omar	7.9	9.8	1.2

TABLE IV. DAMAGED STARCH CONTENT OF 14 VARIETIES EACH AT A HIGH AND A LOW PROTEIN CONTENT

Wheat Type and Variety	Flour Protein %	Damaged Starch %	Modified Micro Sedimentation cm.	Wheat Type and Variety	Flour Protein %	Damaged Starch %	Modified Micro Sedimentation cm.
BREAD				SOFT			
Burt	11.9	4.0	12.3	Marfed	13.0	0.6	10.1
	8.2	7.4	7.1		8.6	1.0	3.3
Itana	12.1	6.3	12.3	Federation	12.5	2.3	7.1
	8.9	9.0	6.5		7.6	4.0	1.9
Henry	12.5	5.8	13.2	Idaed	12.8	2.0	6.7
	7.8	6.3	3.5		8.5	3.1	4.2
Cheyenne	12.8	8.3	13.2	Brevor	11.5	0.5	3.9
	8.7	9.2	7.1		7.9	1.0	3.7
Rio	11.9	7.3	12.0	Omar	12.5	0.8	1.6
	8.1	8.0	5.5		7.0	2.1	1.5
Columbia	13.5	6.9	13.0	Baart	12.6	2.6	6.0
	8.4	9.4	6.5		8.3	3.5	2.3
				Golden	11.6	2.7	1.9
					8.0	1.9	1.6
				Gaines	13.0	1.7	5.2
					7.3	1.1	2.2

except Golden and Gaines, has the highest damaged starch content. Apparently the role of damaged starch in the sedimentation test is negligible or masked by the gluten; and the data suggest that the insoluble proteins are the factors largely responsible for sedimentation values.

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