Hard White and Red Winter Wheat Comparison in Hamburger Buns[1]

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ABSTRACT

Hamburger buns account for a sizable amount of wheat flour consumption. With the increased interest in high-fiber foods, a whole hard white wheat bun that has a lighter color and blander flavor than one from whole hard red wheat but has the same volume and texture might have wide consumer acceptability. However, tests showed that as the proportion of whole wheat in the bun increased, the volume decreased. Vital gluten was used to restore the volume. White wheat bran, as well as cracked and flaked wheats, were added to create the effect of whole wheat without seriously affecting the color. Up to 30% cracked wheat, 40% flaked wheat, or 20% bran could be added to the formula while retaining control height by adding vital gluten. Comparing the red and white wheat buns, the Agtron gave higher values for the white ones (indicating a lighter color) except with cracked wheat, where the values were equal. In a triangle test under red light, taste panelists easily differentiated red-wheat from white-wheat buns. In the preference test, panelists showed no preference for buns made from one wheat over the other.

What is white wheat? Of the thousands of genes in every cell of a wheat plant, only three determine kernel color. If none of the three genes are red, the wheat bran is white, yet the rest of the characteristics of the wheat plant are the same as in its red wheat sister line (Graham 1988).

In the United States, work on hard white wheat began in the 1950s, but not much emphasis was placed on it until recently (Feltner 1988). Why should we develop a hard white wheat? Many world markets prefer hard white wheat (HWW) from Australia to hard red wheat (HRW) from the United States for use in noodles or flat breads. The United States has not had any HWW with which to compete against Australia (Graham 1988). Potential customer preference for HWW is motivated by several perceived advantages: 1) Higher flour extraction rates are possible (1–3%) with HWW than with HRW when both are milled to similar color standards. 2) White wheat flour at high extraction levels appears to have a much lighter color than conventional flour, which has special appeal for consumers interested in whole grain products. 3) Wheat flours contain more protein when the kernel is milled to a higher extraction than when milled at normal extraction rates. 4) Whole wheat products may appear more appealing to many consumers when the flour is milled from HWW. 5) HWW has a less astringent flavor than does HRW. 6) Bran from HWW is potentially more valuable than bran from HRW. White wheat bran is used in many high fiber foods, particularly breakfast cereals and snacks. The short supply of white bran for these uses boosts its price to the extent that it is considered a valuable coproduct, and not a by-product, of the milling process. Also, white bran might be used instead of other materials to increase the fiber content of many baked products, such as high-fiber bread, while still maintaining the preferred lighter product color (Feltner 1988). 7) White wheats are preferred for many export markets. Thus, a quality HWW almost certainly would enhance export potential (Watson 1987).

Interest in HWW has accelerated in recent years because of its potential as an alternative crop or specialty crop that would require little in the way of new technology or machinery. It is viewed as having applications in farina, noodles, whole-wheat bread, and other products in which the light color of the bran would be advantageous. Other applications include bran in breakfast cereals and bakery flour. The California Wheat Commission is promoting its hard white winter variety for export, and thus competing with Australia. Kansas is most interested in developing a bread wheat for domestic use (Anonymous 1988).

During recent years, the public has become more concerned with basic health and good eating habits. This interest has resulted in an increase in the consumption of dietary fiber, and thus, high-fiber breads are being increasingly accepted (Mrdeza 1978). Many researchers have studied the effects of fiber on bread quality (Becker et al 1986, Chen et al 1988, D'Appolonia and Youngs 1978, Dubois 1978, Pomeranz et al 1977, Shogren et al 1981, Sosulski and Wu 1988, Volpe and Lehmann 1977). None of the

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fibers evaluated was from HWW bran, none was ideally suited for breadmaking, and all affected some functional properties of the dough. The production of high-fiber bread in a commercial bakery is made more difficult because of weakness of the dough, blisters, holes under the top crust, and cripples. Also, optimized water absorption and mixing time are critical (Pomeranz 1977).

When fiber is added, there is a decrease in volume that may be due to the dilution of gluten and/or to the interaction between gluten and fiber material (Chen et al 1988). The volume problem may be largely solved by adding vital wheat gluten, but this causes a substantial increase in cost. It is necessary to use vital wheat gluten because of the strain put on the natural gluten by the fibrous material (Pomeranz 1977). If more than 7–10% fiber is added to the formula, additional vital wheat gluten is needed to maintain a quality product (Dubois 1978). Addition of sodium stearoyl-2-lactylate to the formula also improves the loaf volume and overall bread quality of breads baked with different levels of wheat bran (D'Appolonia and Youngs 1978).

According to the National Restaurant Association, 5.2 billion hamburgers were sold in 1987. America's appetite for hamburgers is far from saturated. This market is tough, but there are still opportunities for new ideas (Kochak 1988), such as whole wheat hamburger buns. Ten years ago, few restaurants offered whole wheat rolls; today, however, about one in every four restaurant-goers prefers a wheat roll with his or her meal (Pacyniak 1987).

Hamburger buns are made from formulas resembling those for conventional white bread, except for higher levels of sweetener and shortening. Bun doughs may be prepared by any of the conventional procedures, although liquid ferment systems and continuous mixing processes appear to be generally preferred (Trum 1971). The objective of this project was to develop a high-fiber hamburger bun using HWW.

MATERIALS AND METHODS

Wheats

A commercial HRW control (87-858) (Cargill, Wichita, KS) at 13.1% protein and AgriPro W81-162 HWW (87-853) (from 1987 North American Plant Breeders' flood-irrigated fields in the Fort Morgan, CO, area) at 12.8% protein were processed in three different ways: cracked, flaked, and milled to flour on the Kansas State University pilot mill.

Fiber was incorporated into hamburger buns in four ways: as cracked wheat, flaked wheat, bran, and whole wheat flour. The cracked wheat was made by breaking the wheat kernels into two or three pieces with Lepage rolls. The broken kernels were then sieved, and the products through the 8w over the 14w were used. Flaked wheat was made by tempering the wheat four days to 18% moisture and passing it through smooth rolls with a 0.015-in. gap to flatten the kernels. The kernels were not heated. The entire material was used; nothing was sifted out. Bran was incorporated as whole flakes, about 2–5 mm in size. The whole wheat was a proportional recombination of all the mill streams, with the bran first ground in a Fitz mill (Fitzpatrick and Co., Elmhurst, IL) through a sieve size 0.033 in.

Formula

A control hamburger bun formula was developed using the liquid ferment method with Cargill hard wheat bread flour, Richtex emulsified shortening, Saf-instant active dry yeast, and ADM Arkady Yeast Food. The formula comprised bread flour (100%), water (58%), granulated sugar (12%), emulsified shortening (10%), instant active dry yeast (3.5%), salt (2.0%), sodium stearoyl 2-lactylate (0.5%), Arkaday Yeast Food (0.5%), calcium propionate (0.25%), and potassium bromate (40 ppm). The liquid brew included 40% water, 7% sugar, 0.5% salt, and 3.5% instant dry yeast. All ingredients were on a flour weight basis, including the other materials added later. The brew was prepared in an open beaker for 1.5 hr on a stirring plate with slow stirring, and reached 33°C at its highest temperature. It was then cooled to 10°C in an ice bath. The dry ingredients, except for the salt, were mixed for 15 sec in a 200-g pin mixer (National Manufacturing Co. Lincoln, NE). The shortening, brew, and free water were added, and mixed for 2.5 min. The salt then was added, and the dough was mixed another 1 min. The 3.5-min mixing time was determined by prior experiments to be the optimum for this system. The dough was formed into a ball, rested 5 min, and divided into six 60-g pieces that were rounded by hand. The pieces were sheeted through an ACME bench dough roller (McClain and Sons, Pico Rivera, CA). The first roller was at setting 4 (1.0 cm) and the second at setting 1½ (0.6 cm). The flattened dough pieces were then placed in the 10-cm diameter cups of a greased hamburger bun pan. They were proofed for 50 min at 105°F (40°C) dry bulb and 100°F (38°C) wet bulb (85% relative humidity), and then baked 6 min at 225°C. The buns were bagged after cooling for 1 hr at room temperature.

Cracked Wheat Addition

HWW cracked wheat was added to the control formula at 10, 20, 30, and 40%. These quantities and those used for flaked wheat, bran, and whole wheat were determined from preliminary experiments and the literature on fiber additions to loaf bread. Vital gluten was added at 5, 10, 15, and 20%, on a flour weight basis. For every 1% of cracked wheat added, 0.2% percent of water was added, as determined by prior experiments.

Flaked Wheat Addition

HWW flaked wheat was added to the control formula at 10, 20, 30, and 40%, and vital gluten was added at 5, 10, 15, and 20%. Absorption was increased by 0.4% for every 1% of flaked wheat added.

Bran Addition

HWW wheat bran was added to the control formula at 5, 10, 15, and 20%, and vital gluten was added at 5, 10, 15, and 20%. There was a 1% absorption increase for every 1% of bran added.

Whole Wheat Replacement

HWW whole wheat replaced bread flour in the control formula by 20, 40, 60, and 80%, and vital gluten was added at 5, 10, 15, and 20%. There was a 1% absorption increase for every 10% whole wheat replacement.

For all the formulations, absorption was increased 1% for every 1% of vital gluten added, and the mixing time was increased by half a minute for every 5% increase in vital gluten. A commercial gluten (76.2% protein, 1.48% ash, 1.11% ether extract, and 0.46% crude fiber on a dry matter basis) supplied by Midwest Grain Products (Atchinson, KS) was used.

Measurements

After 24 hr, the bun height in centimeters was measured with a caliper. The best formula was determined by comparing the bun heights to the control using the response surface method. The program, originally described by Walker and Parkhust (1984), uses a second-order regression equation.

Once an acceptable combination that was near the control height was determined, the same formula using Cargill hard wheat bread flour was used, incorporating both hard red and white cracked wheat, flaked wheat, bran, and whole wheat. Their colors were compared using the Agtron model M-500-A colorimeter (Magnison Engineering, San Jose, CA) with a green filter, and the scale was calibrated at 0 and 100, with 0 being black and 100 white reference disks.

Firmness was measured after 24 hr by the Voland-Stevens texture analyzer model TA-1000 (Voland Corporation, Hawthorne, NY). The indenter diameter was 3.65 cm, and the crosshead speed was 2 mm/sec. The buns were sliced 1 in. (2.54 cm) from the bottom and compressed 6 mm (25% of the slice thickness) from the top of the slice. These measurements were based on the AACC method for the universal testing machine (Baker and Ponte 1987).

Total dietary fiber (determination with kit no. TDF-100 from Sigma Chemical Company, St. Louis, MO, using the method of Prosky et al 1984 and Anonymous 1985), neutral detergent fiber (Goering and Van Soest 1970), and proximate analyses (AOAC methods 7.007 for moisture, 7.009 for ash, 7.015 for protein, 7.061 for fat, and 7.071 for crude fiber; AOAC 1984) were obtained for the baked buns.

Sensory Evaluation

The objectives of the sensory tests were to determine if a difference could be detected between HRW and HWW wheats in a hamburger bun, and how much each of these buns was "liked."

The four formula types were examined on different days. Both the triangle difference and the hedonic design sensory tests included a balanced presentation of samples. The triangle test asked "Which is the different sample?" The hedonic test was a nine-point scale anchored with words "dislike extremely" and "like extremely."

The panelists (approximately 82 for each formula) were nonprofessionals of differing ages, education, and economic backgrounds. They were selected only by their availability; no screening was performed. No panelists trained in sensory analysis were allowed to participate. The same panelists completed both the difference test and the hedonic rating scale.

Testing was conducted in a sensory laboratory, in partitioned booths, and under controlled environmental conditions. For the difference test, red lights were used to mask visual color differences. The red lights were then turned off, fluorescent lights turned on, and the booths cleaned out before the hedonic sample trays and ballots were placed in front of the panelists.

The sample buns had been baked the day before each test, cooled, and placed in odor-free plastic bags. One hour before the testing began, the buns were cut into eighths and replaced in the bags. Samples were placed on white plastic foam trays but were not allowed to stand longer than 3 min before testing. All samples were coded with three-digit identification codes.

Before entering the testing lab, panelists were instructed how to perform each test, using a sample ballot: 1) samples were to be examined left to right; 2) a sip of water was to be taken before each sample; 3) panelists were to eat as much of the sample as they desired; and 4) for the triangle test, one sample must be chosen as different from the other two. The hedonic ballot was explained as "we want to know how much you like or dislike the sample." Purified water was used for rinsing; panelists were allowed to work at their own pace.

RESULTS AND DISCUSSION

The objective was to add as much of the cracked wheat, flaked wheat, bran, and whole wheat with the least amount of vital gluten, but limiting vital gluten addition below 20% due to its high cost.

Cracked Wheat Addition

Figure 1 shows the results of cracked wheat and vital gluten addition. The chart was obtained by entering data from three replicate bakes into the response surface method program and arriving at predicted values. These points were then graphed to show the second-order regression lines. The control line was obtained from the mean of the controls. Addition of 30% cracked wheat with 18% vital gluten was the most that could be added while maintaining the desired control height and producing a reasonably acceptable bun appearance.

Flaked Wheat Addition

Results shown on Figure 2 were obtained in the same manner as those in Figure 1; 40% flaked wheat with 10% vital gluten was chosen as the highest addition that could be made while maintaining control height and acceptable appearance.

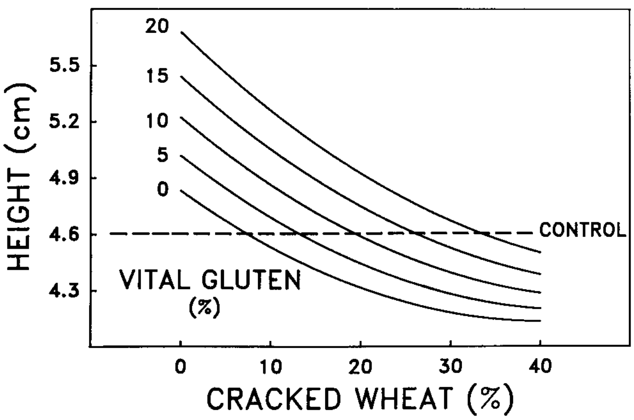

Fig. 1. Hamburger bun height with varied amounts of hard white cracked wheat and vital gluten.

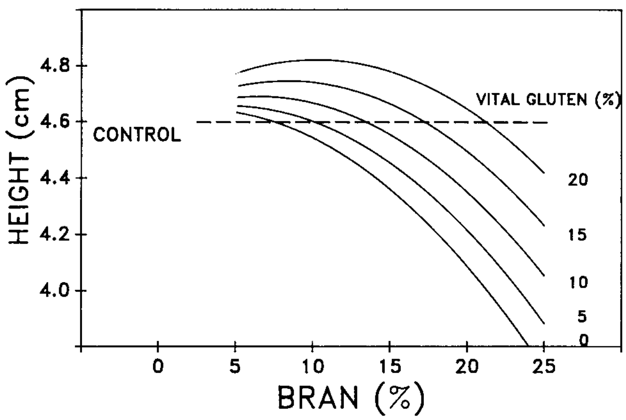

Fig. 3. Hamburger bun height with varied amounts of hard white wheat bran and vital gluten.

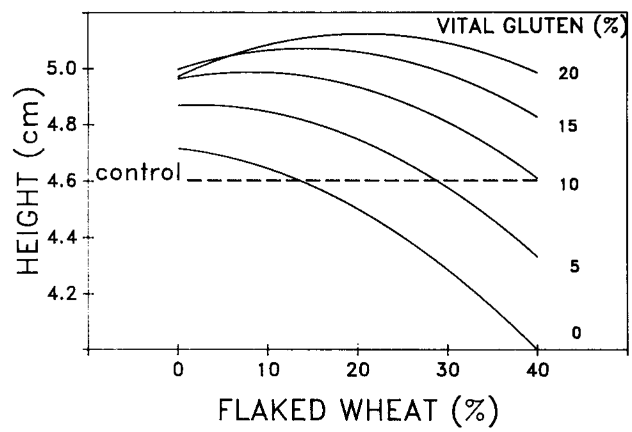

Fig. 2. Hamburger bun height with varied amounts of hard white flaked wheat and vital gluten.

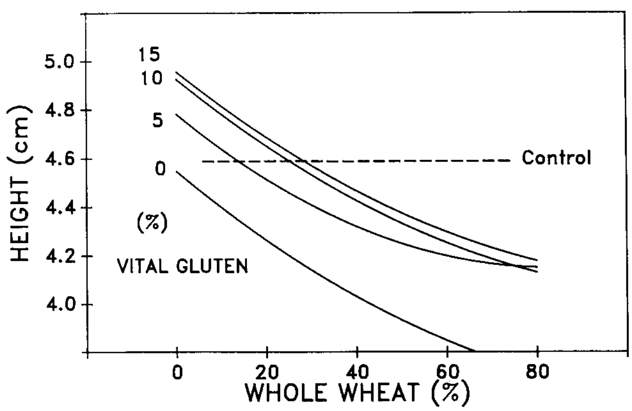

Fig. 4. Hamburger bun height with varied amounts of hard white whole wheat and vital gluten.

TABLE I
Voland-Stevens and Agtron Colorimeter Measurements

Formula Type	% Material	% Vital Gluten	Voland-Stevens (g)		Agtron Value[a]	
			White	Red	White	Red
Cracked	30	18	185 ± 4	196 ± 5	51 ± 1	51 ± 2
Flaked	40	10	246 ± 6	249 ± 6	56 ± 1	50 ± 1
Bran	20	19	129 ± 3	122 ± 15	44 ± 1	39 ± 1
Whole wheat	50	10	146 ± 5	158 ± 14	50 ± 1	43 ± 1
Control	0	0	298 ± 10		66 ± 1	

[a] 0 = Black, 100 = white.

TABLE II
Proximate Analyses, Neutral Detergent Fiber, and Total Dietary Fiber of Hamburger Buns Made with White and Red Wheats (%)

Parameter	Control	Cracked		Flaked		Bran		Whole Wheat	
		White	Red	White	Red	White	Red	White	Red
Moisture[a]	32.4	32.8	33.5	35.3	35.0	38.3	36.9	34.6	35.4
Ash[b]	3.5	3.3	2.6	3.5	3.6	3.9	2.9	2.7	3.1
Crude fiber[b]	0.2	0.3	0.4	0.4	0.5	1.3	1.2	0.6	0.7
Protein[b]	11.9	18.9	19.2	15.9	16.1	20.4	21.0	17.7	17.8
Fat[b]	9.3	6.9	6.9	6.6	6.5	6.4	6.6	8.2	8.3
Neutral detergent fiber[b]	2.8	5.4	4.9	5.2	6.0	10.7	10.4	6.3	5.7
Total dietary fiber[b]	5.8	11.0	10.6	11.9	10.6	14.9	17.3	13.7	15.4

[a] Moisture of fresh hamburger bun.
[b] Value reported on a dry matter basis.

Bran Addition

Results in Figure 3 were also obtained in the same manner as those in Figure 1. It was determined that 20% bran addition with 19% vital gluten was the best combination.

Whole Wheat Replacement

Results in Figure 4 were obtained in the same manner as those in Figure 1. Whole wheat could replace white flour at 30% with 10% vital gluten addition and still maintain control height. Because the aim was to replace white flour at the highest level possible, the rest of the tests were done at 50% whole wheat replacement, which is similar to industry practice. Vital gluten addition at 10% was used, because the small increase in height with 15% addition would probably not merit the higher cost.

TABLE III
Triangle Difference Test of Buns Using Hard Red and Hard White Winter Wheats

Formula Type	No. of Observations	No. Correct	Probability[a]
Cracked wheat	81	42	0.003***
Flaked wheat	82	41	0.001***
Bran	84	39	0.0075**
Whole wheat	83	40	0.0027**

[a] *** $P \leq 0.001$, very highly significantly different; ** $P \leq 0.01$, highly significantly different.

Measurements

Table I contains the results of the firmness and color measurements. The Voland-Stevens results do not indicate a significant difference between firmness with red and white wheats (none was expected), but there was a difference between formulas, with the control bun being the firmest and the bran formula the least firm. The Agtron results showed that the control bun, with highest value, was the lightest in color. The buns containing flakes, bran, or whole wheat flour from white wheat were lighter in color than the red wheat buns, as expected.

Table II contains results of the proximate, neutral detergent fiber, and total dietary fiber analyses. As expected, the protein increased with the increase in vital gluten. The results for both neutral detergent fiber and total dietary fiber show that the bran buns contained the most fiber followed by whole wheat, flaked, and cracked wheat buns. Total dietary fiber in each 50-g bun was 7.5 g for white wheat bran, 6.8 g for whole wheat, 6.0 g for flaked wheat, and 5.5 for cracked wheat. The National Cancer Institute recommends 25–35 g of fiber consumption per day.

Sensory Evaluation

The triangle test results are summarized in Table III. In all cases, the panelists found a significant taste difference between the red wheat and the white wheat hamburger buns. The preference tests results are included in Table IV. There was no significant preference for any of the formulas or between red versus white wheat. Despite the clear taste differences between the red wheat and the white wheat hamburger buns, the panelists showed no clear preference for one over the other.

TABLE IV
Preference Test Results

Category	Cracked		Flaked		Bran		Whole Wheat	
	n	$\bar{x} \pm SD$	n	$\bar{x} \pm SD$	n	$\bar{x} \pm SD$	n	$\bar{x} \pm SD$
Total no. of participants	82	...	83	...	82	...	83	...
Preferred white	33	...	27	...	33	...	33	...
white score	...	6.8 ± 1.6	...	7.9 ± 1.0	...	6.7 ± 1.6	...	7.7 ± 0.8
red score	...	4.8 ± 1.6	...	5.6 ± 1.2	...	5.1 ± 1.5	...	5.0 ± 1.5
Preferred red	34	...	37	...	26	...	30	...
white score	...	4.6 ± 1.7	...	5.4 ± 1.4	...	5.2 ± 1.3	...	4.9 ± 1.5
red score	...	6.9 ± 1.2	...	7.5 ± 1.0	...	7.3 ± 1.2	...	7.5 ± 1.1
Equal preference	15	6.3 ± 1.6	19	6.5 ± 1.7	23	6.6 ± 1.6	20	6.7 ± 1.5

CONCLUSIONS

Hamburger bun control height could be maintained with the following material additions: 30% cracked wheat with 18% vital gluten, 40% flaked wheat with 10% vital gluten, 20% bran with 19% vital gluten, and replacement of whole wheat flour at 50% with 10% vital gluten addition. White wheat buns made with these formulations were lighter in color than buns made with red wheat. Taste-test panelists found a significant taste difference between the red wheat and white wheat buns.

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LITERATURE CITED

ANONYMOUS. 1985. Changes in methods: 1985. J. Assoc. Off. Anal. Chem. 68:399.

ANONYMOUS. 1988. Two varieties of hard white winter wheat for use in Kansas. Milling and Baking News 67(27):1.

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS. 1984. Official Methods of Analysis, 14th ed. The Association: Arlington, VA.

BAKER, A. E., and Ponte, J.G. 1987. Measurement of Bread Firmness with the Universal Testing Machine. Cereal Foods World 32:491.

BECKER, H. G., STELLER, W., FIELDHEIM, W., WISKER, E., KULIKOWSKI, W., SUCKOW, P., MEUSER, F., and SEIBEL, W. 1986. Dietary fiber and bread: Intake, enrichment, determination, and influence on colonic function. Cereal Foods World 31:306.

CHEN, H., RUBENTHALER, G. L., LEUNG, H. K., and BARANOWSKI, J. D. 1988. Chemical, physical, and baking properties of apple fiber compared with wheat and oat bran. Cereal Chem. 65:244.

D'APPOLONIA, B. L., and YOUNGS, V. L. 1978. Effects of bran and high-protein concentrate from oats on dough properties and bread quality. Cereal Chem. 55:736.

DUBOIS, D. K. 1978. The practical applications of fiber materials in bread production. Baker's Dig. 52:30.

FELTNER, K. C. 1988. Hard white winter wheat research. Departmental Report, Kansas Agricultural Experiment Station, Kansas State University: Manhattan, KS.

GOERING, H. D., and VAN SOEST, P. J. 1970. Forage Fiber Analysis. U.S. Dep. Agric. Agric. Handb. 379. U.S. Government Printing Office: Washington, DC.

GRAHAM, S. M. 1988. The Status of Hard White Wheat Research in the United States. Kansas Wheat Commission Report 1/29/88: Manhattan, KS.

KOCHAK, J. 1988. Market segment report: Hamburgers. Rest. Bus. 87(1):95.

MRDEZA, G. 1978. Trends for specialty breads. Cereal Foods World 23:635.

PACYNIAK, B. 1987. Diners prefer crusty breads with their meals. Pages 20-21 in: Foodservice Bakery Annual Report. Gorman Publishing Co.: Chicago, IL.

POMERANZ, Y. 1977. Fiber in breadmaking—A review of recent studies. Baker's Dig. 51:94.

POMERANZ, Y., SHOGREN, M. D., FINNEY, K. F., and BECHTEL, D. B. 1977. Fiber in breadmaking—Effects on functional properties. Cereal Chem. 54:25.

PROSKY, L., ASP, N., FURDA, I., DeVRIES, J. W., SCHWEIZER, T. F., and HARLAND, B. F. 1984. Determination of total dietary fiber in foods, food products and total diets: Interlaboratory study. J. Assoc. Off. Anal. Chem. 67:1044.

SHOGREN, M. D., POMERANZ, Y., and FINNEY, K. F. 1981. Counteracting the deleterous effects of fiber in breadmaking. Cereal Chem. 58:142.

SOSULSKI, F. W., and WU, K.K. 1988. High-fiber breads containing field pea hulls, wheat, corn, and wild oat brans. Cereal Chem. 65:186.

TRUM, G. W. 1971. Bun production by the continuous mixing process. Proc. Am. Soc. Bakery Eng. 47th, p. 106.

VOLPE, T., and LEHMANN, T. 1977. Production and evaluation of a high-fiber bread. Baker's Dig. 51:24.

WALKER, C. E., and PARKHURST, A. M. 1984. Response surface analysis of bake-lab data with a personal computer. Cereal Foods World 29:662.

WATSON, S. 1987. Hard white wheat: Premium specialty crop. Kansas Farmer 125(3):26.

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