DEFATTED AND RECONSTITUTED WHEAT FLOURS. II. EFFECTS OF SOLVENT TYPE AND EXTRACTING CONDITIONS ON FLOURS VARYING IN BREADMAKING QUALITY[1]

O. K. CHUNG, Y. POMERANZ, K. F. FINNEY[2], and M. D. SHOGREN[3], U.S. Grain Marketing Research Center, Agricultural Research Service, North Central Region, U.S. Department of Agriculture, Manhattan, KS 66502

ABSTRACT

Cereal Chem. 54(3): 484-495

Extractability of lipids in three widely differing bread flours increased with solubility parameter of the solvent (Skelly B < benzene < acetone < 2-propanol) and extraction temperature (30° to 75°C). For any solvent-temperature combination, more lipids usually were extracted by Soxhlet than by the shaker technique used. Temperature-controlled extraction (for 2 hr) by shaker had little effect on rheological properties of doughs made with the reconstituted flours. Without shortening, breads baked with the reconstituted strong flours that had been extracted with Skelly B, benzene, or acetone had larger loaf volumes than those of the controls. The improving effects were masked, however, when shortening was used. Soxhlet extraction with 2-propanol appeared to infinitely increase mixing time and irreversibly impair the functionality of reconstituted, good breadmaking flours; but it substantially improved the functionality of a poor quality flour, especially when the flour was made into bread with 3% shortening. To maximize lipid extraction and minimize damage to breadmaking properties of reconstituted flours, extraction with 2-propanol should be for 2 hr at 75°C by the shaker technique for good quality flours and for 72 hr by Soxhlet for poor quality flours.

To demonstrate the role of flour lipids in breadmaking, it is necessary to establish conditions which maximize extraction of lipids yet minimize damage to functional properties of wheat flour. In most lipid studies (1−10), the extracting conditions (type of solvent or device) were selected primarily on the basis of the amount and composition of extracted lipids rather than on the basis of maintenance or restoration of the original breadmaking (functional) properties of the reconstituted flours. Previous studies from our laboratory (11) showed that slightly more flour lipids were extracted by a regular than by a vacuum Soxhlet for any of the solvents Skelly B, benzene, acetone, or 2-propanol. Vacuum extraction, however, damaged breadmaking properties much less than regular extraction, especially with 2-propanol. Reducing the pressure in a modified Soxhlet lowered extracting temperature by 12° to 18°C. The results suggested that the extracting temperature would affect lipid extractability and, especially, functionality of reconstituted flours.

In the present study, we used reconstituting techniques to study the effects of extraction methods (temperature-controlled shaker *vs*. Soxhlet) and conditions (type of solvent and temperature) on extractability of lipids and on functional properties of good and poor breadmaking flours.

[1]Mention of firm names or trade products does not constitute endorsement by the U.S. Department of Agriculture over others of a similar nature not mentioned.
[2]Research Chemists.
[3]Research Cereal Technologist.

MATERIALS AND METHODS

Materials

Untreated straight-grade flours were experimentally milled (Allis) from two selections, Chiefkan/Tenmarq (KS501097) and Shawnee (C.I. 14157), of hard red winter wheats harvested in 1973 and from a composite grist of many wheat varieties harvested at many locations throughout the Great Plains in 1973, Regional Baking Standard—RBS-74. The three flours had the following characteristics:

Flour Sample	*Protein* (N × 5.7) (%, 14% mb)	*Ash*
RBS-74	12.4	0.41
Shawnee (C.I. 14157)	13.0	0.40
Chiefkan/Tenmarq (KS501097)	13.4	0.43

RBS-74 and Shawnee were good breadmaking flours and KS501097 was extremely poor.

Organic solvents were analytical reagent grade and solutions were prepared from analytical reagent-grade compounds.

Analytical Procedures

Protein, ash, and moisture contents were determined by AACC methods (12). The 10-g baking procedure has been described (13). The loaves were cooled to 25°C, and loaf volumes were determined by dwarf rapeseed displacement. Loaves were cut and their crumb grains were evaluated: S, satisfactory; Q, questionable; and U, unsatisfactory. Mixograms of 10 g flour (optimum water) were also determined (14).

Extracting Lipids

Lipids were extracted by two methods: 1) by shaking in a water bath and 2) by a Soxhlet. By the first method, 30 g (db) flour and 240 ml solvent (Skelly B, benzene, acetone, or 2-propanol) in a 500-ml flask plugged with glass wool were shaken in a water bath for 2 hr. During the 2-hr extraction period, the flasks were taken out of the water bath and hand-shaken vigorously at room temperature for 3 min every 15 min, because the water bath shaker (Lab-line Instruments, Cat. No. 3581) mainly provided a gentle horizontal agitation. Extraction temperature by the shaker method was controlled by the water bath; temperatures were 30°, 45°, 60°, or 75°C for Skelly B, benzene, and 2-propanol; 75°C was omitted for acetone because of its low boiling point. Small portions of fresh solvent were added during hand-shaking, if necessary, at 60°C for acetone and 75°C for Skelly B to maintain a constant flour:solvent ratio. The initial ratio was maintained for all temperature-solvent combinations. The lipid extract was filtered through a Buchner funnel with a fine fritted disk. The residue was further extracted for 3 min by hand-shaking at room temperature with three 50-ml portions of fresh solvent. Solvent from the combined extracts was evaporated at reduced pressure below 40°C and the lipids were stored at −18°C.

Temperature effects on functional properties of flours were also determined on samples shaken for 2 hr without solvent. The Soxhlet extraction procedure has been described (11). Temperature in the chamber of the Soxhlet extractor depended on the boiling point of the solvent and its condensation rate. Temperatures (°C) of the extracting chambers were up to 40° for acetone, 42° for Skelly B, 45° for benzene, and 50° for 2-propanol. The defatted flours were air-dried until the odors of the solvents were not detected, sifted through a 100-mesh sieve (149-μm openings), and then stored at 4°C.

Lipid extractions were replicated three times by the shaker and at least twice by the Soxhlet methods. For preliminary studies, various shaker extraction times (2, 4, or 8 hr) were studied using RBS-74 flour with the four solvents at 60°C. In addition, lipids were extracted from Shawnee and KS501097 flours with 2-propanol for 72 hr by a shaker at 75°C. Prolonged extraction times did not increase amounts of lipids but increased total 2-propanol extracts which contained nonlipid material, especially when extracted for 72 hr. When the dried crude extracts were redissolved in petroleum ether (three times with 25 ml) and centrifuged at 20,384 × *g* for 10 min at 4°C, amounts of purified lipids equaled the amounts extracted for 2 hr. Extraction times for the two methods were selected for maximum extraction of lipids under the given conditions.

Reconstituting Flour Lipids and Defatted Flours

The defatted flours were blended with appropriate amounts of extracted lipids in a Stein mill for 1 min. The low moisture contents of the reconstituted flours were increased to those of the original flours in an equilibration cabinet, as described previously (11). Mixograph, mixing time, water absorption, and breadmaking tests were all made on reconstituted flours.

RESULTS AND DISCUSSION

Flour Lipids

Increasing the solubility parameter of the solvent increased lipid extractability of the three flours by both methods (Table I). Lipid extractability for all solvents increased with temperature of extraction. Analysis of variance (ANOVA) and Fisher's Least Significant Difference (LSD) were used to determine statistical significance of all treatment effects or varietal differences. Data from the shaker-extraction series showed that solvent (S), flour (F), temperature (T), and all the interactions S × F, S × T, F × T, and S × F × T affected the amount of lipids extracted at the 0.01 level. Tests for LSD further confirmed the significant effects of solvent, flour, and temperature. Differences in amounts of extracted lipids larger than 0.015% were significant at the 0.05 level and differences larger than 0.020% at the 0.01 level. Data for the Soxhlet-extraction and the shaker-extraction series at the highest temperature showed that solvent (S), flour (F), and extraction method (M), and all the interactions except for F × M affected lipid extractability at the 0.01 level. For comparisons between two treatments, the effects were significant at the 0.05 level if differences in extracted lipids were larger than 0.031%, and at the 0.01 level if larger than 0.042%.

Therefore, extracting methods by the Soxhlet or the shaker affected amounts of lipids extracted from all three flours with all four solvents except for KS501097 and RBS-74 with benzene. Although Soxhlet temperatures were lower than the highest shaker-extraction temperatures (60°C for acetone and 75°C for the other solvents), lipid extraction was greater in the continuous Soxhlet than in the batch-type shaker extraction, except for that from KS501097 with Skelly B. Lipid extractability was greater by the Soxhlet than by the shaker method and was more pronounced for acetone and 2-propanol than for Skelly B and benzene.

The amounts of lipid extracts were slightly higher for Shawnee and slightly lower for KS501097 than for RBS-74 with Skelly B, benzene, or 2-propanol, irrespective of the extracting method.

Water Absorptions

The solvent treatments did not affect mixograph water absorptions of reconstituted Shawnee and KS501097 flours, but did increase absorption of RBS-74 flour by 1 to 2 percentage points (Table II). However, both heat- and solvent-treatments increased baking absorption, on the average, by 2.5 percentage points for KS501097 and Shawnee flours, and by 1.5 percentage points for RBS-74 flour. Baking absorptions for breads with 3% shortening were, in general, equal to or slightly higher than mixograph absorptions for the good quality, treated flours (Shawnee and RBS-74) and lower by 3 percentage points for the poor quality flour (KS501097). Baking absorptions were significantly

TABLE I
Flour Lipids Extracted with Four Solvents

Extracting Method : Solvent		Water Bath Temp. °C	Lipids (%, db)[a] Extracted from Flour		
			RBS-74	Shawnee	KS501097
Soxhlet	: Skelly B (7.27)[b]		1.03	1.05	0.88
	Benzene (9.16)		1.12	1.18	1.04
	Acetone (9.62)		1.17	1.23	1.24
	2-Propanol (11.44)		1.43	1.47	1.41
Shaker	: Skelly B (66.7)[c]	30	0.86	0.88	0.79
		45	0.88	0.92	0.84
		60	0.96	0.97	0.88
		75	0.99	1.01	0.93
	Benzene (80.1)	30	0.95	0.97	0.87
		45	0.99	1.02	0.92
		60	1.05	1.07	0.98
		75	1.10	1.13	1.04
	Acetone (56.5)	30	1.00	0.99	0.98
		45	1.02	1.03	1.03
		60	1.06	1.08	1.10
	2-Propanol (82.3)	30	1.18	1.21	1.15
		45	1.23	1.26	1.21
		60	1.28	1.32	1.26
		75	1.32	1.38	1.27

[a]Averages of two extractions by the Soxhlet and three extractions by the shaker; overall standard deviation: 0.0086.
[b]Solvent solubility parameter at 25°C, according to Hoy (15). Value for Skelly B is solubility parameter of hexane.
[c]Solvent boiling point, °C.

TABLE II
Water Absorption (14% mb) of Reconstituted, Solvent-Extracted Flours

Extracting		Water Absorption, %					
		RBS-74		Shawnee		KS501097	
Solvent	Method	Mixogr.	Baking[a]	Mixogr.	Baking[a]	Mixogr.	Baking[a]
None:	control	63.1	63.1	67.0	64.0	67.5	62.1
No solvent:	shaking[b]	63.1	63.0	67.0	67.0	67.5	65.0
Skelly B:	shaking[b]	64.1	64.0	67.0	66.8	67.5	65.4
	Soxhlet	64.1	65.4	67.0	67.0	67.5	65.5
Benzene:	shaking[b]	64.1	64.4	67.0	67.0	67.5	63.5
	Soxhlet	64.1	65.6	67.0	67.0	67.5	63.5
Acetone:	shaking[c]	65.1	65.4	67.0	67.0	67.5	64.2
	Soxhlet	65.1	66.4	67.0	67.0	67.5	64.5
2-Propanol:	shaking[b]	64.1	64.1	67.0	67.0	67.5	64.5
	Soxhlet	64.1	62.2	67.0	62.0	67.5	64.5

[a]With 3.0% shortening added; averages of two replicates; overall standard deviation: 0.363.
[b]Average values for flours treated at 30°, 45°, 60°, and 75°C.
[c]Average values for flours treated at 30°, 45°, and 60°C.

TABLE III
Mixing Characteristics of Reconstitutd Solvent-Extracted Flours

Extracting		Mixing Time (min)					
		RBS-74		Shawnee		KS501097	
Solvent	Method	Mixogr.	Baking[a]	Mixogr.	Baking[a]	Mixogr.	Baking[a]
None:	control	3-7/8	4.0	4-1/4	5.0	7/8	7/8
No solvent:	shaking[b]	3-3/4	3-3/4	4-7/8	5-1/4	7/8	7/8
Skelly B:	shaking[b]	4-3/8	4-5/8	5-1/4	6-3/4	7/8	1-1/4
	Soxhlet	4.0	4-7/8	5-3/4	6-1/2	7/8	7/8
Benzene:	shaking[b]	4-1/8	4-3/8	5-3/8	6-1/8	7/8	7/8
	Soxhlet	5-3/4	6-7/8	5-1/2	6.0	7/8	7/8
Acetone:	shaking[c]	4-3/8	5-1/4	6-1/8	7.0	1.0	1-1/8
	Soxhlet	7-1/2	8-5/8	10-3/4	12-5/8	1-3/8	1-1/2
2-Propanol:	shaking[b]	4-3/8	4-1/2	5.0	5-3/4	3/4	7/8
	Soxhlet	∞	2(∞)[d]	∞	2(∞)[d]	3-1/2	3-1/2

[a]With 3.0% shortening added; averages of two replicates; overall standard deviation: 0.176 ≃ 3/16.
[b]Average values for flours treated at 30°, 45°, 60°, and 75°C.
[c]Average values for flours treated at 30°, 45°, and 60°C.
[d]Mixed for 2 min to incorporate the ingredients.

higher for Shawnee flour than RBS-74 or KS501097 flours. Differences in baking absorptions were significant at the 0.05 level if they were larger than 1.68 and at the 0.01 level if larger than 2.27 percentage points. Therefore, baking absorptions were significantly lower for the Soxhlet than for the shaker-extracted flours when Shawnee and RBS-74 were treated with 2-propanol. For the other solvent-treated flours, baking absorptions were not consistently different for the two extraction methods. There were only small temperature effects on baking absorptions of the three flours when shaker-extracted with each of the four solvents (data not given). Baking absorptions of doughs without shortening were, on the average, 1.5 percentage points higher than those of doughs with shortening (data not given).

Mixing Requirements

Mixograph and bake mixing times were affected by the extracting solvent and method and by flour quality (Table III). Overall effects on bake mixing time of

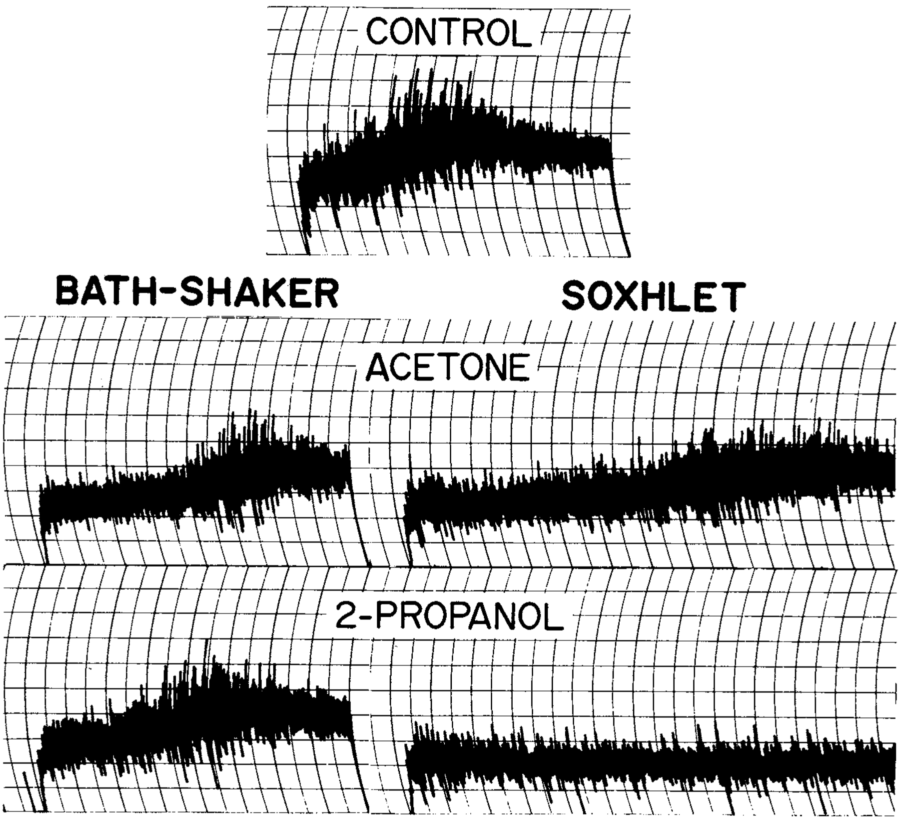

Fig. 1. Mixograms (10 g reconstituted flour) of aliquots of Shawnee flour that were extracted with acetone in a water-bath shaker (60° C) and in a Soxhlet, and with 2-propanol in a water-bath shaker (75° C) and in a Soxhlet. Heavy-lined arcs are at 1-min intervals.

solvent (S), flour (F), extraction method (M), and all the interactions S × F, S × M, F × M, and S × F × M were significant at the 0.01 level. All the 2-propanol treatment data were excluded for statistical analysis because of infinite mixing times for the Soxhlet-treated Shawnee and RBS-74 flours. Differences in mixing times were significant at the 0.05 level if they were larger than 0.5 min and at the 0.01 level if larger than 0.75 min. Mixing time increased with solubility parameter value of solvent for all three flours; Soxhlet-extracted flours usually had longer mixing times than shaker-extracted flours; differences in mixing times of Soxhlet- and shaker-extracted flours were pronounced for acetone and especially for 2-propanol; and solvent treatment affected mixing times of the good quality flours more than those of the poor quality flour.

Some typical mixograms for treatments described in Table III are shown in Figs. 1 and 2. Shaker extraction with acetone at 60°C increased mixograph mixing time (MMT) of the Shawnee control flour from 4-1/4 to 6-1/8 (about 44%); Soxhlet extraction with acetone increased MMT to 10-3/4 min (about

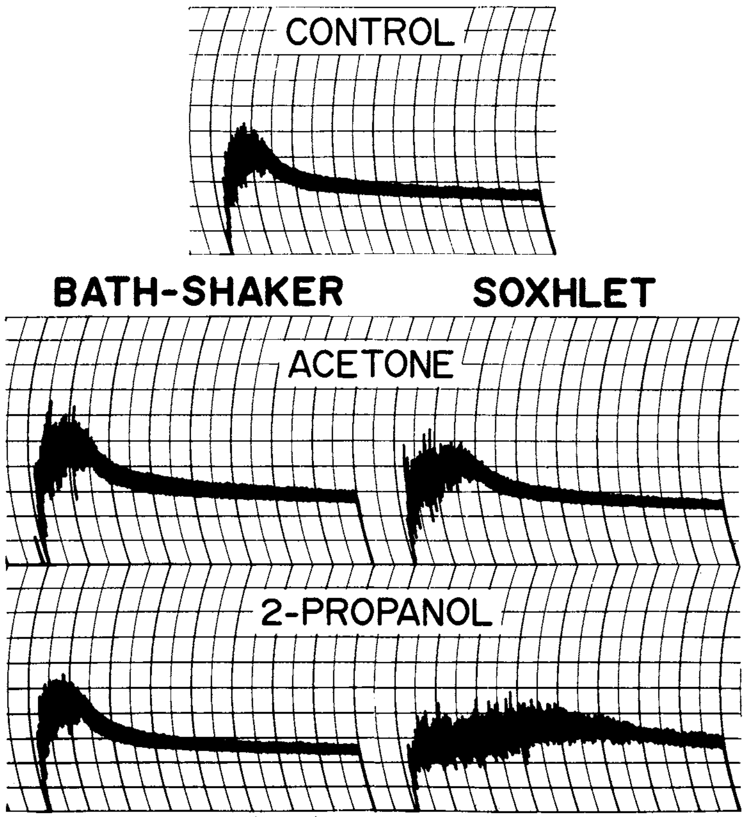

Fig. 2. Mixograms (10 g reconstituted flour) of aliquots of KS501097 flour that were extracted with acetone in a water-bath shaker (60°C) and in a Soxhlet, and with 2-propanol in a water-bath shaker (75°C) and in a Soxhlet. Heavy-lined arcs are at 1-min intervals.

153%, Fig. 1). Shaker-propanol treatment at 75°C increased MMT only about 17%; but the Soxhlet-propanol-treated flour had an essentially infinite mixing time, as even mixing for 28 min with 10% water below-optimum to speed up rate of development produced no point of minimum mobility as described previously (11). Consequently, doughs for RBS-74 and Shawnee flours treated with 2-propanol in the Soxhlet were mixed for 2 min merely to incorporate the ingredients.

The MMT of the KS501097 flour was 1.0 min after shaker extraction with acetone at 60°C (only about 14% higher than control) and 1-3/8 min after Soxhlet extraction (about 57% higher than control) (Fig. 2). Shaker extraction with 2-propanol decreased MMT of KS501097 flour by about 14%, but Soxhlet extraction increased it threefold. The rheological properties of the KS501097 flour that had been Soxhlet-extracted with 2-propanol were substantially better than those of the parent flour.

However, mixing times were infinite for the reconstituted flours of both Shawnee and KS501097 when they were treated for 72 hr with 2-propanol by a shaker at 75°C (data not given).

TABLE IV
Loaf Volume of Bread Baked with 10 g Reconstituted, Solvent-Extracted Flours

Extracting Solvent:	Method	Water Bath Temp. °C	Loaf Volume (cc)[a] RBS-74 0	RBS-74 3[b]	Shawnee 0	Shawnee 3[b]	KS501097 0	KS501097 3[b]
None:	control	...	64.7	77.7	63.3	78.3	50.1	53.6
No solvent:	shaking	30	64.3	79.8	67.2	82.2	51.9	52.0
		75	62.9	79.0	67.7	78.6	49.4	51.8
Skelly B:	shaking	30	66.9	80.7	74.2	82.5	54.2	60.0
		75	67.8	78.7	77.6	80.4	48.0	58.5
	Soxhlet	...	68.2	76.5	77.3	78.9	49.1	53.6
Benzene:	shaking	30	66.0	76.7	74.8	80.4	50.1	50.2
		75	65.7	76.1	71.8	78.9	46.0	50.6
	Soxhlet	...	62.0	74.0	78.1	79.2	47.5	52.6
Acetone:	shaking	30	69.4	80.5	71.2	82.0	51.2	54.6
		60	65.1	76.8	69.3	81.0	53.7	55.3
	Soxhlet	...	68.4	74.0	69.6	72.7	51.8	58.1
2-Propanol:	shaking	30	67.3	77.0	71.4	83.3	47.8	51.4
		75	64.3	76.6	69.2	78.4	47.6	52.8
	Soxhlet	...	25.9	25.8	28.5	28.3	53.5	65.7

[a]Averages of two replicates; overall standard deviation: 1.77.
[b]0 and 3 = 0 and 3% shortening added.

Proof Heights

Proof heights averaged 7.5 cm and they were generally unaffected by either heat or solvent treatment. Proof heights were 6.4 and 6.8 cm for the Soxhlet-extracted with 2-propanol RBS-74 and Shawnee flours. Similarly, proof heights were 6.1 and 6.5 cm, respectively, for Shawnee and KS501097 flours treated with 2-propanol by a shaker at 75°C for 72 hr. The extraction greatly impaired gas retention of the two flours but not, as expected, of KS501097 flour when treated by the Soxhlet.

Loaf Volumes and Crumb Grains

In breads from the shaker-treated flours at various temperatures (data not given), loaf volumes with or without shortening added were affected at the 0.01 level by solvent, flour, and interaction solvent × flour, but not by temperature or the other interactions. In breads from the Soxhlet-treated and the shaker-treated flours at the highest temperature (Table IV), solvent (S), flour (F), extraction method (M), and all the interactions S × F, S × M, F × M, and S × F × M affected

TABLE V
Crumb Grain of Bread Baked with 10 g Reconstituted, Solvent-Extracted Flours

Extracting Solvent :	Method	Water Bath Temp. °C	Crumb Grain[a] RBS-74 0	RBS-74 3[b]	Shawnee 0	Shawnee 3[b]	KS501097 0	KS501097 3[b]
None:	control	...	Q-U	S	Q	S	U^4	U^4
No solvent:	shaking	30	Q-U	S	S-Q	S	U^4	U^4
		75	Q-U	S	S-Q	S	U^4	U^4
Skelly B:	shaking	30	Q	S	S-Q	S	U^4	U^4
		75	Q	S	S-Q	S	U^4	U^3
	Soxhlet	...	Q	S	Q	S	U^3	U^4
Benzene:	shaking	30	Q	S	Q	S	U^4	U^4
		75	Q	S	Q	S	U^4	U^4
	Soxhlet	...	Q-U	S-Q	Q	S	U^4	U^4
Acetone:	shaking	30	Q	S	S-Q	S	U^3	U^4
		60	Q-U	S	Q	S	U^3	U^3
	Soxhlet	...	Q-U	Q-S	Q	S	U^2	U^2
2-Propanol:	shaking	30	Q-U	S	Q	S	U^4	U^4
		75	Q-U	S	Q-U	S	U^4	U^4
	Soxhlet	...	U^6	U^6	U^6	U^6	U	Q-U

[a]S = Satisfactory; Q = questionable; U = unsatisfactory (the higher the number, the poorer the crumb grain).
[b]0 and 3 = 0 and 3% shortening added.

loaf volumes with or without shortening added. Differences in loaf volumes were significant at the 0.05 level if larger than 5.96 or 4.41 cc, and at the 0.01 level if larger than 8.04 or 5.95 cc, respectively, for the no shortening or the shortening series.

When shortening was omitted, volumes of loaves baked from flours that were reconstituted after extracting with the four solvents by both methods (except for 2-propanol in the Soxhlet) averaged 66.5 cc compared with 64.7 cc for the RBS-74 control, and 73.1 cc compared with 63.3 cc for the Shawnee control (Table IV). Solvent extraction by either method had little "improving effect" on loaf volume for the KS501097 flour. The average volume for the reconstituted flours was 50.0 cc as compared with 50.1 cc for the control.

Generally, each solvent treatment (except that with 2-propanol in the Soxhlet) somewhat improved crumb grain of breads baked from the reconstituted RBS-74 and Shawnee flours; extraction by shaking seemed to improve crumb grain of breads without shortening slightly more than the Soxhlet extraction (Table V). Crumb grain of the KS501097 bread was improved slightly by acetone and substantially by 2-propanol treatment in the Soxhlet.

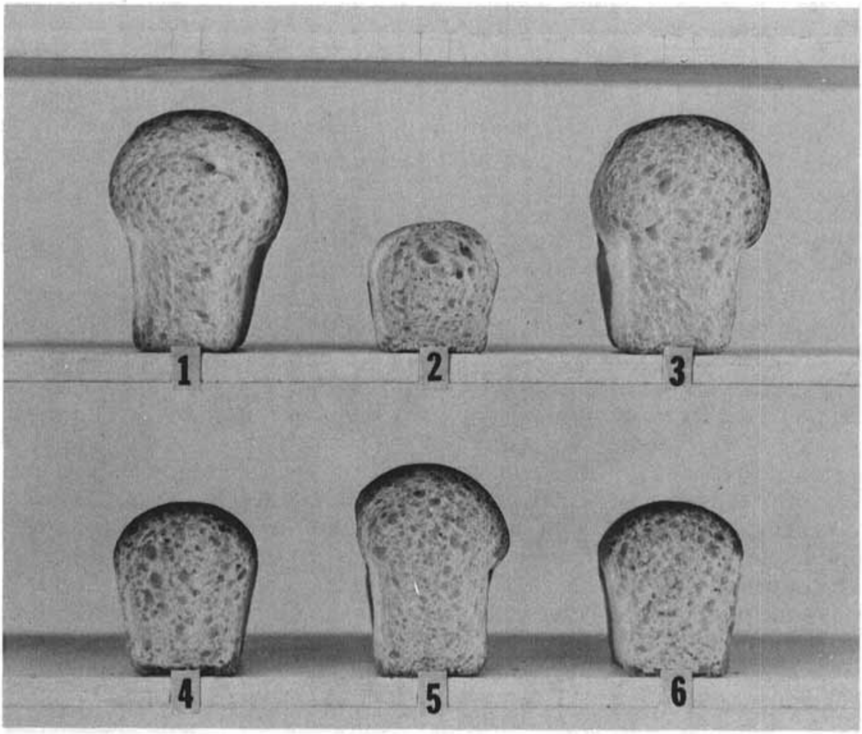

Fig. 3. Bread (10 g flour, 3% shortening) baked from Shawnee (top row) and KS501097 (bottom row); 1 and 4, control flours; 2 and 5, flours extracted with 2-propanol in a Soxhlet and then reconstituted; and 3 and 6, flours extracted with 2-propanol in a water-bath shaker (75°C) and then reconstituted.

Shortening masked some of the improving effects of solvent extraction on breads made with RBS-74 and especially Shawnee flours, but it significantly improved breads baked with the solvent-treated KS501097 flours. The most notable improvements for the poor flour were increases in loaf volumes of bread from Skelly B shaker-treated flours and Soxhlet-extracted flours with acetone and 2-propanol (Table IV). Those increases in loaf volumes were generally accompanied by improvements in crumb grain (Table V).

The effects of extracting method on breadmaking characteristics depended on flour strength (Tables IV and V). The most conspicuous differences were with 2-propanol treatment for the good and poor quality flours baked with shortening (Fig. 3). Soxhlet extraction with 2-propanol impaired functionality of good flour but substantially improved baking quality of poor flour. Shaker extraction with 2-propanol restored the original breadmaking properties of the reconstituted flours for both good and poor flours, when extraction times were only 2 hr. If shaker extraction with 2-propanol at 75°C lasted 72 hr, loaf volumes for the reconstituted flours were only 25.8 or 21.1 cc for Shawnee and 28.8 or 24.3 cc for KS501097 flour, respectively, with or without shortening added. Extreme decreases in loaf volumes were accompanied by extremely poor crumb grains.

COMMENTS AND CONCLUSIONS

Lipid extractability was affected by the solvent, the extracting temperature, and the extracting method for three flours that differed widely in breadmaking (functional) properties. Increasing either the solubility parameter of the solvent or the extraction temperature increased the amounts of extracted lipids. Soxhlet extraction was more effective than shaker extraction, regardless of the temperature of extraction.

Heating of the flours without solvent did not substantially affect mixograph or bake mixing time, loaf volume, or crumb grain, but increased bake water absorption by 3 percentage points for the Shawnee and KS501097 flours.

Lipid extractability patterns were similar for all the flours and depended on the solvent and method of extraction. Effects of solvent treatments on breadmaking characteristics also depended on flour quality. In discussing the effects of solvent treatments on bread quality, we stress that loaf volume and crumb grain are affected by many factors. Both wheat flour lipids and shortening contribute to the final size and quality of the bread; yet, the mechanism of that contribution likely is not the same. Solvent treatment improved bread from the good RBS and Shawnee flours baked without shortening. The improvement may have resulted from rearrangement of the wheat flour lipids in such a manner that they performed, in part, the role of shortening. Solvent treatment affected mixing time of the poor quality flour only if the solvent had a high solubility parameter and extraction was exhaustive in the Soxhlet. Soxhlet extraction with 2-propanol appeared to irreversibly impair the functional properties of the reconstituted good quality flours with about a 13% decrease in proof heights of fermented doughs; yet, those extracting conditions substantially improved the breadmaking quality of the poor flour. The results suggest that differences in breadmaking quality might be related, at least in part, to differences in structural binding of flour lipids. Differences in lipid composition of flours varying in breadmaking quality and structural interactions of lipids are being investigated.

Of the four solvents studied, 2-propanol extracted the most flour lipids. Yet, Soxhlet extraction with 2-propanol was not satisfactory because it was detrimental to the breadmaking properties of the good quality flours. Based on the results of this study, the best extraction procedure for maximum lipid extractability and minimum damage to breadmaking would be 2-hr shaking with 2-propanol at 75° C for good flours and 72-hr extraction by Soxhlet for poor flours. The 2-hr shaker extraction at 75° C with 2-propanol was highly effective as it extracted from good flours about 1.35% lipids in comparison with only about 1.20% extracted with acetone in the Soxhlet.

Extended treatment with 2-propanol by a shaker at 75° C for 72 hr extracted no additional lipids compared with 2-hr extraction, and yet it irreversibly impaired the functional properties of the reconstituted good and poor quality flours. The results suggest a temperature-time relationship potentially critical to irreversible damage. Further studies along this line are deemed desirable.

Acknowledgments

Lerance C. Bolte milled the wheat samples; Donna Carville extracted flour lipids.

Literature Cited

1. MECHAM, D. K. Lipids. In: Wheat: Chemistry and technology, ed. by Y. Pomeranz. Amer. Ass. Cereal Chem.: St. Paul, Minn. (1971).
2. MECHAM, D. K., and WEINSTEIN, N. E. Lipid binding in doughs. Effects of dough ingredients. Cereal Chem. 29: 448 (1952).
3. BLOKSMA, A. H. Influence of the extraction of lipids from flour on gluten development and breakdown. Chem. Ind. (London) 1959: 253.
4. BLOKSMA, A. H. Extraction of flour by mixture of butanol-1 and water. Cereal Chem. 43: 602 (1966).
5. MEREDITH, P., SIMMONS, H. G., and FRAZER, A. C. Examination of wheat gluten by partial solubility methods. I. Partition by organic solvent. J. Sci. Food Agr. 11: 320 (1960).
6. TSEN, C. C., and HLYNKA, I. The role of lipids in oxidation of doughs. Cereal Chem. 39: 209 (1962).
7. WOOTON, M. Binding and extractability of wheat flour lipid after dough formation. J. Sci. Food Agr. 17: 297 (1966).
8. GRAVELAND, A. Combination of thin layer chromatography and gas chromatography in the analysis on a microgram scale of lipids from wheat flour and wheat flour doughs. J. Amer. Oil Chem. Soc. 45: 834 (1968).
9. CLAYTON, T. A., MacMURRAY, T. A., and MORRISON, W. R. Identification of wheat flour lipids by thin-layer chromatography. J. Chromatogr. 47: 277 (1970).
10. MacMURRAY, T. A. and MORRISON, W. R. Composition of wheat-flour lipids. J. Sci. Food Agr. 21: 520 (1970).
11. CHUNG, O. K., POMERANZ, Y., FINNEY, K. F., HUBBARD, J. D., and SHOGREN, M. D. Defatted and reconstituted wheat flours. I. Effects of solvent and Soxhlet types on functional (breadmaking) properties. Cereal Chem.
12. AMERICAN ASSOCIATION OF CEREAL CHEMISTS. Approved methods of the AACC. Method 08-01, approved April 1961; Method 44-15A, approved April 1967; and Method 46-11, approved April 1961. The Association: St. Paul, Minn.
13. SHOGREN, M. D., FINNEY, K. F., and HOSENEY, R. C. Functional (breadmaking) and biochemical properties of wheat flour components. I. Solubilizing gluten and flour protein. Cereal Chem. 46: 93 (1969).
14. FINNEY, K. F., and SHOGREN, M. D. A ten-gram mixograph for determining and predicting the functional properties of wheat flours. Baker's Dig. 46(2): 32 (1972).
15. HOY, K. L. New values of the solubility parameters from vapor pressure data. J. Paint Technol. 42(541): 76 (1970).

[Received April 30, 1976. Accepted September 23, 1976]