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Abstract. Solubilities of "vital" wheat gluten in dilute solutions of sodium hydroxide, acetic acid, sodium carbonate, ethanol, and monoethanolamine at 55°C were determined. Solubilities at 30°C in dilute solutions of sodium hydroxide, acetic acid, monoethanolamine, and sodium borate were also determined. Sodium hydroxide, monoethanolamine, and acetic acid solutions were the best solvents.

The current studies were initiated to secure data on the dispersibility and solubility in various chemical solutions needed for studies on the reaction of the gluten with dialdehyde starch. Work on gluten solubility including viscosity studies has been reported by Cook and Rose (1). The change in physical properties of gluten solutions with the ageing of flour was studied by McCaig and McCalla (3). Work on the composition and behavior of gluten has been reported by McCalla and Gralen (4). Other work on the composition of gluten has been done by Jones, Taylor, and Senti (6), Simmonds and Winzor (5), and Woychik, Dimler, and Senti (6). In spite of the work done the needed data for the solubility of wheat gluten in different reagents is not available.

EXPERIMENTAL

"Vital" gluten, having an actual gluten content of approximately 80 percent, and reagent chemicals were used. Weighed amounts of gluten were added slowly with stirring to reagent solutions held at constant temperature in a water bath. Care was taken to follow the same procedure of addition and to maintain the same stirrer speed throughout the work. After stirring for the specified time the solution was centrifuged and the supernatant liquid was decanted to give the gluten solution.

The density of the gluten solution was determined by a picnometer, the viscosity by an Ostwald viscosimeter, hydrogen ion concentration by a pH meter, and the nitrogen content by the Kjeldahl method.

RESULTS

After preliminary work five reagents in the concentrations shown in Table I were used at 55°C. Solution times varied from

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15 to 60 minutes. Density values are not shown, since these do not vary appreciably from what would be expected. The pH values showed only small changes upon addition of the gluten. For example, sodium hydroxide solutions ranged from pH 11.6 to 12.3 and after addition of the protein ranged from 9.8 to 12.0. Acetic acid ranges were 2.0 to 2.9 and 2.4 to 3.6 respectively.

Table I. Solubility of Wheat Gluten at 55°C. Gluten used for 100 ml of solution: 5 grams.

Reagent Con. Per 100 ml*	Solution Time Min.	Properties of the Gluten Solution Viscosity cp	Nitrogen mg	Gluten Dissolved %**
		Sodium Hydroxide		
0.05 g.	30	1.9	6.8	100
0.10 g.	60	2.2	7.0	100
0.50 g.	15	2.6	7.0	100
1.00 g.	60	2.6	7.3	100
		Acetic Acid		
1 ml	60	1.9	5.8	84
5 ml	60	3.2	6.1	92
10 ml	60	3.5	6.0	90
20 ml	60	6.2	6.5	98
		Sodium Carbonate		
1 g.	60	1.3	3.3	50
5 g.	60	0.2	0.8	12
10 g.	30	1.4	0.1	2
15 g.	30	1.9	0.1	2
		Ethanol		
5 ml	30	0.9	1.0	15
10 ml	30	1.0	1.5	23
15 ml	30	1.3	1.9	29
20 ml	30	1.4	2.5	38
		Monoethanolamine		
0.10 ml	30	0.9	1.4	21
0.25 ml	60	1.4	5.1	77
0.50 ml	30	1.8	6.5	98
1.00 ml	15	1.8	6.5	98

* Amount of reagent dissolved in water to produce 100 ml. of solution.
** An approximate value based on the following assumptions: all of the nitrogen is present as gluten; 80% of the gluten used was gluten; and a conversion factor of nitrogen to gluten of 6.0.

Sodium hydroxide, acetic acid, and monoethanolamine showed the best solvent action. For some uses the increase in viscosity of the solution made with the higher acetic acid concentrations might be a disadvantage. The decreasing solubility of the gluten with increasing concentrations of sodium carbonate may have resulted from the precipitation of certain protein fractions from the previously dissolved gluten by the increased concentration of the sodium carbonate. The nitrogen value does not specifically apply to the gluten as a whole or to any fractions of it.

The next studies were carried out at 30°C to avoid any degradation of the protein at the higher temperature. The solution times were changed in an effort to bring out more readily any

change in properties of the solutions. The amount of gluten added was varied to check on possible effect of mass on the solubility. Sodium borate was substituted for sodium carbonate because of the poor results with the latter. Ethanol, which also did not appear highly promising, was also dropped. The more important data for this second series are shown in Table II. The maximum amount of gluten dissolved in 100 ml of reagent solution is shown for each reagent concentration. This is an approximate value based on the assumption that the nitrogen content of the solutions is all gluten and may vary slightly from the true value.

Table II. Solubility of Wheat Gluten at 30°C.

Reagent Con. per 100 ml.*	Gluten per 100 ml.	Nitrogen Content of Solution mg per ml			Max. Amount of Gluten Dissolved in 100 ml*
		Solution Time in Minutes			
		15	45	75	
		Sodium Hydroxide			
0.05 g	2	2.52	2.40	3.00	5.0
	5	5.93	5.70	**6.80**	
	10	1.06	0.80	1.30	
0.10 g	2	2.63	2.44	3.20	
	5	5.71	5.80	6.60	
	10	10.03	**11.30**	11.30	8.6
0.50 g	2	2.34	2.36	2.96	
	5	6.51	6.20	6.90	
	10	11.20	**12.20**	...	9.1
1.00 g.	2	2.44	2.18	2.30	
	5	5.74	5.65	6.40	
	10	12.60	12.70	**13.40**	10.0
		Acetic Acid			
0.5 ml	2	2.10	1.80	2.30	
	5	5.40	5.20	5.80	
	10	10.00	**11.00**	1.14	8.2
1.0 ml	2	...	1.73	2.60	
	5	4.90	5.10	5.60	
	10	10.10	10.20	**11.20**	8.4
2.0 ml	2	2.10	2.20	1.80	
	5	5.20	5.70	6.00	
	10	10.60	11.00	**12.00**	9.0
5.0 ml	2	2.00	1.90	2.40	
	5	5.60	5.90	5.90	
	10	11.00	**11.50**	...	8.6
10.0 ml	2	2.00	2.20	2.20	
	5	5.40	5.70	6.10	
	10	11.00	11.60	**12.30**	9.2

* See Table I.

When the amount of gluten added was increased from five to ten grams per 100 ml of the solution containing 0.05 g sodium hydroxide, the total amount of gluten dissolved was decreased. This was accompanied by a decrease in viscosity. At 75 minutes solution time the viscosity decreased from 1.72 cp. to 0.88 cp. It was believed that the decreased amount of protein dissolved resulted from preferential attack by the sodium hydroxide upon non-protein constituents, thus reducing the amount of the sodium hydroxide available for protein solution. Sodium borate solutions did not show good solvent properties, giving results similar to those secured with sodium carbonate.

The general trend of viscosities of the gluten solutions with the increase in reagent concentrations and amount of gluten was upward. The extreme viscosity range for sodium hydroxide was 0.88 to 4.56 cp.; for acetic acid, 1.12 to 8.61 cp.; for monoethanolamine, 0.85 to 5.39 cp.; and for sodium borate, 0.83 to 0.94 cp.

Summary

Sodium hydroxide and monoethanolamine solutions were very good solvents for gluten and produced gluten solutions of relatively low viscosities. Acetic acid solutions were good solvents, but they produced more viscous solutions. Except for the most dilute sodium hydroxide solution and the two lower concentrations of monoethanolamine the most concentrated solutions were produced by adding 10 grams of gluten per 100 ml of reagent solution. In general the 45 and 75 minute solution times resulted in more concentrated solutions than the 15 minute solution time.

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