WET-PROCESSING OF LOW-PROTEIN HARD WINTER WHEAT FLOUR TO IMPROVE ITS BREADMAKING POTENTIAL

by

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INTRODUCTION

The baking performance of a bread flour depends in large measure on its protein content. Finney and Barmore (1948) found that the relation between loaf volume and the protein content of wheat flour within a variety was essentially linear between the limits of protein from 8% to 18%. A high-protein bread flour usually costs more than a low-protein one, provided the protein quality is about the same. High protein in bread flour is valued because it: (a) increases tolerance in fermentation, make-up and proofing; (b) improves loaf volume and grain; (c) strengthens the crumb and crust in rolls and bread; (d) permits addition of other grains to produce specialty products; (e) reduces the rate of crumb firming; and (f) improves the nutritional value of bread and rolls (Holme 1966, Bietz et al 1973, Mecham 1973, Pyler 1983a and 1983b, and Kim et al 1977).

Much of the wheat now available in the world is low in protein. The protein content of wheat is influenced by genetics, environment, soil, and fertilization (Schmidt 1974, Pyler 1982). In general, protein in wheat is inversely related to crop yield, which is the primary agronomic factor, and the climate and soils of most countries are not conducive to high protein content in existing varieties. To make good-quality bread economically from low-protein wheats is of interest.

Wallace (1981) patented a breadmaking process that, in effect, increases the protein content of the starting flour. In the Wallace process a portion of the formula flour is wet-processed into two fractions: one is a starch slurry, and the other is the remaining components of the flour in wet form. Removal of the starch increases the percentage of protein in the remainder of the flour, which we termed the protein-rich fraction.

In the Wallace patent the starch slurry is converted into sweetener, which is then combined with the protein-rich fraction and remaining ingredients to produce a dough for making bread. The advantages claimed for this process are: (a) the breadmaking quality of a low-protein flour can be improved by increasing its protein content through removal of a part of its starch; (b) the starch can be converted into sweetener for breadmaking; (c) the gluten gained in the process is not dried, hence is more potent than an equal amount of dried vital gluten; and (d) breadmaking integrated with wet-processing a part of the flour is a closed system with no effluent streams.

Lu et al (1983) showed the technical feasibility of the Wallace process to prepare white-pan bread. Those workers were able to wet-process up to 20% of the formula flour, and they used the protein-rich fraction to produce bread with improved grain and volume compared to a control. They reported that: (a) high-shear on the flour-water mixture during wet-processing gave bread with open grain; (b) the sweetener generated from the starch slurry had a brown color which caused the crumb of test loaves to be darker than a control; and (c) only 50% of the expected increase in loaf volume was achieved.

The objectives of this work were to: (a) use a low-shear process on a flour-water mixture to separate a starch slurry and a protein-rich fraction with low damage to gluten; (b) determine the yield, protein and water content of the two fractions; (c) use the wet, protein-rich fraction to produce bread with maximum loaf-volume; and (d) use the wet starch in foam-type cakes, muffins, and soft cookies.

MATERIALS AND METHODS

Ingredients and Assay Methods

Protein was determined by Kjeldahl nitrogen (AACC Method 46-11, 1976), ash by muffle furnace (AACC Method 08-01, 1961), moisture by oven-drying one hour at 130°C (AACC Method 44-15A, 1975), and pH by a glass electrode pH meter (AACC Method 02-52, 1961). All analytical data on flour were reported on a 14% moisture basis.

Flours A and B were wet-processed and were used in breadmaking. Flour A was a Kansas HRW wheat flour obtained from the pilot flour mill in the Department of Grain Science and Industry, Kansas State University. It had protein content 9.3% (N x 5.7), ash 0.40%, and moisture 14.7%. Flour B was a commercial bread flour obtained from Ross Industries, Inc., Wichita, KS, and had protein 12.2%, ash 0.46%, and moisture 12.9%.

Flour C was a commercial soft-wheat cake flour from Mennel Milling Company, Fostoria, OH, and had protein 8.8%, ash 0.37%, moisture 9.0%, and pH 4.8. Flour C was used with the wet starch fraction from flour A in angel food cakes. Flour D, which was used with the wet starch from flour A in muffins and soft cookies, was a commercial pastry flour from Pillsbury Company, Minneapolis, MN, with protein 8.1%, ash 0.44%, and moisture 11.6%.

The shortening used in pup-loaves was Crisco from Procter and Gamble Company, Cincinnati, OH; non-fat dry milk was Bread-Lac from Galloway-West Co.,Fond du Lac, WI; and yeast was compressed fresh yeast from Busch Industrial Products Corp., St. Louis, MO.

Dried egg white solids used in angel food cakes was the spray-dried Type P-20 (protein 80%, moisture 8%, pH 7) from Henningsen Foods, Inc., Omaha, NE; and leavening acid was monocalcium phosphate monohydrate (MCP) from Monsanto Company, St. Louis, MO.

High-fructose corn syrup (HFCS) used in soft cookies was CornSweet 42 (42% fructose) from ADM Corn Sweeteners, Cedar Rapids, IA. Baking powder used in muffins was Calumet double-acting baking powder from General Foods Corp., White Plains, NY.

Wet-Processing to Separate Flour into Two Fractions

To minimize damage to gluten, a gentle separation of starch and gluten was done using the procedure of Shogren et al (1969). Flours A and B were fractionated using identical conditions. Flour A or B (20g, 14% m.b.) and water (5°C, 45ml) were stirred gently with a glass rod for 5 min to form a smooth slurry. The water to flour ratio was 2.25 (w/w), and the mixture had pH 5.8, which was the native flour pH. The slurry was centrifuged for 20 min at 1000xg, and the supernatant and centrifugate removed from the centrifuge bottle and combined. After gentle massaging by hand for 15 min, a coherent, soft gluten mass formed and separated from a starch slurry. The starch slurry was decanted and allowed to stand 12 hours at 5°C, after which time a portion (15 ml) of the supernatant aqueous phase was drawn off and added to the protein-rich fraction. Wet-processing of flours A and B gave 31.5g and 36.1g, respectively, of wet protein-rich fraction, which contained respectively, 5.5g and 8.1g dry solids, and 1.5g and 2.2 g protein. The wet-starch fraction from flours A and B was 30.2g and 25.4g, respectively, containing 11.2g and 8.7g dry solids and 0.3g and 0.2g protein. The protein-rich fraction was stored in the freezer (-5°C) overnight after separation, and was thawed before test baking. The starch fraction was stored in the refrigerator (5°C) overnight. The storage of the two fractions was only for convenience in the laboratory, and could be omitted if work was done continuously.

Test Baking with Pup-Loaves

Pup-loaves (six replicates) were baked using the straight-dough method optimized for water and oxidant (Finney and Barmore 1945a and 1945b, Finney 1984). Table I gives the formula for the pup-loaves. In the test loaves the wet, protein-rich fraction from 20g of flour A or B (31.5g or 36.1g) was added to the mixer bowl with the other ingredients. Doughs were mixed to optimum consistency (minimum mobility), fermented for 180 min at 30°C and 90% relative humidity,and punched twice at 105 min and 155 min during fermentation. The doughs were moulded on a drum molder at 180 min and panned. After proofing for 55 min at 30°C and 90% R.H., proof height was recorded and the bread was baked 24 min at 218°C (425°F). Loaf weight was taken immediately after baking, and loaf volume was determined by rapeseed displacement. The loaf grain was scored after cooling for one hour. Loaf volumes were reproduced to ±10 cc.

Angel Food Cakes Containing Wet Starch Fraction

Angel food cakes were baked in triplicate using the formula given in Table III. The AACC Method 10-15 (1976) was followed, except in the test cakes where the wet starch obtained from 40g of flour A was added at the last fold-in stage. Cakes were baked for 35 min at 190°C (375°F). After baking, the pans were inverted and cooled for 40 min, and the cakes depanned. Cake heights were measured immediately after depanning (h_d) and after 3-4 hour's cooling (h_c). Cake diameters were also measured after cooling. The internal characteristics of cake were scored, and cake volume calculated using the equation for a truncated, hollow cone.

The firmness of cake crumb was measured on triplicate 25mm-cubes taken from the mid-section of a cake after storing 12, 36, and 60h at room temperature. A Voland-Stevens-LFRA Texture Analyzer (Voland Corp.,Hawthorne, NY), which was fitted with a 5kg-load cell and a cylindrical probe (d=25mm, L=35mm), was used to measure crumb firmness at a probe speed of 2.0mm/sec, and a compression distance of 4.0mm.

Muffins and Soft Cookies

The wet starch was added to a cake-type muffin formula (Table V) and a soft-cookie formula (Table VII) to replace 26% of pastry flour. After creaming and mixing, batter (40g per muffin) was scaled into aluminium muffin-pans fitted with paper liners. Muffins were baked at 193°C (380°F) for 22 min and cooled for one hour. Muffin volume was determined by rapeseed displacement, and the firmness of muffin crumb was measured in the same manner as angel food cakes.

To bake soft cookies, AACC Method 10-50D (1975) was followed except the formula was modified. Cookie dough was mixed, sheeted to 7mm thickness, and cut with a circular (d= 60mm) cookie-cutter. Cookies were baked on an aluminium sheet at 205°C (400°F) for 10 min. After cooling for 30 min, cookie width and thickness were measured to the nearest mm using a ruler fitted with calipers. The breaking force of cookies was determined on an Instron Universal Testing Instrument (Model

1132, Instron Corp., Canton, Mass.) in the compression mode using a 50kg-load compression cell. The Instron was set to give a full-scale deflection of 5kg, and a crosshead speed of 2.5 cm/min and a chart speed of 25 cm/min. A Plexiglas blade with a rectangular contact area of 1mm x 50mm was used to break a cookie sample that bridged two supports separated by 5cm. The average peak height of three measurements was taken as the "breaking force".

RESULTS AND DISCUSSION

Fractionation of Bread Flour

Two hard-wheat flours were wet-processed in this work. Flour B (12.2% protein) was a good-quality bread flour commonly used in the United States. It was examined to determine whether the wet-processing technique could improve the volume of bread made from a relatively high-protein flour. Flour A, which was also a good-quality bread flour except for its low protein content (9.3% protein), was the type of hard-wheat flour better suited for the Wallace process. Most of the work was done on flour A.

To insure the most gentle treatment of flour components, starch was separated from bread flour using the hand-washing procedure of Shogren et al(1969). Lu et al (1983) had reported that the least damage to gluten was achieved by hand-washing. Starting from 20g of flour A (9.3% protein on 14% m.b.)and 45ml of water according to scheme shown in Fig.1, a starch fraction and a protein-rich fraction were obtained. The starch fraction contained 19.0g of water and 11.2g of dry solids of which 2.8% (d.b.) was protein. Thus, the yield of starch was about 60% of the flour weight versus a theoretical yield of 70%. The protein-rich fraction from 20g of flour A contained 26.0g water and 5.5g dry solids of which 28.1% (d.b.) was protein. When 20g of flour B (12.2% protein on 14% m.b.) was wet-processed using 45ml of water (Fig.2), the starch fraction contained 16.7g water and 8.7g dry solids (2.7% protein, d.b.), and the protein-rich fraction, 28.0g water and 8.1g dry solids (27.2% protein, d.b.). During wet-processing, about 2.5% (0.5g) of total dry-solids and 6% (2.9g) of water were unaccounted for; those losses could be minimized in a continuous process.

Flours A and B behaved differently during wet-processing. The gluten ball of flour B was more cohesive and stronger, and the separation was easier than for flour A. In addition, flour B produced more gluten than flour A because of its higher protein content. The starch fraction did not have to be highly purified in this work, since both the starch and remaining fraction were used directly in cake batter and bread dough, respectively. If desired, the starch portion could be further purified by improved straining and centrifugation. Improved separation could also be achieved by adding small amounts of sodium chloride to the flour-water mixture at the beginning of the process. Nevertheless, the wet-processing of flour A was quite satisfactory.

Separation of 30g instead of 20g of flour A was also done using the gentle washing procedure. However, the water (39 ml) in the protein-rich fraction, when combined with the water in the sugar-salt solution (6.7 ml) and yeast suspension (18.3 ml) used in test breadmaking, exceeded the optimum absorption of flour A for dough mixing. The optimum absorption of flour for breadmaking and the direct incorporation of the wet fraction into a dough dictated the amount of flour that could be wet-processed. If instant dry-yeast was used instead of compressed yeast, and sugar and salt added dry, up to 45g of flour A could be wet-processed, and the wet protein-rich fraction could be used in breadmaking. The same was true for flour B.

Because the Wallace process is a closed system with no effluent streams, it is necessary to use limited amounts of water in the process. In a large-scale fractionation of flour by the proposed process, a ribbon blender commonly used in the Martin process (Knight 1984), or a Morton continuous starch-gluten extractor (Morton 1965 and 1968, Anderson 1974) which is used to produce starch and vital gluten in Australia, could be used to imitate hand-washing of starch from a flour-water mixture. To prevent any microbial problems, the wet gluten and starch should be used in the bakery soon after separation. Clean-up of the equipment might be required everyday.

Pup-Loaves

The straight-dough breadmaking method described by Finney (1984) was used to verify the beneficial effects of increased gluten in dough prepared by the Wallace process. To compensate for the starch fraction removed from 20g of bread flour and the solids lost during the hand-washing, 13.6g of flour A and 10.6g of flour B was added, respectively, to the bread formula (Table I) along with the 80g of remaining flour. Table II gives the results of the test baking of bread.

It is known that the volume of a pup-loaf increases approximately 70 cc for each percentage point increase in flour protein in today's hard red winter wheats. According to Finney (1979), the slope of the regression lines of loaf-volume versus flour-protein was 70 cc per 1% protein for flour A and 65 cc for flour B (see appendix). Wet-processing 20g of flour increased the protein content of the flour in the breads from 9.3% to 10.2% for flour A and from 12.2% to 13.2% for flour B (both 14% m.b.). At the same time, the volume of the loaves increased 54cc and 57cc, respectively, compared to control loaves. The increase in loaf volume observed was approximately 86% of the potential increase expected for flour A and 88% for flour B. The color, symmetry, grain, texture, and flavor of test loaves were comparable to those of control loaves. It is worth noting that the doughs containing the protein-rich fractions from the wet-processed flours felt much stronger than control doughs, indicating the increased amount of vital gluten in the test doughs improved bread-dough properties.

Angel Food Cakes

The main reason for test-baking angel food cakes was to utilize the wet starch fraction isolated in the Wallace process. In foam-type cakes a low-protein flour is desirable, and wheat starch is often added to dilute the flour protein. The major role of starch in cakes is to set the cake structure during baking (Hoseney et al 1978). Dubois (1959) showed that wheat starch may be used advantageously in angel food cakes and in other foam-type cakes. He found that substituting wheat starch for as much as 30% of cake flour in a foam-cake formula increased cake volume, improved grain, texture and eating properties, and contributed to extended shelf-life. No previous records on the incorporation of wet wheat starch into angel food cakes were found in the literature.

In this work approximately 24% of cake flour(14% m.b.) was replaced with the wet starch fraction (14% m.b.), and the formula water adjusted appropriately. Because dried egg-whites were used in the cake formula, the water in the wet starch posed no problem in balancing the cake formula. When the wet starch was added to the foamed cake batter, little loss of foam was observed.

With 24% starch replacement of cake flour, the cake volume increased 160 cc (5% of the total volume) and the crumb grain was finer than that of the control cake (Table IV). Crumb tenderness, as measured by the Voland texture analyzer (Table IVa), was significantly improved at the 5% confidence level. Replacing 24% of cake flour with pure, dry wheat-starch gave the same results as with the wet-starch fraction. An untrained taste panel tasted the cakes and found the cakes with added starch had a softer eating texture than a control. These results agree with those of Dubois (1959).

The baking results on muffins are given in Table VI. When the wet-starch replaced 26% of pastry flour (14% m.b.) and some of the water in the formula, no significant improving effects were observed, but neither were detrimental effects.

To test the starch in soft cookies, 40g of flour A was fractionated to give a wet-starch fraction containing 22.4g dry solids and 38 ml water. After the starch sedimented, part of the aqueous supernatant (22 ml) in the starch fraction was discarded to prevent excess water in the cookie formula. The 22ml of supernatant represented approximately 24% of the initial water added to the 40g of flour. The discarded supernatant would likely cause an effluent problem if done at a bakery.

Replacement of 26% of the flour (14% m.b.) in the soft cookie with wet starch failed to show any effect on cookie softness (Table VIII), probably because the high levels of HFCS, sugar, and shortening in the formula were more decisive in cookie characteristcs.

The wet-processing of wheat flour to remove starch and increase flour protein may be economical only when high-protein bread flour is not readily available. The process would require extra equipment, more floor space, and added instrumentation and quality control.

CONCLUSIONS

(1) Up to 20% of a low-protein hard-wheat flour in a pup-loaf formula was wet-processed to give only two streams, a wet protein-rich fraction and a wet starch fraction.

(2) The protein-rich fraction obtained from 20g of bread flour was combined with 91-94 g of unfractionated flour to give a mixture wherein the flour contained about 1% more protein (14% m.b.) than the native flour. Bread baked from the protein-rich flour increased in loaf volume by 86-88% of theoretical.

(3) The wet-starch fraction was added to angel food cakes to replace 24% of the cake flour (14% m.b.). Cake volume increased 5% and crumb tenderness also improved.

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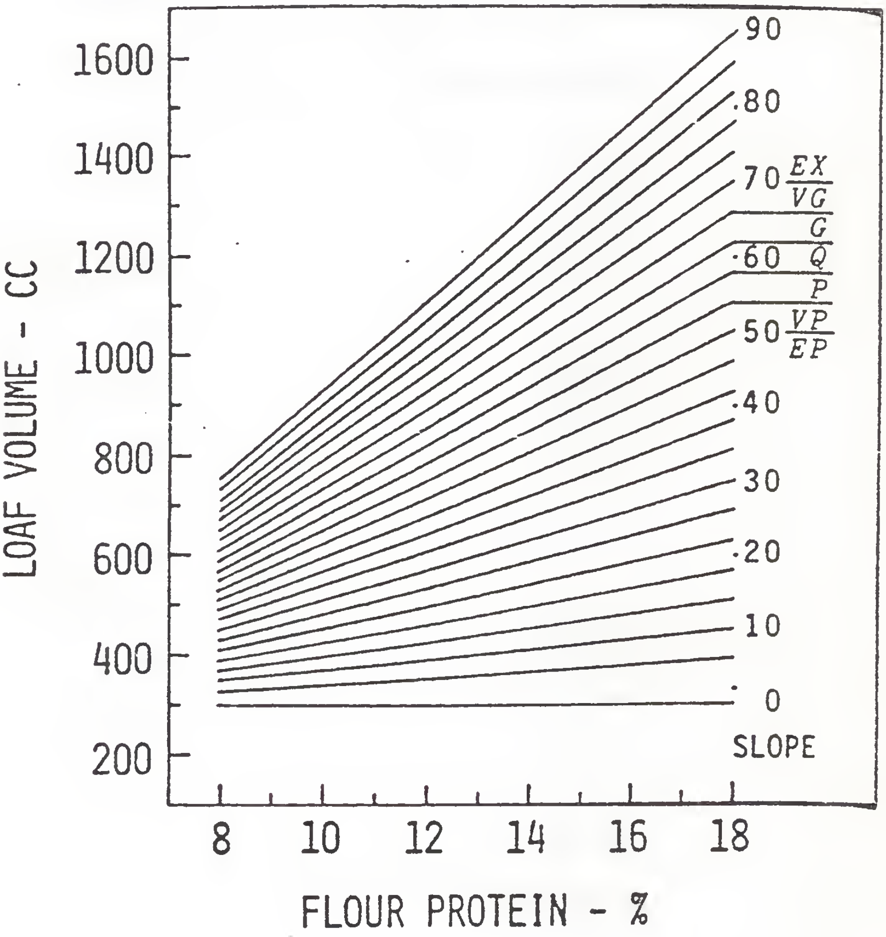
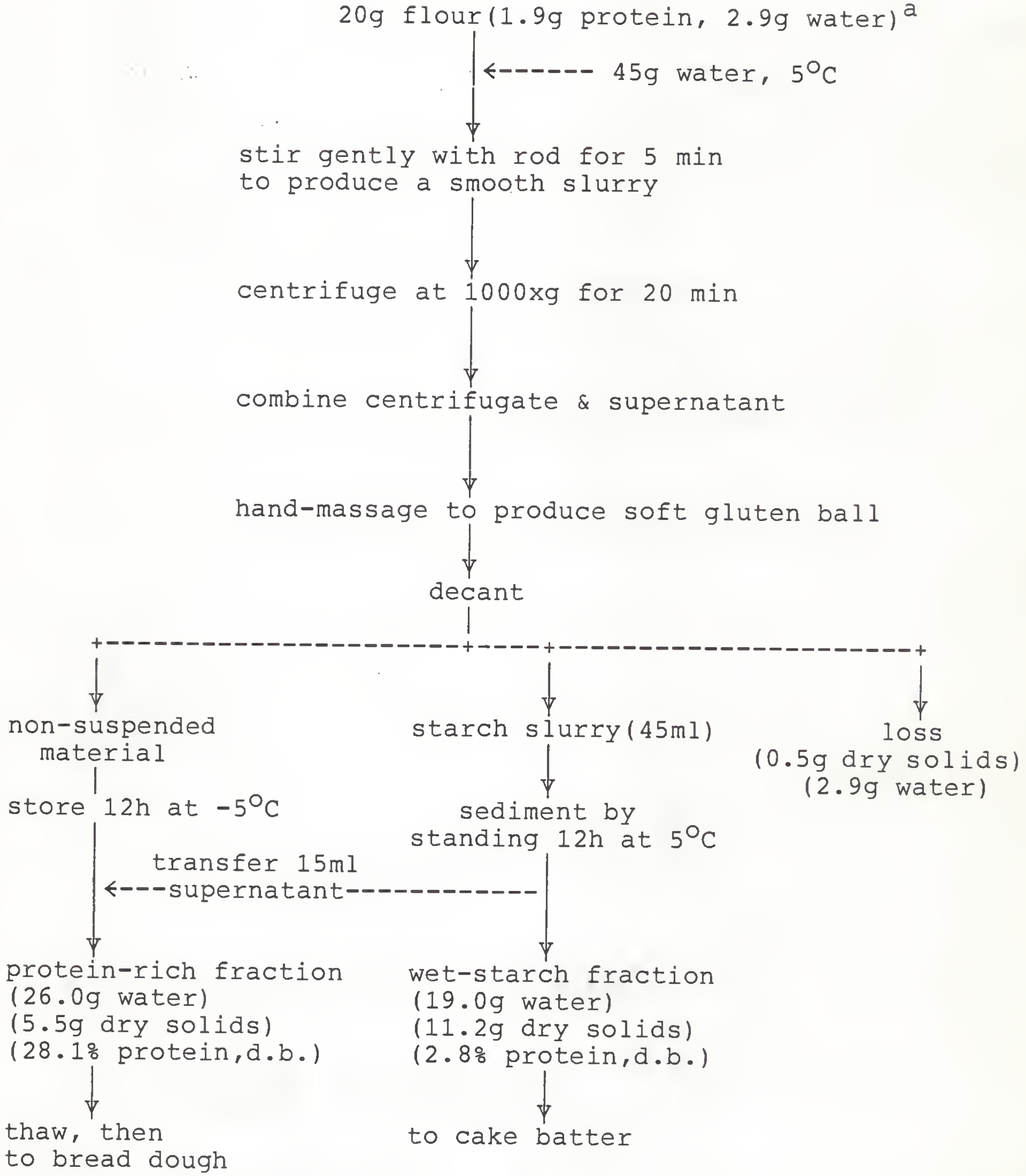
APPENDIX

Loaf volume (100 g flour) versus protein content regression lines for correcting loaf volumes of wheat varieties to a constant protein basis (From Finney 1979).



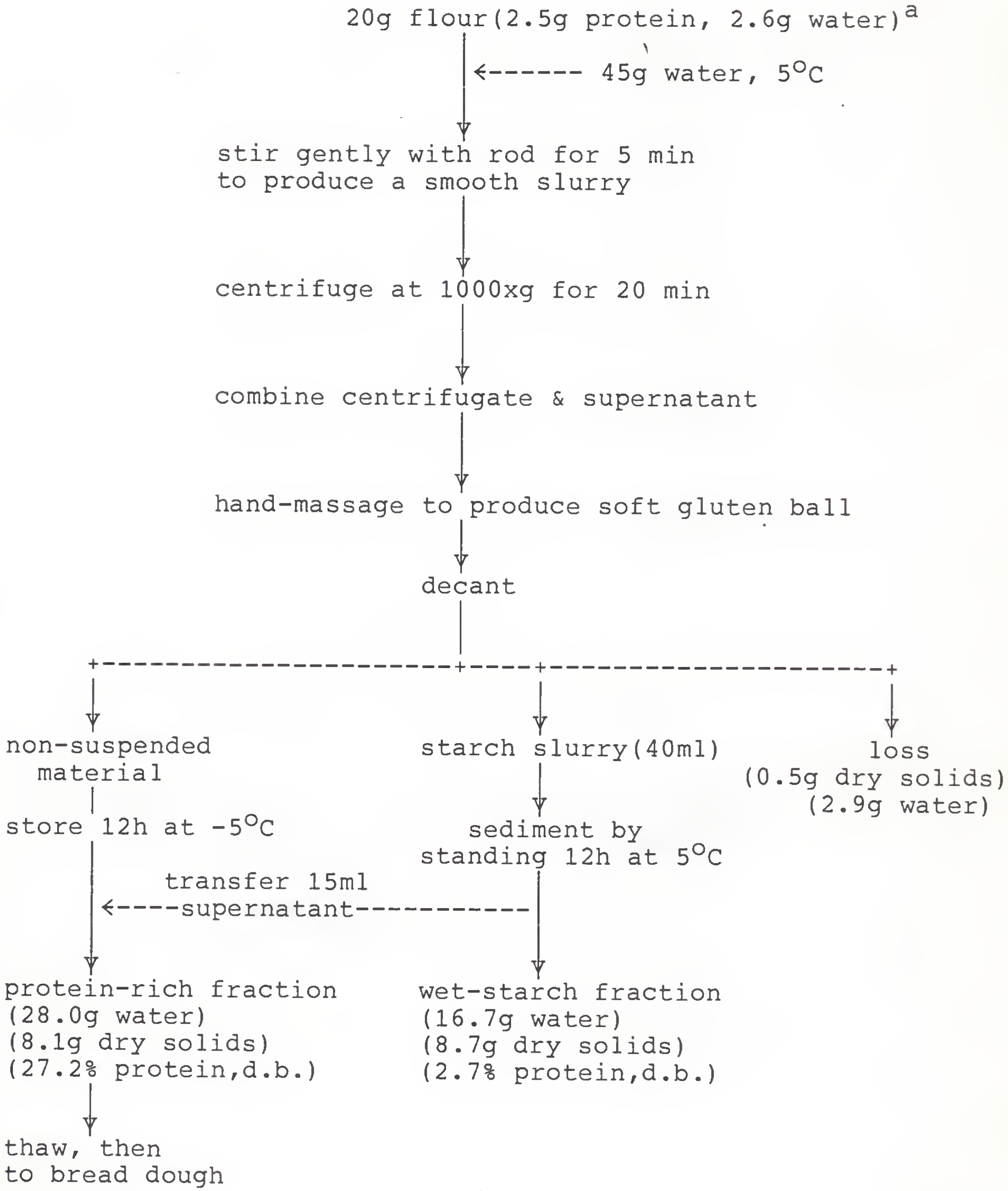
The slope of a regression line is the rate of change in loaf volume per 1% protein increase. To determine the corresponding regression line for a particular wheat variety, use the values of flour-protein and loaf-volume of control loaves to find the intersect point. The nearest line would be the best regression line for that sample of flour.

Fig. 1. Scheme for Wet-Processing of Flour A



[a] Flour adjusted for 14% m.b.
Water includes moisture in flour.

Fig. 2. Scheme for Wet-processing of Flour B



[a] Flour adjusted for 14% m.b.
Water includes moisture in flour.

Table I. Formula for Pup-Loaves Using Wet Protein-Rich Fraction from 20g of Wet-Processed Flour[a]

Ingredients	Control (g)		Test Loaf (g)	
	Flour A	Flour B	Flour A	Flour B
Flour (14% m.b.)	100.0	100.0	93.6[b]	90.6[c]
Water	59.0	63.0	35.0	38.0
Yeast (compressed)	2.0	2.0	2.0	2.0
Shortening	3.0	3.0	3.0	3.0
NFDM	4.0	4.0	4.0	4.0
Sodium chloride	1.5	1.5	1.5	1.5
Malt (240°L)	0.15	– [d]	0.15	– [d]
Potassium bromate	0.002	0.002	0.002	0.002
Protein-rich fraction				
Solids (14% m.b.)	-	-	6.4	9.4
Water	-	-	25.0	27.0

[a] Doughs were mixed to optimum, fermented 180 min at 30°C with 55min proofing, and baked at 218°C for 24 min.

[b] Sum of flour A (93.6g) plus protein-rich fraction (6.4g) from flour A equal to 100g (14% m.b.) of flour in formula.

[c] Sum of flour B (90.6g) plus protein-rich fraction (9.4g) from flour B equal to 100g (14% m.b.) of flour in formula.

[d] Malt was included in flour B.

Table II. Pup-Loaves Containing Wet Protein-Rich Fraction from Wet-Processing of 20g Bread Flour

Loaf (n=6)	Absorption (ml)	Flour-Protein,% (14% m.b.)	Loaf Wt (g)	Volume (cc)	Bread Grain
Control,flour A	59	9.3	142.3±.5	756±8	S[a]
Test loaf A	60	10.2	143.1±.5	810±8	S
Control,flour B	63	12.2	143.9±.5	878±10	S
Test loaf B	65	13.2	145.5±.5	935±10	S

[a] S = satisfactory.

Table III. Formula for Angel Food Cakes Using Wet Starch Fraction from 40g of Wet-Processed Flour A

Ingredients	Control(g)	Test Cake(g)
Cake flour (14% m.b.)	110.0	84.0
Sugar	314.0	314.0
Dried egg albumen	40.0	40.0
MCP	1.5	1.5
Sodium chloride	3.0	3.0
Water	295.0	260.6
Wet-starch fraction[a]		
Solids(14% m.b.)	-	26.0
Water	-	34.4

[a] Wet-starch fraction from 40g of wet-processed flour A.

Table IV. Characteristics of Angel Food Cake Containing Wet Starch Fraction from 40g of Wet-Processed Flour A

Cake[a]	h_d (cm)	h_c (cm)	D (cm)	d (cm)	Volume[b] (cc)	Grain
Control	8.5±.1	8.1±.1	22.2	5.7	2930±40	Medium
Test cake	8.9±.1	8.5±.1	22.3	5.8	3090±40	Fine

[a] Triplicate cakes. Test cake contains wet starch from flour A to replace 24% of cake flour(14% m.b.).

[b] Cake volume was calculated by the equation:

$$V = 3.1416\ h_c(D^2 - d^2)/4$$

where V = cake volume after cooling;

h_c = cake height after cooling;

D = average outside-diameter of cake after cooling;

d = average inside-diameter of the hole in the center of cake after cooling.

Table IVa. Firmness of Angel Food Cakes Measured by Voland Texture Analyzer

Cake	*Compression Force (g)		
	12hr	36hr	60hr
Control	56±4	65±4	73±4
Test cake	45±4	54±4	64±4

*Compression force was the average of three replicate readings.

*Cakes were stored at 20°C after baking for 12, 36, 60 hours before measuring.

*$\text{LSD}_{.05}$= 9.07 for each pair of data.

Table V. Formula for Plain Muffins Using Wet Starch Fraction from 40g of Wet-Processed Flour A

(From American Institute of Baking, Manhattan, KS.)

Ingredients	Control(g)	Test-Muffin(g)	Procedure
Honey	47	47	cream together at low speed for 6 min
Brown sugar	33	33	
Salad oil(Crisco)	20	20	
Unsalted butter	20	20	
Sodium chloride	2.5	2.5	
Whole eggs	82	82	mix in slowly at low speed
Vanilla	2	2	
Pastry flour	100	74	blend dry ingredients together, add to creamed mixture, and mix at low speed for 3 min to make a smooth mixture
Baking powder (double acting)	7.0	7.0	
NFDM	6.6	6.6	
Cinnamon	0.3	0.3	
Wet-starch fraction			
Solids(14%m.b.)	-	26	
Water	-	34	
Water	41	7	blend in at low speed for 3 min

*Scale individual muffins 40g each. Bake muffins at 380°F for 22 min.

Table VI. Characteristics of Muffins Containing Wet Starch Fraction to Substitute 26% of Flour (14% m.b.)

Muffin	Muffin Weight (g)	Muffin Volume (cc)	*Compression Force (g)		
			3hr	24hr	48hr
Control	33.8±.6	110±2	134±5	268±8	321±8
Test	33.9±.6	114±2	136±5	248±8	308±8

*Compression force was the average of six replicate readings on the Voland texture analyzer. Muffins were stored at 20°C for 3, 24, 48 hours after baking.

Table VII. Formula for Soft Cookies Using Wet Starch Fraction from 40g of Wet-Processed Flour A

Ingredients	Control(%)	Test-Cookie(%)
Pastry flour	100	74
Sucrose	40	40
HFCS(42% fructose)	35	35
Shortening	35	35
Whole eggs	16	16
NFDM	3	3
Sodium chloride	2	2
Sodium bicarbonate	1	1
Water	12.5	-
Wet-starch fraction		
Solids(14%m.b.)	-	26
Water	-	12.5[a]

[a] The starch fraction separated from 40g of flour A contained 26g of solids and 34g of water. Some of the water (22g) in the starch fraction was discarded. The 22g discarded represents 24% of the initial water added to wet-process the flour.

Table VIII. Characteristics of Soft Cookies Containing Wet Starch Fraction to Substitute 26% of Flour (14% m.b.)

Cookie	Width (mm)	Thickness (mm)	W/T Ratio	*Breaking Force (kg)	
				1 day	3 day
Control	83.0	8.5	9.8	0.50±.05	0.75±.05
Test	84.0	8.0	10.5	0.48±.05	0.76±.05

*Breaking force was the average of three replicate readings of peak-height on the Instron Universal Testing Instrument.

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WET-PROCESSING OF LOW-PROTEIN HARD WINTER WHEAT FLOUR TO IMPROVE ITS BREADMAKING POTENTIAL

by

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ABSTRACT

A method to make white-pan bread from low-protein wheat flour by wet-processing a portion of the formula flour was tested for technical feasibility. Starting with two different hard winter wheat flours, 20% of the flour in a pup-loaf formula was wet-processed (water/flour=2.25)into a protein-rich fraction and a starch fraction. The wet, protein-rich fraction was combined with flour to make bread, while the wet starch fraction was used with soft wheat flour to prepare cakes, muffins, and cookies. Wet-processing of 20g of flour A (9.3% protein) and flour B (12.2% protein) gave 31.5g and 36.1g of the wet protein-rich fraction, respectively, which contained 5.5g and 8.1g dry solids, and 1.5g and 2.2g protein. The wet, protein-rich fraction when incorporated with other ingredients gave a bread-dough whose flour contained about a 1% increase in protein (14% m.b.). After baking, the resulting bread gave approximately 86% of the increase in loaf volume expected for the increased protein content of a dough. The wet starch fraction from 40g of flour A (containing 22.4g dry solids and 0.6g protein) was added to an egg-foam cake in place of about 24% of cake flour in the formula. The starch improved cake volume by 5%. Replacing 26% of formula flour in muffins and soft cookies showed little or no effect on their appearance or softness.