Flour Constituents Affecting MacMichael Viscosity[1]

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ABSTRACT

Conventional reconstitution procedures gave reconstituted wheat flours whose MacMichael viscosities were only half those of the parent flours, or less. Water-extraction of flours gave residues whose viscosities were much higher than the values obtained with the original unfractionated flours and which retained varietal viscosity differences. Combinations of water-extracts and residues from the same flour gave viscosities almost identical with those of the parent flour. Interchanges of water-extracts and residues between different flours showed that the water-extract accounted for part of the varietal viscosity differences. The water-extracts were separated into the dialyzables and the nondialyzables. The dialyzables lowered the viscosities of the residues more than did the total extract and showed a close relation to the viscosity values of the original unfractionated flours. Nondialyzables contained most of the water-soluble proteins and pentosans but had little or no effect on viscosity. Gluten, tailings, and starch could be reconstituted to residues whose viscosity matched closely those of residues from water-extraction of flours. Interchange experiments with reconstituted residues showed that the flour fraction causing the high residue viscosity and responsible for varietal differences was the gluten. Only in one experiment involving two soft wheats with a small viscosity difference did the tailings cause part of the viscosity difference, and starch never played a significant role in MacMichael viscosity.

One of the most useful tests for evaluating baking quality of soft wheat varieties is the MacMichael viscosity test. Currently at this Laboratory all early-generation wheat samples of 100 to 250 g. are milled and subjected to two tests: protein by dye binding, and viscosity. From these two tests the sample can be classified into hard wheat, soft wheat, or club wheat market classes. For samples of over 250 g. wheat, the viscosity test is one of the important tests routinely applied. It is also particularly useful in the Pacific Northwest for identifying club wheats or mixtures containing club wheats, as they have the lowest viscosities of all wheats. Gaines, the soft common variety that now dominates the Pacific Northwest crop, has viscosities higher than desired for many soft wheat purposes.

Despite the widespread use of this test, little is known about the factors affecting it. The instrument was first described in 1915 (1), and Sharp and Gortner (2) about 1923 introduced the use of the torsion-balance type of viscometer to replace use of the capillary viscometer with flour-water suspension. Then in the 1920's and 1930's came a number of studies of flour-water suspensions, and the MacMichael instrument predominated in these studies. The test originally was used in attempts to correlate with bread-baking quality. By the 1930's, use of the test had spread to the soft wheat industry (3), and Bayfield appears to be the first to have studied the correlation with soft wheat quality (3). The work of these early investigators, summarized in the report by Bresson and Barmore (4), showed that there was a

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positive, linear correlation between protein content and viscosity, and that increases in flour ash decreased viscosity markedly. Udy (5) determined MacMichael viscosities for the normal and reconstituted flours from strong, medium, and weak wheats. He found that the water-soluble fraction of the strong wheat flour was essential for obtaining the higher viscosities in the reconstituted flours.

Recent advances in research techniques now make it possible to re-examine the role of flour constituents in flour-water viscosities. The present study is particularly directed toward varietal differences in viscosity and, as the first phase of the study, attempts to evaluate through fractionation and reconstitution studies the contribution of each fraction to the varietal viscosity value.

MATERIALS AND METHODS

Flours

Five single-variety flours were selected to cover the entire viscosity range at 8% protein level. Wheat composites were made carefully and milled on a Buhler mill. The flours were tested for conformity to the varietal ratings compiled in this laboratory (6). Table I shows that the protein level was confined to the narrow range from 7.7 to 8.1%, except for Omar at 8.7%, and ash content was confined to a very narrow range. Thus the effects of protein and ash *content* were virtually eliminated for these samples, and the viscosity differences are due primarily to varietal differences.

Table I shows that the viscosities of these flours ranged from 30 for the club wheat, Omar, to nearly 100 for the hard wheat, Columbia. Desirable values at 8% protein level for most soft-wheat purposes are 25 to 70. The four soft wheats fall within this range, although Gaines is near the upper limit.

TABLE I. ANALYTICAL DATA FOR FLOURS[a]

Flour	Class	Protein %	Ash %	Viscosity degrees MacMichael
Columbia	HRW	8.0	0.39	98
Gaines	SWW	7.8	0.38	63
Brevor	SWW	7.7	0.42	54
Golden	SWW	8.1	0.41	44
Omar	Club	8.7	0.41	30

[a]Viscosity data on "as-is" basis; other data on 14% moisture basis.

Flour Fractionation

Flour fractions were obtained by a dough-kneading procedure similar in principle to that used by numerous investigators. Flour (300 g.) was mixed with about 170 ml. distilled water for 1 min. in a laboratory dough mixer; the amount of water was adjusted to give a firm, smooth dough. The dough was rested for 1 hr. under 600 ml. distilled water and then kneaded, with occasional decantations of the aqueous starch and tailings suspension through a fine-mesh cloth and addition of six 100-ml. portions of distilled water. The starch and tailings suspension was centrifuged, and the water-extract was decanted. The tailings fraction was removed with a spatula and resuspended. The starch was resuspended, filtered through a Büchner funnel, and air-dried. The water-extract, gluten, and tailings were lyophilized.

It was possible but difficult to fractionate the very soft Golden and Omar flours by kneading. Once obtained, however, the fractions from these flours corresponded closely in yield and protein content to those from the other flours.

Frequently the flours were separated only into the water-extract and the extracted residue. In this paper, the water-soluble fraction when retained and used as a liquid is termed the water-extract. When recovered as a dry material, it is called the water-solubles; otherwise the two terms are synonymous. Samples of 20.0 g. flour were stirred for 10 min. at ratios of 2.5, 5, or 10 ml. water to 1 g. flour.

For the viscosity test, the residues were recovered by the mildest centrifugation that would effect a clean separation of the supernatant; generally this was about 300 × *g*. Centrifuging at 2,000 × *g* as normally employed here gave hard residues that were difficult to resuspend and gave lower viscosities. The retained water was determined from the gain in weight, and enough water was added to make the 100 ml. required in the test. Best results in resuspending the residues were obtained by adding a few drops of water to make a paste and slowly diluting this with stirring to achieve a smooth, lump-free suspension. Viscosity was then determined in the usual manner.

Further fractionation of the water-extracts was by dialysis in Cellophane tubing 1 1/8 in. in diameter, against distilled water at 4° C. for 3 days with twice-daily changes of water. The material remaining inside the tubing was lyophilized to obtain the nondialyzables. All the dialysis water was saved, combined, and concentrated under partial vacuum below 40°C. to a liquid concentrate. Lyophilization of this concentrate gave a hard, flinty product that was difficult to remove from the bottles. The dialyzables were therefore left as a liquid concentrate and stored at 4° C., and aliquots were taken for analysis and testing.

Reconstitution of Residues

Three fractions—gluten, tailings, and starch—made up the water-extracted residue. For preparing reconstituted residues, the basic fractionation scheme was modified slightly to use a total of 1,500 ml. water for the kneading of 300 g. flour, to correspond to a 5:1 ratio of water to flour. Gluten, tailings, and starch from this procedure were blended in the proportions obtained in fractionation, and 50-g. lots were mixed with distilled water in a 100-g. dough mixer to doughs of normal consistency. The doughs were lyophilized and ground but not rehydrated. Protein was determined for each individual blend and kept very close (by minor adjustment of gluten amount, if necessary) to that of the corresponding unfractionated residue.

Interchange Experiments with Water-Extracts and Unfractionated Residues

Two 20.0-g. lots were taken from each of two different flours and extracted at 5:1 ratios. The total extract was added to either the residue from the same flour or to the residue from the other flour of the pair. No correction was necessary to obtain the 100 ml. water needed for the viscosity test. Duplicate or more interchanges were made.

Interchange Experiments with Reconstituted Residues

A typical (one fraction at a time) interchange experiment was applied to pairs of reconstituted residues differing in viscosity. The design of the experiment was a randomized complete block, 2 × 2 × 2 factorial, and each block was replicated three times. Ash and protein were determined for each individual sample. Protein contents of unfractionated residues were 7.1 to 8.0%; reconstituted residues had

7.0 to 7.9% protein. Ash contents of unfractionated residues were 0.23 to 0.26%, and reconstituted residues had 0.17 to 0.22% ash.

Analytical Methods

Conventional methods were used for ash, protein, and moisture (7). Viscosity was determined by a modification of the official method (7); mechanical shaking was used, the digestion time was omitted, one addition of 7 ml. 1*N* lactic acid was made, and the reading was taken within 15 to 30 sec. after the bob was resuspended. Pentosans were determined by a previously described method (8) which included redistillation and titration by the Hughes and Acree bromination analysis.

Furfural-yielding substances in the dialyzables were assumed to be pentoses; those in the nondialyzables were considered to be pentosans.

RESULTS

Viscosity of Reconstituted Flours

The original objective of this study was to assess the contribution of each of the four major flour fractions to MacMichael viscosity by a typical fractionation and reconstitution project. Previous investigators (9,10) have shown that for successful cookie flour reconstitutions it was necessary to make a dough from the fractions, lyophilize the dough, grind the dried dough to a flour, and rehydrate the flour to about 14% moisture. For reconstitution for cake-baking, the water content of the batter in the cake test will permit introduction of the reconstituted dough directly into the cake-baking tests, thus eliminating the lyophilization, grinding, and rehydration steps (11).

Although numerous variations of the fractionation and reconstitution procedures were tried, it was not possible to reconstitute the four fractions of any flour and recover the original viscosity. Typical results for two of the flours were as follows:

Procedure	Viscosity (Degrees MacMichael)	
	Columbia	Brevor
Original unfractionated flour	98	54
Simple mechanical blend of fractions	15	5
Doughed but not lyophilized		
(as in cake-baking reconstitutions)	24	9
Above dispersed by Waring Blendor	26	10
Doughed, lyophilized, and ground,		
not rehydrated	67	11
Rehydrated to about 14% moisture	52	14

As with cookie-baking, a simple blend of the fractions in correct proportions gave very poor results. Use of reconstituted doughs without lyophilization and grinding, as in cake-baking, increased values only slightly; poor dispersion of the doughs appeared to be a problem, but use of a blender caused only a slight increase. Lyophilization of the reconstituted doughs gave viscosities from 20 to 70% of those of the parent flours. Rehydration of the lyophilized doughs, so essential for cookie-baking, usually lowered the readings slightly. Udy (5) obtained MacMichael viscosities for reconstituted flour that were 22 to 38% of those of the original unfractionated flours.

As a final check, fractions separated by kneading were reconstituted to flours by doughing, lyophilization, grinding, and rehydration as previously described (10) and baked into cookies. Close agreement was obtained between the diameters of the cookies from the original flours and those from the reconstituted flours.

Viscosity of Individual Fractions

Viscosities of the individual fractions in the approximate amounts that they occurred in 20.0 g. of reconstituted, rehydrated flour were determined. Air-dried starch at about 10% moisture and lyophilized gluten, tailings, and water-solubles at about 4% moisture were used, and appropriate corrections in the amounts were made. Very stable readings and uniformly low values were obtained for each of three of the fractions regardless of the variety tested (see table below). Bayfield (12) listed values of 2 to 3 for 20.0 g. starch.

	g.	*MacMichael Viscosity*
Water-solubles	0.7	3-4
Tailings	4.7	2-3
Starch	11.2	2-3

When 2.0-g. amounts of lyophilized gluten were tested, the suspensions exhibited very rapid rises in viscosity. Readings taken within 15 sec. after re-

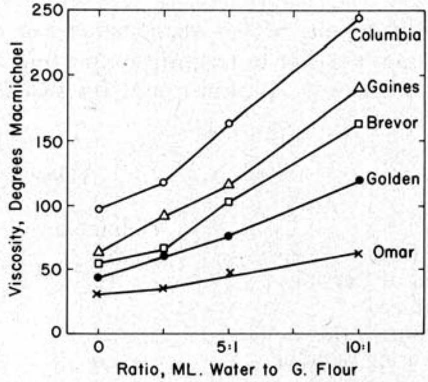

Fig. 1. MacMichael viscosities of water-extracted residues from the five flours used.

TABLE II. VISCOSITIES OF LYOPHILIZED AND RECONSTITUTED RESIDUES

	Columbia	Gaines	Brevor	Golden	Omar
Unfractionated residues[a]					
Wet residues	158	124	98	77	46
Lyophilized residues	160	129	87	72	49
Reconstituted residues[b]	151	118	83	73	45

[a]From 20.0 g. flour extracted with 100 ml. water.
[b]17.2 g. of the material reconstituted from gluten, tailings, and starch and lyophilized.

suspension of the bob gave the following viscosities: Omar, 12; Brevor, 15; Gaines, 26; and Columbia, 35.

These values for 2.0 g. gluten were higher than those given earlier for complete, four-fraction but not reconstituted blends. Lots of 18.6 g. of fractions (starch at 10% and other fractions at 4% moisture) were again made up as simple, mechanical blends. The following values were obtained for these blends: Omar, 7; Brevor, 6; Gaines, 7; and Columbia, 12. One or more constituents of the complete blend appeared to be depressing the gluten viscosity.

Effect of Water-Extraction on Viscosity

The low viscosities of reconstituted flours was quite surprising, since Sharp and Gortner (2) reported much higher viscosities for flours extracted with water. The effect of water-extraction on the flours was determined. As the soluble material was removed, viscosity went up sharply (Fig. 1). Results at the 2.5:1 ratio were somewhat erratic because of the difficulty in obtaining sharp separations, but at the 5:1 and 10:1 ratios, varietal differences were retained and even enhanced in the residues.

The effect of lyophilizing the residues from the 5:1 ratio of water extraction is shown in Table II. The lyophilized residues from 20.0 g. flour extracted with 100 ml. water averaged about 17.2 g., and viscosity was determined directly on the dry

TABLE III. EFFECT OF THE WATER-EXTRACT ON VISCOSITY OF UNFRACTIONATED RESIDUES

	Columbia	Brevor	Omar
		degrees MacMichael	
Original unfractionated flour	98	54	30
Wet residue	161	102	51
Water-extract	2	2	3
Wet residue plus water extract	102	53	30
Lyophilized residue	160	90	49
Lyophilized water-solubles	3	3	2
Lyophilized residue plus lyophilized water-solubles	97	52	29

[a]The amount of each material used was that obtained from 20.0 g. flour extracted with 100 ml. water.

TABLE IV. EFFECT OF THE WATER-EXTRACT ON VISCOSITY OF RECONSTITUTED RESIDUES

	Columbia	Brevor	Omar
		degrees MacMichael	
Original unfractionated flours	98	54	30
Reconstituted residues[a]	149	81	44
Reconstituted residues plus water-extract[b]	75	35	18

[a]17.2 g.
[b]From 20.0 g. flour extracted with 100 ml. water.

samples (no rehydration). The changes in viscosity, if any, caused by lyophilization and grinding of residues were small.

For the data in Tables II through VII and Figs.1 through 3, duplicate determinations only were made (if marked disagreement existed between duplicates, three or more replicate determinations were made). No attempt at statistical analysis was made for these data.

Reconstituted residues (17.2 g. of lyophilized residues) had viscosities close to but usually slightly lower than those of the corresponding unfractionated residues (Table II). Kneading separations using a 5:1 ratio of water to flour may not give exactly the same results as extracting flour with water at that ratio.

Effect of Water-Extract on Viscosity of Residues

The addition of liquid water-extracts to the unfractionated residues caused the viscosity to return to levels approximately those of the original unfractionated flours (Table III). Lyophilized water-solubles added to lyophilized residues also gave viscosities close to those of the original unfractionated flours (Table III).

However, the addition of liquid water-extracts to reconstituted residues gave viscosities only 60 to 77% of those of the original unfractionated flours (Table IV).

Interchange Experiments with Water-Extracts and Unfractionated Residues

The viscosities obtainable by combining water-extracts with unfractionated residues made it possible to evaluate the role of the water-solubles in varietal viscosity values (Table V). Viscosities were decidedly higher when the Columbia extract was used. Columbia extracts with Columbia residues gave values about 30 units higher than did Brevor and Omar extracts with Columbia residues. Columbia extracts with Omar and Brevor residues gave values 15 and 43 units higher respectively than did the use of Omar and Brevor extracts with their own residues.

Brevor extracts caused somewhat higher viscosities than did Omar extracts for the three residues with which both of these extracts were used.

For the Gaines-Brevor pair, where only a small difference existed, the interchange of extracts caused about half of the small difference.

Subfractions of the Water-Extract

The early investigators concluded that the effect of the water-solubles on viscos-

TABLE V. INTERCHANGES OF WATER-EXTRACTS AND UNFRACTIONATED RESIDUES

Extract[a]		Residue	Viscosity degrees MacMichael	Extract		Residue	Viscosity degrees MacMichael
Columbia	+	Columbia	107	Brevor	+	Brevor	58
Brevor	+	Columbia	73	Omar	+	Brevor	46
Brevor	+	Brevor	52	Omar	+	Omar	36
Columbia	+	Brevor	95	Brevor	+	Omar	38
Columbia	+	Columbia	111	Gaines	+	Gaines	62
Omar	+	Columbia	72	Brevor	+	Gaines	57
Omar	+	Omar	32	Brevor	+	Brevor	52
Columbia	+	Omar	47	Gaines	+	Brevor	55

[a]All extracts and residues from 20.0 g. flour extracted with 100 ml. water.

ity was due to the soluble ash or inorganic constituents. Bayfield (12) added flour ash to the flour-water slurry and observed a large decrease in readings. The role of the soluble proteins and pentosans contained in the water-solubles seems to have been ignored.

The water-extracts from 50.0-g. samples of each flour extracted with 250 ml. distilled water were separated into dialyzables and nondialyzables. Duplicate extractions and dialyses were made for each flour. Yields and analytical data are given in Table VI. The dialyzables contained over half of the water-soluble material but little nitrogenous material and very little pentose material. The bulk of the proteins and pentosans were in the nondialyzables. There was a greater range in the yields of the dialyzables than in the nondialyzables.

There was a close, direct relation between the yield of total water-extract and the original flour viscosity (Fig. 2) and a somewhat poorer relation between yield of dialyzables and original flour viscosity.

All of the depressing effect of the total water-extract was due to the dialyzables (Table VII). The dialyzables invariably lowered the residue viscosity more than did the total water-extract, whereas the nondialyzables occasionally caused a small elevation in residue viscosity.

Varietal Differences in the Dialyzable Subfraction

The dialyzables were prepared from 50.0-g. samples of each flour, concentrated, and made up to 250-ml. volume. Aliquots of 25 and 50 ml. plus enough water to make 100 ml. total liquid were added to a flour whose original viscosity was 146

TABLE VI. YIELDS AND ANALYTICAL DATA FOR SUBFRACTIONS OF THE WATER EXTRACTS

	Dialyzables[a]			Nondialyzables[b]			Combined Yield
	yield[c] g.	N X 5.7 %	pentoses %	Yield g.	protein %	pentosans %	g.
Columbia	3.14	4.1	1.2	1.66	39.5	25.2	4.80
Gaines	2.92	2.4	1.3	1.50	43.8	30.6	4.42
Brevor	2.57	5.4	1.4	1.46	43.7	30.2	4.03
Golden	2.82	6.4	1.4	1.34	45.8	27.1	4.16
Omar	2.19	7.7	1.8	1.53	48.2	27.0	3.72

[a]Data for dialyzables are on dry basis.

[b]Data for nondialyzables are on "as-is" basis after lyophilizing; generally this is about 4% moisture.

[c]Yield is g. from 100 g. flour.

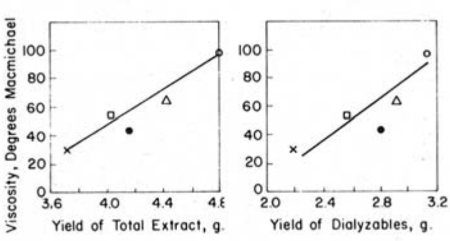

Fig. 2. The relation between water-soluble materials and viscosity of the original flours.

TABLE VII. EFFECT OF THE WATER-EXTRACT SUBFRACTIONS ON VISCOSITY OF RESIDUES

	Columbia	Brevor	Omar
	degrees Macmichael		
Wet residues[a]	160	103	50
Residues plus total extract	108	51	35
Residues plus dialyzables only	91	45	27
Residues plus nondialyzables only	173	102	52

[a]The amount of each material used was that obtained from 20 g. flour extracted with 100 ml. water.

degrees MacMichael. Duplicate extractions and dialyses were made for each flour, and the effect on viscosity of each dialysate was determined. Yield was determined on duplicate 25-ml. aliquots. The dialyzables from Columbia and Golden flours had smaller effects per unit weight than did the dialyzables from the other three flours (Fig. 3).

Interchange Experiments with Reconstituted Three-Fraction Residues

It was shown (Table II) that gluten, tailings, and starch could be successfully reconstituted to residues. Results and the analysis of variance for the interchange experiments with the reconstituted residues from Columbia, a hard wheat, and Brevor, a soft wheat, are given in Table VIII. The standard deviation for this experiment was 4.3 degrees MacMichael. The variability between duplicate determinations made on the same day on the same sample was small and is not shown in Table VIII. The day-to-day variability (Dates, Table VIII) was small relative to the mean squares of the residues (R) and the residues by substitution (R $\times$ S), and substitution *per se* did not have any effect. The type of residue substituted (Residues, Table VIII) had a very large effect on viscosity.

The substitution of Brevor gluten in the Columbia blend caused a large drop in viscosity to practically the level of the all-Brevor blend (Table VIII). The substitution of Columbia gluten in the Brevor blend caused the viscosity to rise to nearly that of the all-Columbia blend. The interchange of tailings and starches resulted in practically no change in viscosity.

A similar, complete interchange experiment was applied to the reconstituted residues from Columbia and the club wheat, Omar, and the results, omitted for brevity, were almost identical. The standard deviation for this experiment was 3.9

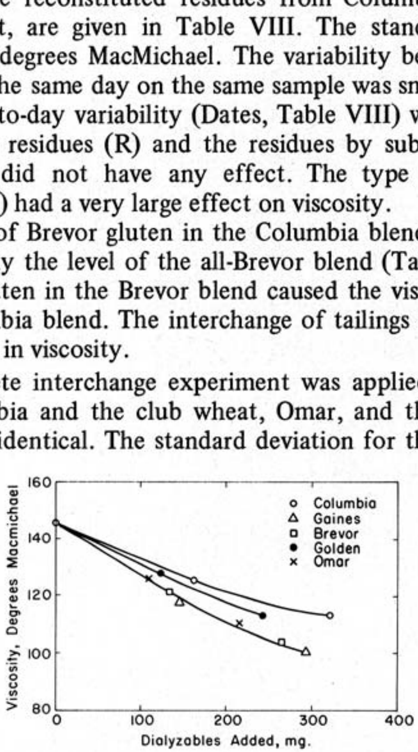

Fig. 3. The effect of the dialyzable subfractions on the viscosity of an unfractionated flour.

TABLE VIII. SINGLE-FRACTION INTERCHANGES BETWEEN COLUMBIA AND BREVOR RECONSTITUTED RESIDUES

	All One Variety	Other Gluten	Other Tailings	Other Starch
		degrees MacMichael		
Columbia residues[a]	152	86	147	150
Brevor residues	83	141	86	83

ANALYSIS OF VARIANCE OF EXPERIMENT

Sources of Variation	Degrees of Freedom	Mean Square	Sources of Variation	Degrees of Freedom	Mean Square
Dates	2	150	R × S	3	5,470
Residues	1	7,668	Error	14	19
Substitutions (S) (Interchanges)	3	16	Total	23	.....

[a]Either all three fractions or two out of three were Columbia; the same for Brevor residues

degrees MacMichael, day-to-day and substitution variabilities were small, and the type of residue substituted caused a large variability. The all-Omar blend, of course, had a much lower viscosity (48 degrees), but the substitution of Columbia gluten raised this blend to 116 degrees whereas substitution of Omar gluten in the Columbia blend caused the readings to drop to 56. Omar tailings and starch caused small depressions in the viscosity of Columbia blends, but Columbia tailings and starch did not elevate the viscosity of Omar blends.

Likewise, a complete interchange experiment with reconstituted residues from Brevor and Omar showed that the gluten accounted for all of the difference. Tailings and starch fractions had no effect on viscosity.

Gaines and Brevor flours, both from soft common wheats, differed only slightly in viscosity (Table I). A complete interchange experiment was used in an attempt to determine the fractions responsible for the small difference. The standard deviation for this experiment was 3.3 degrees MacMichael. Although gluten caused part of the difference, the tailings fraction was also involved, and the difference appeared to be about equally divided between these two fractions.

DISCUSSION

The data would be relatively easy to interpret if only the results with reconstituted residues were considered. For these, gluten alone appeared to be responsible for the varietal effect. Were water-extracted flours to be used, as suggested (13), viscosity values might depend entirely on gluten quality.

It would be incorrect, however, to say that starch and tailings had no effect on viscosity. The viscosity of a reconstituted residue was always much higher than that of 2.0 g. gluten. Either starch and tailings when doughed with gluten or the doughing itself caused the entire blend to increase in viscosity compared to that of gluten alone.

Inclusion of the water-soluble fraction presented some contradictions. Most data showed that this fraction acted as a depressant and that there was a direct relation between normal flour viscosity and the depressing effect, Columbia water-solubles having a larger depressing effect than Brevor water-solubles, and Brevor in turn having a larger effect than Omar. The data in Fig. 1 and Tables III and VI indicate this. This direct relation is puzzling. It implies that the gluten from varieties with high normal flour viscosity must have additional viscosity to offset the larger depressing effects of the water-solubles or dialyzables from these varieties. An inverse relation would seem to be more logical and would help account for varieties having low viscosity values.

However, from the interchange experiments with water-extracts and unfractionated residues (Table V), Columbia water-solubles had the ability to raise viscosity compared to Brevor and Omar water-solubles. Not only is this contradictory to the other evidence with water-solubles, but it also suggests that the water-solubles may be responsible for part of the varietal differences in viscosity. The role of the water-solubles in viscosity is still far from clear.

Some constituent of the nondialyzables, possibly the water-soluble proteins, made a contribution to viscosity (Table VII). This was shown both by the direct but small increase from the nondialyzables and by the fact that the dialyzables had a larger depressing effect than the total water-extract. Thus the net effect of the water-extract is due to the large depressing effect of the dialyzables, tempered by the small elevating effect of the nondialyzables.

No reason is known for the failure of complete reconstituted flours (four fractions) to achieve normal flour viscosities. The damage occurred during separation into gluten, tailings, and starch, since unfractionated residues plus water-extracts gave normal viscosities. Two possibilities may be an increased susceptibility of gluten to depressing effects of dialyzable materials after gluten is freed from tailings and starch, and an enhanced effect of dialyzables after fractionation.

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