

BREADMAKING POTENTIAL OF STRAIGHT GRADE AND WHOLE WHEAT
FLOURS USING VARIETIES HAVING CONTRASTING PHYSICAL DOUGH
PROPERTIES

by

GREGG J. MODER

B. S., University of Wisconsin, 1974

A MASTER'S THESIS

submitted in partial fulfillment of the
requirements for the degree

MASTER OF SCIENCE

Department of Grain Science and Industry

KANSAS STATE UNIVERSITY

1981

Approved by:


Major Professor

SPEC
COLL
LD
2668
.TH
1981
M63
C.2

TABLE OF CONTENTS

	Page
LIST OF TABLES	ii
ACKNOWLEDGEMENTS	iv
INTRODUCTION	1
LITERATURE REVIEW	3
MATERIALS AND METHODS	10
RESULTS AND DISCUSSION	13
CONCLUSIONS	40
REFERENCES	42

LIST OF TABLES

I.	Chemical, Physical and Baking Data	16
II.	Crumb Grain Scores for Varying Shortening Treatments	17
III.	Specific Data Pertaining to Shortening and Surfactant Treatments	24
IV.	Agtron Readings on Bread Crumb with White Bran Versus Red Bran, Coarse Bran Versus Fine Bran	30
V.	Preference Taste Test Panel Results for Coarse Granulation	37
VI.	Preference Taste Test Panel Results for Fine Granulation	38

LIST OF FIGURES

I.	Mixographs of Triumph, Eagle and Plainsman V Making up the Blends	15
II.	Eagle Loaves with No Shortening, 3% Shortening, and 1% DATE	19
III.	Triumph Loaves with No Shortening, 3% Shortening, and 1% DATE	20
IV.	Eagle Blends of Straight Grade and Whole Wheat Flours	21
V.	Triumph Blends of Straight Grade and Whole Wheat Flours	22
VI.	The Relation Between Whole Wheat Percentage and Loaf Volume with Various Shortening and Surfactants	24
VII.	The Relation Between Whole Wheat Percentage and Loaf Volume in Loaves Containing Fine Granulated Whole Wheat Flour (F) Versus Coarse Granulated Whole Wheat Flour (C)	29
VIII.	The Relation Between Whole Wheat Percentages and Loaf Volume in Loaves Containing Fine Granulated Wheat Flour (F) Versus Coarse Granulated White Wheat Flour (C)	30
IX.	Triangle Taste Test Panel Score Sheet	35
X.	Preference Taste Test Score Sheet	36

ACKNOWLEDGEMENTS

My sincere appreciation is expressed to Professor Joseph G. Ponte, Jr., my major professor, for his warm manner, guidance, and patient advice throughout this study.

Appreciation is also expressed to Professors Ward, Marston, and Seib for serving on the examination committee. Special thanks is expressed to Karl F. Finney, Bernie Bruinsma, and Lorantz Boldt, for their help in obtaining the data in the study and for the use of equipment and personnel at USDA Grain Marketing Research, Manhattan, Ks. Thanks are extended to other members of the faculty at K.S.U., who I do not mention by name, but who have provided assistance during my stay in the department.

INTRODUCTION

The consumption of whole wheat and variety breads in the U. S. has been increasing at the expense of white pan bread. In the last decade variety breads have grown from a relatively minor portion of the bread business to about 30% of bread sales. This dramatic change raises the question as to whether the current wheat varieties will adequately fill the requirements demanded in production of these breads.

Many varieties of wheat grown in Kansas have physical dough properties ranging across the entire spectrum from mellow to strong. The quality factors necessary to produce an acceptable loaf of whole wheat bread have been the subject of some speculation. A common contention is that a mellow or "weak" variety may not be as capable of carrying the bran and germ present in a whole wheat product as an average "strong" variety.

Another quality factor in the production of whole wheat breads is the granulation of the bran, shorts and red dog fractions that go into the whole wheat flour. Work done in the 1940's by Shetlar indicated that finer granulations of bran and shorts in whole wheat breads produced higher volumes as well as a grain more like that of white pan bread. More recent work by Finney, et. al. (1963) in which soy flour in varying granulations were added to bread, indicated the opposite trend. In their study the larger the particle size the greater the loaf volume.

It seemed necessary, therefore, to test whether there would be a significant difference between fine and coarse granulations of bran and shorts in whole wheat bread.

The breakfast cereal industry has, for many years, used white wheat bran in their wheat bran flakes breakfast cereal products, believing that white wheats have a more bland flavor than red wheat bran. We wanted to determine whether that premise was valid in terms of breadmaking, and whether blandness is a desirable trait for a whole wheat bread product.

The main objectives of the study were 1) to compare the ability of wheat varieties with contrasting physical dough properties to produce loaves of whole wheat bread and white (straight grade) bread and some intermediate blends 2) to demonstrate the effects of bran granulation on loaf volume in various blends of whole wheat bread for each variety 3) and to organoleptically compare breads made with a high percentage of whole wheat flour composed of both a white hard winter variety (HWW) and a hard red winter wheat (HRW) to test the hypothesis that a taste difference can be detected and, further that one would be preferred over the other in a whole wheat bread product.

LITERATURE REVIEW

Bakery Consumption Trends

Bakery Production and Marketing (1979) notes in an article on bakery trends that "king white bread has been deposed". Enriched white bread which has long dominated the baking industry has dropped from 58% of all bread type products in 1972 to 45% just five years later. The drop in total poundage of white pan bread produced in the U. S. has been a dramatic 22% from 6.8 billion pounds to 8.7 billion pounds. However, the bakery foods market is growing not declining. The slack left by the drop in white pan bread has been taken up, for the most part, by variety breads. This trend continues as a Bakery Production and Marketing (1980) article surveying the current market stated that the poundage of variety breads produced increased 8% a year between 1972-77, but the increase was 12% a year between 1977-79.

Wheat Varietal Differences

This change in bread consumption patterns necessitates a reevaluation of the wheat varieties currently grown for bread production. The question arises as to whether the varieties currently used to produce primarily white pan bread are adequate for use in variety bread production.

The varieties commonly grown in Kansas reflect a full range of physical dough and breadmaking qualities. Physical dough and breadmaking qualities are not necessarily synonymous.

Physical dough qualities usually reflect a flour's mixing time requirement, its absorption, its mixing tolerance and its oxidation potential. The terms used to generalize about a specific varieties' physical dough properties are words like strong, weak or mellow. In practice these terms are often misused to predict the varieties bread making potential.

To begin a discussion of physical dough properties a discussion of the basics of mixing is essential. Hosney (1974) states that the continuous phase of a dough is the result of applying mechanical energy to a mixture of water and flour.

When water is added to flour the flour particles are wetted and slowly hydrated. With no mechanical energy the process stops at that point. Upon mixing however, several changes occur. The flour water mass gradually becomes a smooth, homogeneous appearing dough. Further mixing produces an optimal loaf of bread. This point in time is physically evidenced by the peak in the minogram curve which represents the point of minimum mobility. Mixing a longer time "breaks down" the dough and mixing to a shorter time fails to develop the protein network to the extent needed for optimum gas retention.

It has been known for some time that certain other characteristics are related to the mixing time requirement of flour. To summarize from an article by Finney and Shogren (1972), generally a flour with a very short mixing time has a correspondingly poor mixing tolerance. The flour will begin to overmix or breakdown fairly rapidly after the point of minimum mobility. Also associated with short mixing flours are a higher oxidation requirement and a less elastic, less stable, more extensible dough. Finney and Shogren (1972) stated that flours with a mixing time of less than three minutes have lower volumes than flours of the same protein level with longer

mixing times. Conversely, long mixing flours are associated with physical dough characteristics which include excellent mixing tolerance, little or no oxidation requirement, and very elastic or bucky handling characteristics. Long mixing flours are generally described as being "strong" flours and short mixing flours are normally termed mellow or "weak" type flours.

It is desirable at this point to try to define the term strength as it is commonly used. E. E. Humpries in a report on the improvement of English wheat (1905) stated that many differences of opinion are due to the fact that we do not all refer to the same characteristics when we speak of strength. "A view which I have never seen in print but which appears to be the view in practice adopted by many bakers trading for profit, is that strength is to be judged by the way a flour behaves in a dough, its toughness, elasticity, freedom from stickiness, in other words, by the facility with which large masses of dough can be handled in the bakehouse. Another view is that strength should be defined as the flours capacity to make big, well piled loaves." The term "strength" is, therefore, not always equated with physical dough characteristics. A flour with physical dough properties may very well produce "well piled loaves". Finney and Barmore (1945) stated that though physical dough characteristics may correlate with, they do not determine a flours quality in breadmaking.

An important gauge for determining a varieties breadmaking quality is the regression line, relating protein content to loaf volume. Larmour (1931) showed that for a normal range of protein content the relationship between protein content and loaf volume was linear. Sandstedt and Ofelt (1940) made a study of the various wheat varieties grown in a particular season and concluded that protein and loaf volume was approximately linear within a variety. Finney later showed that the relationship between protein content and loaf volume is linear from about seven to eight percent protein and up to twenty percent. Below seven percent the relationship is curvilinear with all curves meeting at zero percent protein and 275cc of loaf volume.

"The regression of loaf volume on protein content was different for different varieties. Regression lines for loaf volume suggests a fan shaped family of lines when many varieties are compared."

The greater the slope of these lines the better a variety is in its breadmaking potential, taking other characteristics aside. A study of these lines show that some typically "weak" varieties exceed some typically "strong" types. From a report on Kansas wheat varieties Finney and Shogren have classified the Triumph 64 and Eagle-Plainsman flours used in this study by their functional properties. Triumph 64 is rated as having very good milling, fair mixing, and good loaf volume potentials.

It was released in 1967 and accounts for 6½% of the 1979 crop planting. It has been chosen to represent a wheat variety with mellow or weak physical dough characteristics. Eagle and its sister variety, Plainsman, are rated as having good milling properties, very good mixing quality and very good loaf volume. Eagle accounts for 21.1% of the seed acreage in Kansas in 1979. It was first released in 1970. Plainsman $\bar{V}$ is relative newcomer (1975-1976) with a gene for higher protein. These both are blended to achieve the identical protein content of the Triumph variety and together they represent a fine example of a typically "strong" set of physical dough characteristics. To scientifically justify the blending of two varieties (Eagle and Plainsman $\bar{V}$) when a single manifestation of physical dough properties is desired the early work by Finney and Barmore (1944) is essential. Their work indicated that a flour blend will produce loaf volumes and bread color scores, and other traits directly proportional to the amount of each flour in the blend. Since both flours represent typically strong physical dough characteristics; then we expect the blend will produce this singular set of traits.

GRANULATION OF WHOLE WHEAT

During the first and second world war there was a great deal of interest in the promotion of whole wheat bread products

over straight grade (white) breads. Arguments were made on both sides over the relative nutritive values of each type. Research done by Shetlar and Lyman (1944) was done to produce a whole wheat bread that was not "vastly technically inferior" to white bread. Their study concluded that bran of finer granulations produced loaves of higher volume. In their publication they did not indicate whether these differences were statistically significant although their photographs indicated that it well might be. Some of their work is repeated in the study with this objective in mind. There is also an attempt to evaluate the subjective contentions that Shetlar and Lyman make about the grain and crumb colors of breads with bran of varying granulations. They contend that a fine granulation gives a crumb very similar to white bread but with a darker color than a corresponding loaf with coarse granulation.

SHORTENING AND SURFACTANTS

It was to be of interest to demonstrate the effects upon volume of adding a surfactant to a whole wheat bread product. This then required a no shortening and shortening controls in able to demonstrate conclusively the surfactants' improving effects.

It has been known for years that the inclusion of some solid fat in a bread formula improves the loaf volume significantly.

Carlin (1947) stated that

"Doughs made without shortening produce loaves of bread which are considered bound or tight by the baker. Inclusion of shortening in the loaf will produce a progressive increase in loaf volume dependent upon flour strength and shortening percentage. Most flours will show progressive improvement in loaf volume with shortening ranging up to two percent of the flour weight."

Surface active agents or surfactants may be defined as materials that can alter conditions prevailing at the interfaces of systems. Surfactants are widely used in the baking industry as dough strengtheners and crumb softeners. The term "dough conditioner" refers to a number of distinct actions on dough and bread, some of which are related and some are not. Hoseney (1976) listed a number of functions which had been reported: (a) to improve the handling properties of a dough, thus making it machine better, (b) to increase loaf volume, (c) to increase the water absorption of the dough, (d) to replace shortening in the formula, (e) to counteract the deleterious effects of foreign proteins, and (f) to retard the firming of bread.

A recent comparison of some commonly used surfactants by Shogren, et. al. (1980) indicated that diacetyl tartaric acid esters of mono-glycerides, (DATE), out-performed, with the exception of sucrose monoesters, all others tested in producing volume in bread. The tests designed for this study do not attempt to duplicate the scope of their study. The treatments included no shortening, as an indicator of base volume, 3% shortening to represent the contribution on fats and oils, and 1% DATE to represent an optimum volume formula.

Hoseney (1976) corroborated the increase in volume which Finney obtained but further concluded that the reason that DATE are not, as yet, as popular in the U. S. as they are in Europe is because of comparatively high costs. DATE esters are approved by the USDA as a GRAS material.

MATERIALS

The unbleached, unmalted, straight-grade flours used were milled from samples of pure varieties of hard red winter wheats selected to represent contrasting physical dough characteristic types. The flours that were milled were harvested in Kansas in the years 1977-1979. The Triumph 64 blend was composed of a mixture of five wheat samples from as many Kansas locations. These samples were selected because of relatively high protein content. The Eagle-Plainsman blend was composed of a pure Plainsman $\bar{V}$ wheat harvested the same year in Garden City, Kansas. These wheats were blended to give a straight-grade flour identical to that of the Triumph flour in protein content at 12.1%.

A white hard red winter wheat sample was obtained from the Agronomy Department of KSU and was identified as KS 75-216. It was obtained for its white bran, shorts and red dog fractions. The flour was not utilized in this experiment but was bake tested to assure that the flour was of good baking quality.

The DATE used in the surfactant treatment was obtained from US Grain Marketing Research Center and was manufactured by a German firm; Chemische Fabrik, Grunaul, GMBH.

METHODS

Physical Dough Tests

Studies of the rheological properties of the straight grade and whole wheat flours were measured on the ten gram mixograph as described by Finney and Shogren (1972).

Bake Tests

All milling was done on a Buhler experimental mill. The Triumph blend was milled to 72.6% extraction and the Eagle-Plainsman $\bar{V}$, hereafter referred to as just "Eagle", was milled to a similiar extraction of 71.2%. Four separate fractions were obtained and segregated: straight grade flour, bran, red dog and shorts.

Bake tests were conducted by straight-dough procedure with optimized absorption, malt and ascorbic acid as the oxidizing agent. This procedure was described by Finney, et. al. (1976). The formula included 100 g flour (14% moisture basis), 1.5 g salt, 6 g sucrose, 2 g shortening or 1 g DATE with 0.75 g malted wheat flour with 120 SKB alpha-amylase units per gram (30 C) and approximately 5 g of yeast. Doughs were punched after 52 minutes and 78 minutes and panned after 90 minutes of fermentation. Proof time was generally 30-40 minutes with loaves proofed to 7.8 cm in height. Loaves were weighed as they came from the oven and volumes were determined by dwarf rape seed displacement.

Taste Tests

A triangle taste test was conducted with participants asked to taste three slices and to pick the sample that was different.

Samples of 75% whole wheat bread containing 1% DATE were provided with either white or red coarse brans. Samples were also tested that were made with 75% whole wheat of either fine red or fine white granulations. The colors of the crumb of both samples were disguised by low level red lighting.

A taste preference test was also conducted with participants free to perceive the color differences in the crumb before tasting. The same 75% whole wheat samples were provided and the questionnaire asked the taste panelists to state a preference for either red or white whole wheat breads, made either with coarse or fine granulated materials present.

Flour protein, moisture and ash contents were determined by standard AACC methods at the U. S. Grain Marketing and Research Center in Manhattan, Kansas.

Regrinding bran and shorts fractions to produce a particle size similar to that of flour was done on the Utey experimental grinder. Usually ten to twelve passes were required before the particle size was sufficiently reduced.

Experimental Design

The straight grade flours, bran, shorts and red dog of the Triumph, Eagle-Plainsman, and hard white winter wheats were reconstituted from the separate fractions to form five blends ranging from 100-0 which was the symbol devised for 100% straight grade flour, to 0-100 which represented 100% reconstituted whole wheat. Intermediate levels were 75-25, 50-50 and 25-75 with the first number representing the fraction of straight grade flour in the blend while the second represents the percentage of whole wheat flour.

The first set of treatments, variations in additions of shortening and surfactants, were applied to Triumph and Eagle using sample blends ranging from whole wheat to straight grade flours. In one case shortening was excluded from all loaves. In the second 3% shortening alone was added and lastly 1% DATE was added without shortening.

The second set of treatments involved regrinding the bran, and shorts of each variety so that the largest portion would go through a 100 mesh sieve. A comparison was made of the volumes of 50-50, 25-75 and 0-100, of both Triumph and Eagle-Plainsman $\bar{V}$ with both the original coarse bran and shorts fractions present versus the newly reground fine bran and shorts fraction that were substituted.

In the final treatment, bran, shorts and red dog from hard white winter wheats replaced the natural red brans of both Triumph and Eagle-Plainsman Blends. The white wheat fractions were then included in baked loaves in both coarse and reground fine granulations.

RESULTS AND DISCUSSION

Physical Dough Properties

To guarantee that the Triumph flours that went into the blend were typical of that variety, mixograms were run on each of the five wheats that made up the composite.

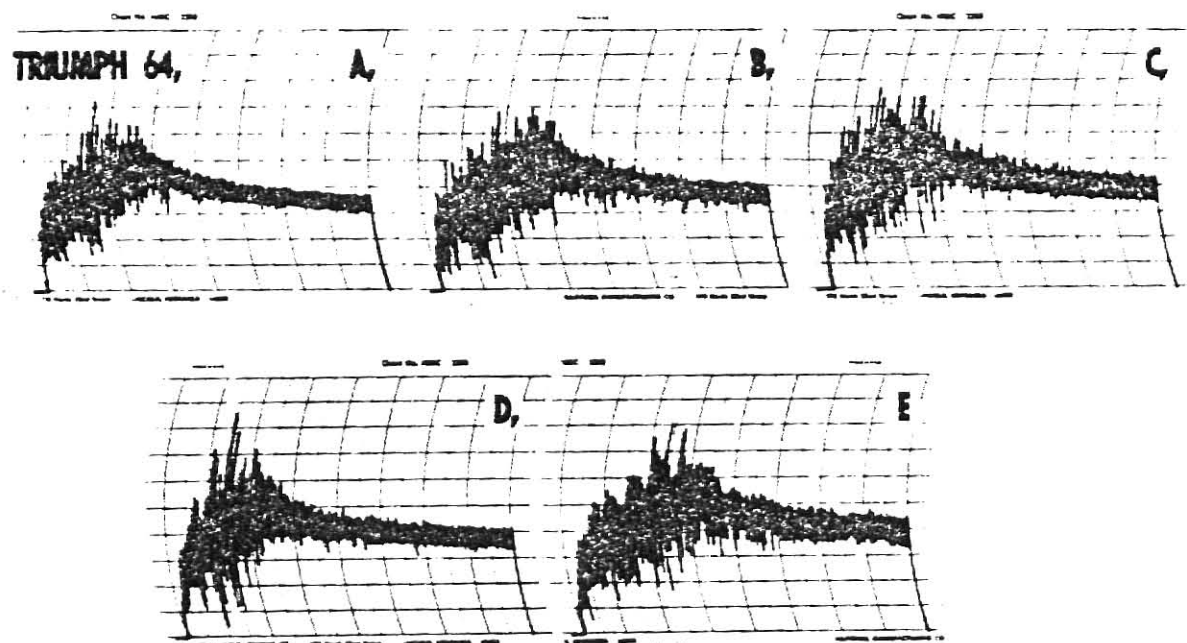
Curves pictured in Figure I for all five were typical of Triumph. Mixing times averaged $2\frac{1}{2}$ minutes for the Triumph blend with a visible poor mixing tolerance. In contrast, mixograms run on both the Eagle and Plainsman $\bar{V}$ indicated a typically "strong" flour with a mixing time of $6\frac{1}{2}$ minutes with very good mixing tolerance. As Table I indicates, oxidation requirements also reflected the contrast in physical dough characteristics with the mellow Triumph blend requiring 75 ppm ascorbate while the Eagle-Plainsman for all practical purposes required none at $2\frac{1}{2}$ ppm.

Bakery Properties Related to Physical Dough Properties

As predicted by their differences in mixograph mixing time, the two flours behaved quite differently during the mixing process. The long mixing Eagle-Pl $\bar{V}$ Blend gravitated to the sides and bowl bottom until the pick up stage some five to seven minutes after mixer start up. The Triumph blend began pick up almost immediately. When blends with higher percentages of whole wheat were being mixed, the Eagle blend had to be scraped off the bowl quite frequently to facilitate more efficient mixing action while the Triumph would not require this additional care.

In handling, the blends again displayed a contrast. The Eagle blend was frequently bucky and difficult to punch and mold without damaging the dough surface. The Triumph, on the other hand, machined very well, never displaying the sometimes excessive elasticity of the Eagle blend.

MELLOW WHEAT BLEND



STRONG WHEAT BLEND

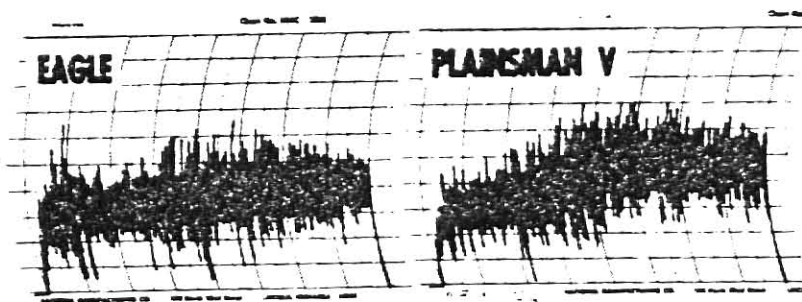


FIGURE I. Mixograms of the individual wheats making up the Eagle and Triumph blends.

TABLE I

Chemical, Physical, and Baking Data

Variety	Whole Wheat %	Protein ¹ %	Functional Protein ² %	Water Abs. %	Oxidation Req. ³ ppm
Eagle	100	13.1	8.7	78	2½
	75	12.9	9.6	76	2½
	50	12.7	10.4	74	2½
	25	12.4	11.3	72	2½
	00	12.2	12.2	71	2½
Triumph	100	13.1	8.8	73	75
	75	12.9	9.6	71	75
	50	12.6	10.4	69	75
	25	12.4	11.3	68	75
	00	12.1	12.1	67	75

1 all protein figures corrected to 14% moisture basis

2 Functional protein is defined as gluten and water soluble protein and is equivalent to protein of straight grade flour.

3 oxidant used was ascorbic acid

TABLE II

Crumb Grain Scores for Varying Shortening Treatments

Variety	Whole Wheat Percentage	Shortening	DATE	Crumb Grain Score*
Eagle	00	none	none	Q
Triumph	00	none	none	Q
Eagle	25	none	none	Q-U
Triumph	25	none	none	Q
Eagle	50	none	none	Q-U
Triumph	50	none	none	U
Eagle	75	none	none	U
Triumph	75	none	none	U
Eagle	100	none	none	U
Triumph	100	none	none	U
Eagle	00	3%	none	S
Triumph	00	3%	none	S
Eagle	25	3%	none	S
Triumph	25	3%	none	S
Eagle	50	3%	none	S
Triumph	50	3%	none	S
Eagle	75	3%	none	Q-S
Triumph	75	3%	none	S
Eagle	100	3%	none	S
Triumph	100	3%	none	S
Eagle	00	none	1%	S+
Triumph	00	none	1%	S+
Eagle	25	none	1%	S-
Triumph	25	none	1%	S+
Eagle	50	none	1%	S+
Triumph	50	none	1%	S+
Eagle	75	none	1%	S
Triumph	75	none	1%	S+
Eagle	100	none	1%	S+
Triumph	100	none	1%	S $\frac{1}{2}$ +

* Where S=satisfactory, Q=questionable, and U=unsatisfactory

The easier handling and machining of the Triumph blend could be attributed to its "mellow" physical dough characteristics. These same "mellow" characteristics could also be responsible for some of the differences in crumb grain between Triumph and Eagle loaves. Some subtle differences may be seen comparing Figures II and III, although the crumb grain scores of Table II indicate little difference between the varieties.

In Figure II, with Eagle loaves pictured, there are some loaves which display some very round, thick walled cells in the core area. In this core area the cells are not as numerous or as fine as the Triumph samples in Figure III and the texture of the Eagle was slightly more harsh. The grain of the Triumph blend straight grade flour loaves was finely celled and had a velvety texture. The crust showed a break and shread that was smooth with no signs of capping. Eagle often displayed a rough and uneven break and shread with some evidence of capping in individual loaves. These traits in Eagle loaves are a manifestation of the "bucky" characteristics which are often associated with a strong physical dough type.

Effects of Varying Percentages of Whole Wheat

The design of this experiment allowed us to look at the effects of adding, stepwise, a greater and greater percentage of whole wheat flour. Figures IV and V picture five wheat flour blends for Eagle and Triumph respectively.

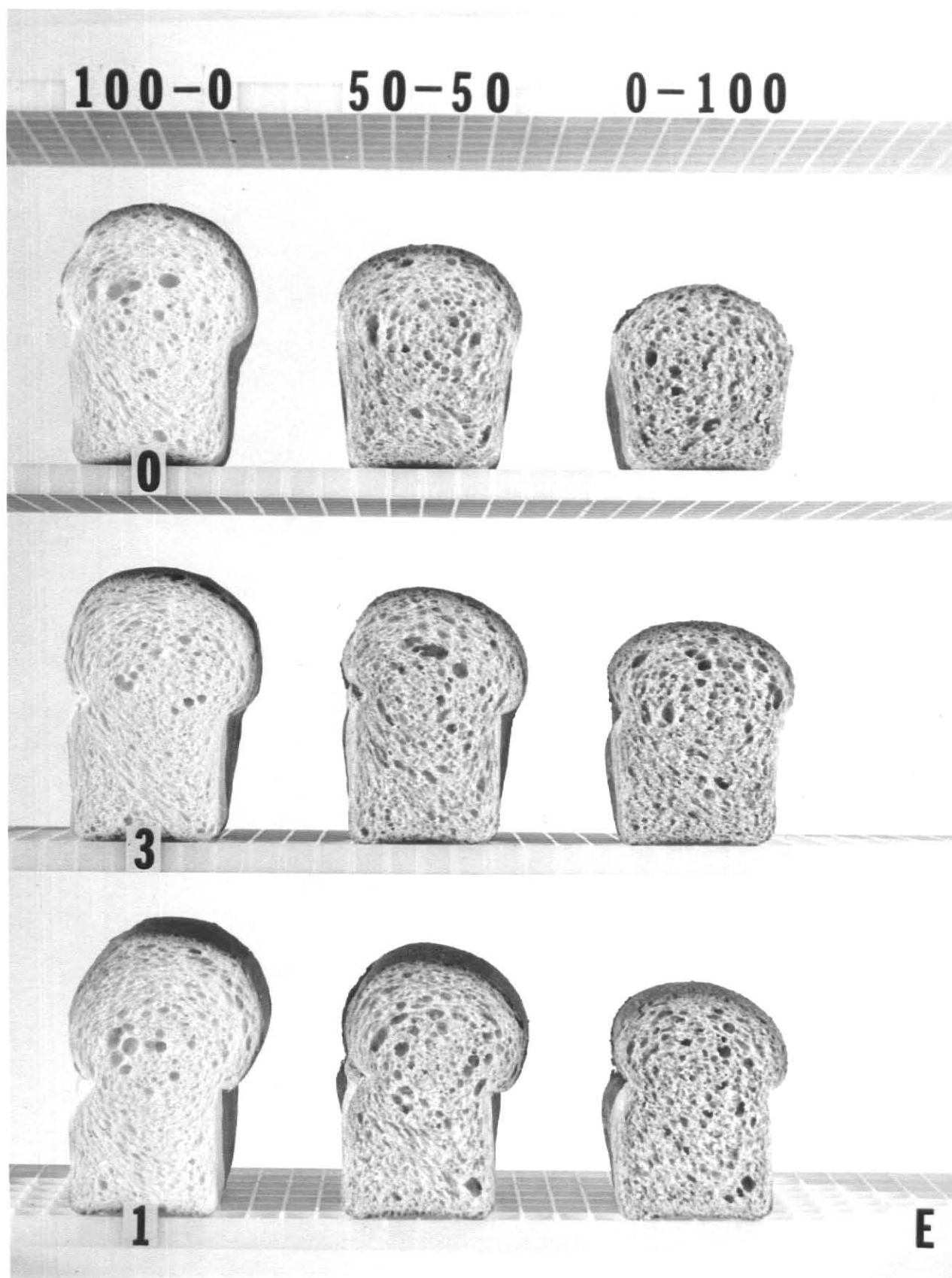


FIGURE II. Eagle loaves with no shortening, 3% shortening and 1% DATE.

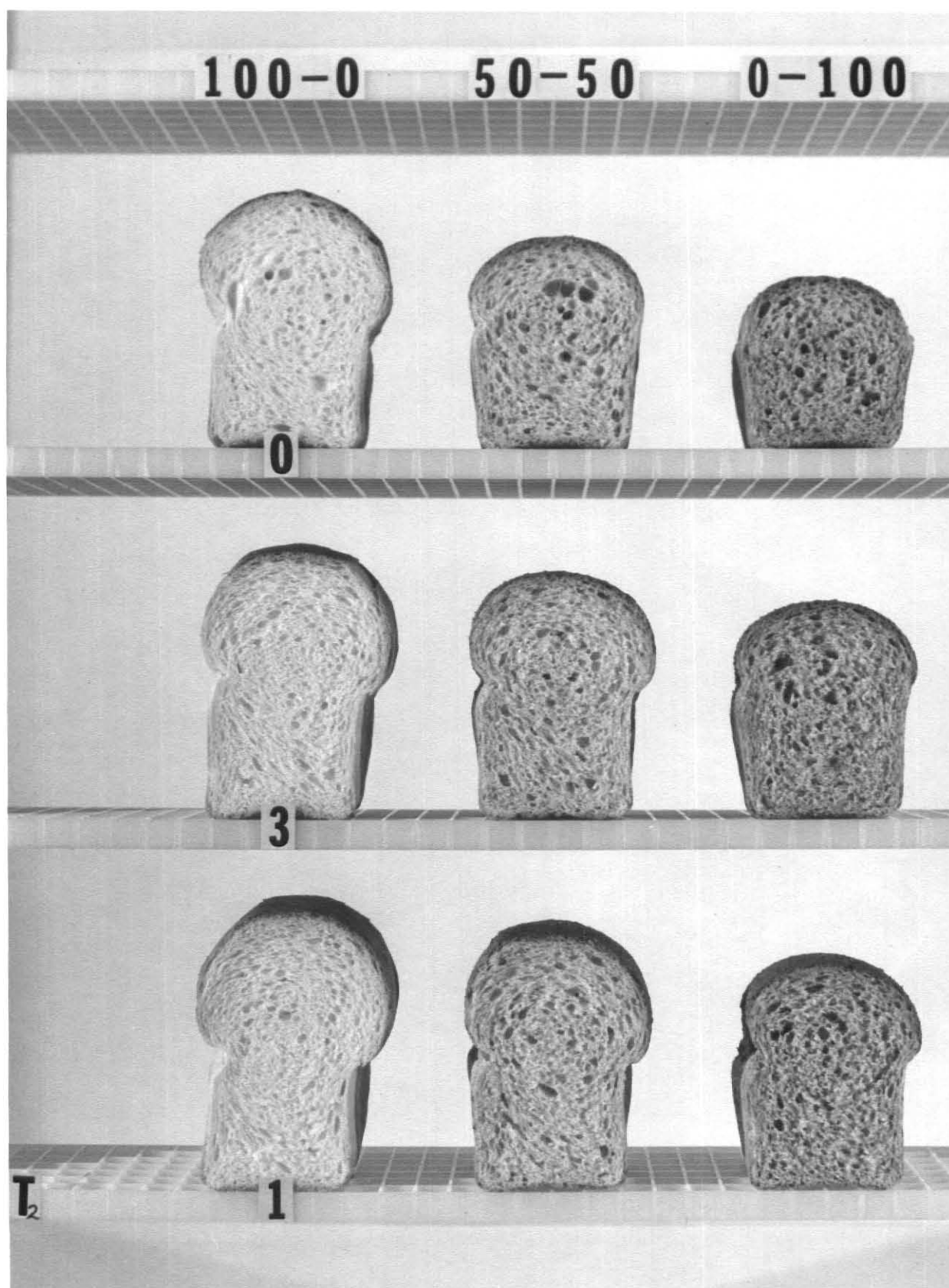


FIGURE III. Triumph loaves with no shortening, 3% shortening and 1% DATE.

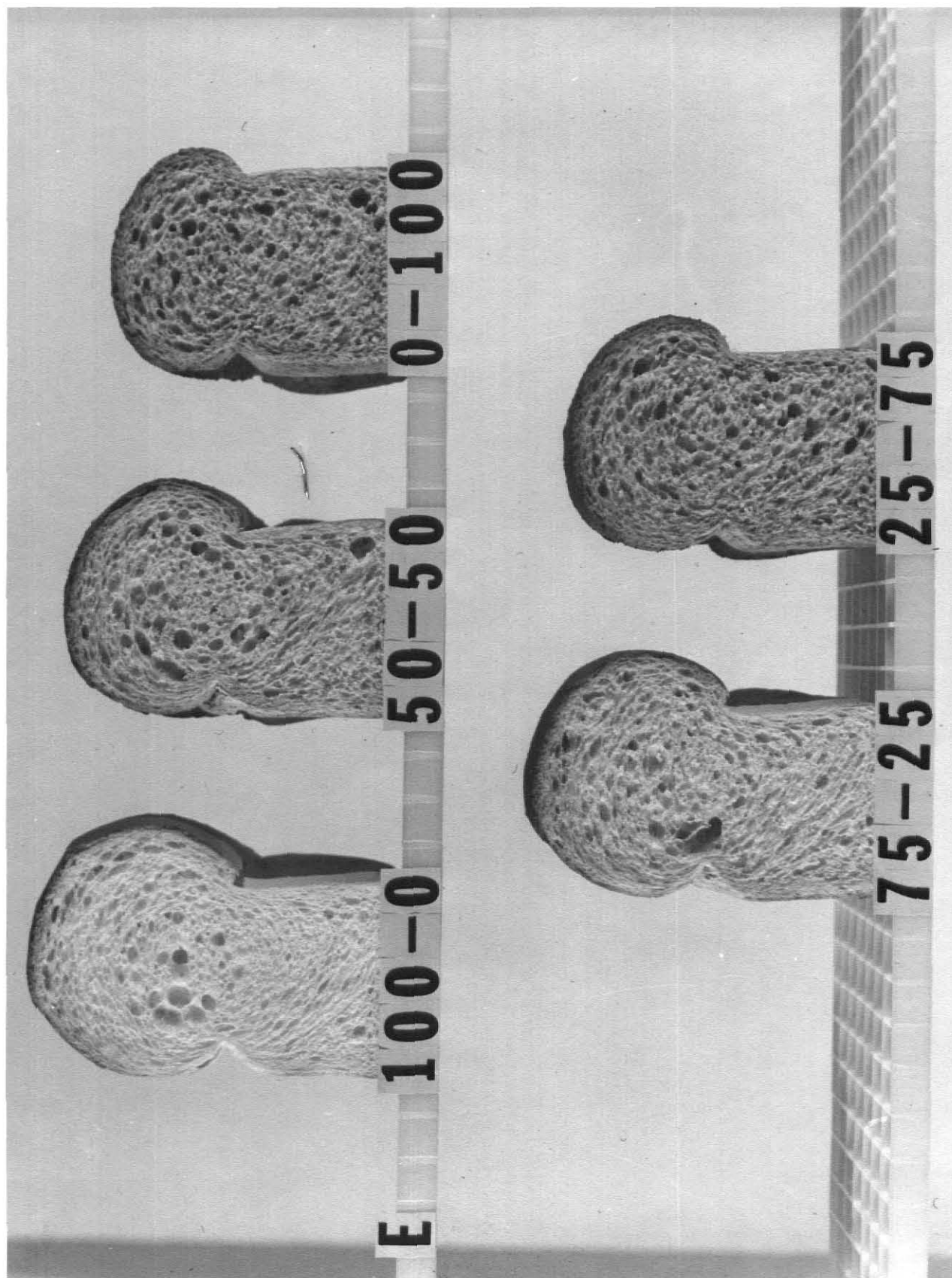


FIGURE IV. Eagle blends of straight grade and whole wheat flours.

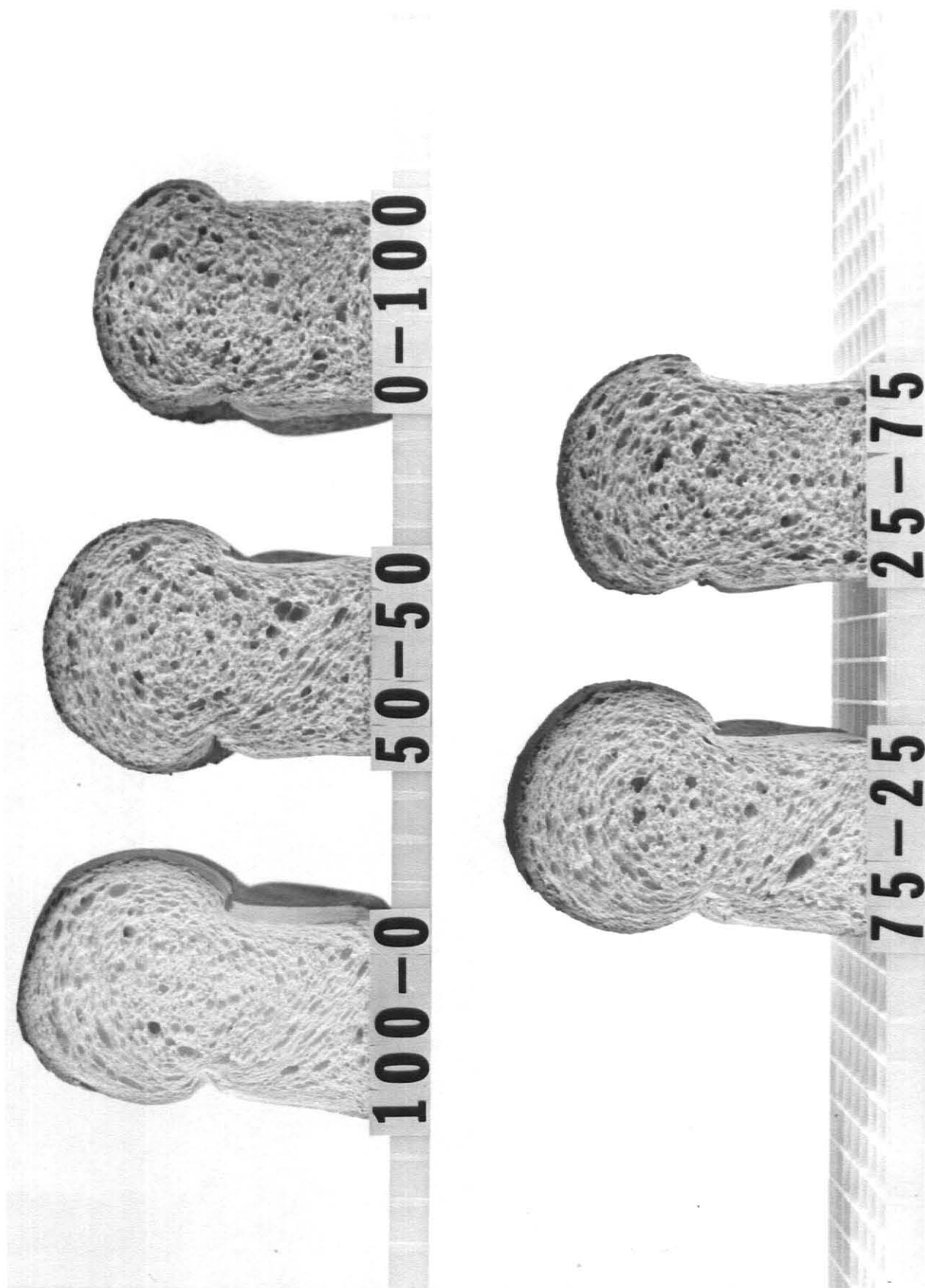


FIGURE V. Triumph blends of straight grade and whole wheat flours.

The blends were 100% straight grade flour, 25% whole wheat, 50% whole wheat, 75% whole wheat, and 100% whole wheat. As expected, each higher addition of whole wheat had a negative effect on volume. The effect was extremely linear with R-square values ranging from 0.94 to 0.99. If the independent variable in Figure VI is redefined from "Whole Wheat Percentages" to percent functional protein, what we then have is regression lines for the two varieties with various treatments superimposed.

Table I also shows that as the whole wheat percentages increase the percentage of functional protein decreases. Functional protein is defined in the table as gluten and water soluble proteins. It is equated with the protein in a straight grade flour. An important point to make here is that even though the total protein of the whole wheat loaf is higher, the functional protein or gluten plus water solubles is around nine percent. This explains the gradual decline in volume from a straight grade loaf with 12.1% functional protein to the gluten diluted whole wheat loaf with 8.8% functional protein. In addition to diluting the functional protein with higher and higher bran, shorts and red dog additions one is simultaneously calling upon this lower functional protein level to carry larger and larger amounts of deleterious material which must further affect the loaf volume potential.

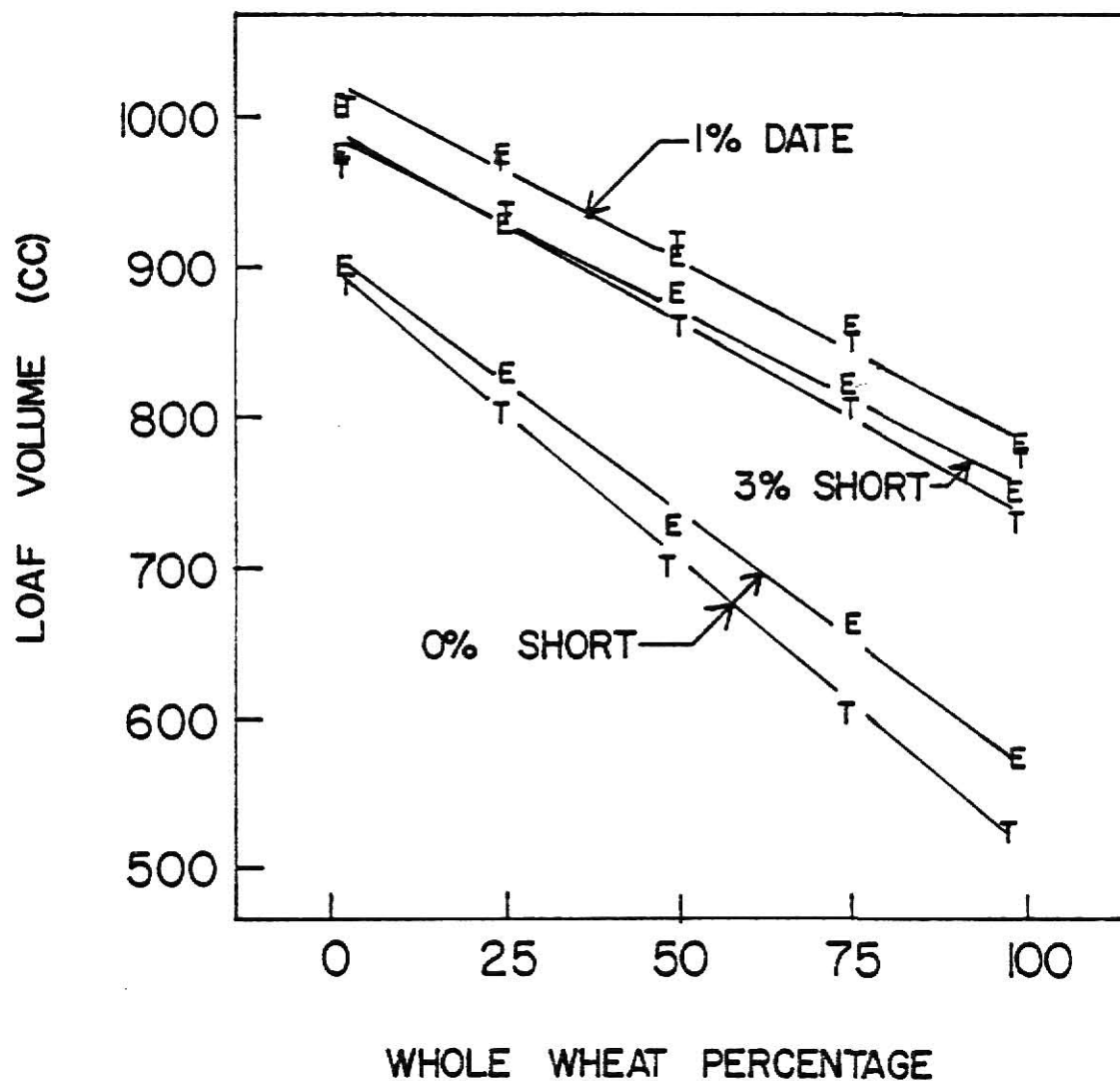


FIGURE VI. The Relation Between Whole Wheat Percentage and Loaf Volume With Various Shortening and Surfactants.

TABLE III

Specific Data Pertaining To
Shortening and Surfactant Treatments

Treatment	Variety	R-Square	Slope	Intercept
No Short.	Eagle	0.989	-3.45	910
No Short.	Triumph	0.990	-3.90	898
Short. 3%	Eagle	0.978	-2.35	988
Short. 3%	Triumph	0.979	-2.59	992
DATE 1%	Eagle	0.962	-2.40	1025
DATE 1%	Triumph	0.962	-2.44	1025

It was then calculated that to produce a loaf of whole wheat bread with the volume of loaf of white bread (average 11.5% protein) it would require a wheat with a protein of about 16% to get a functional protein level of 11.5% in the whole wheat bread. Similarly, if an average protein wheat is used (about 12 or 13% protein), about a four percent addition of vital wheat gluten would be required to obtain the same volume as a white pan loaf from whole wheat flour.

Shortening and Surfactant Addition

The results of the bake tests with varying shortening and surfactant treatments (refer to Figure VI) indicate more similarities between Triumph and Eagle than would be indicated by comparing their physical dough characteristics. Both the Triumph and Eagle blends were baked at the five levels of whole wheat enumerated above. Figure VI indicated that within any variety and treatment the relationship between whole wheat percentage and volume was very linear, as did the R values in Table III. The differences between the lines was analyzed statistically by LS means.

A significant difference was found between the Triumph and Eagle blends made with no shortening at the 5% significance level, with Eagle greater in volume.

The addition of shortening at 3% increased the volume of both Eagle and Triumph blends over that of their respective loaves with no shortening. Between 100 to 150cc separated the respective curves for these two treatments.

The grains were also greatly improved from the bound, heavy, coarse grain of the no shortening loaves to a light product with fine cell structure with the 3% shortening treatment. In this case, however, there was no significant difference between the Eagle and Triumph blends at the 5% level. Since shortening is used in most bread formulations in the U. S. either by itself or in conjunction with a surfactant, one can conclude that under normal conditions there is no significant difference in the volume potentials of Eagle and Triumph.

Lastly, 1% DATE was added to the blends of each variety. Referring, again, to Figure VI one can see that the line for both Eagle and Triumph is identical under optimal conditions. Statistically there is no significant difference between Eagle and Triumph. Specifically there is an 82% chance the differences between Eagle and Triumph with 1% DATE could occur purely by chance.

There is, however, a highly significant difference in volume between either Eagle or Triumph blends with 1% DATE and their respective blends with either 3% shortening or no shortening treatments. The grain of the bread made with 1% DATE is also superior to the corresponding bread made with 3% shortening in that the crumb displays a more finely developed cell structure and a less open, brighter appearance. The texture was almost velvety compared to the soft texture of the 3% shortening treatment.

Fine versus Coarse Granulations

The loaves baked with the original coarse granulation of bran and shorts were compared in volume, grain and texture with loaves baked with bran and shorts fractions reground to pass through a flour cloth. (Refer to Figures VII and VIII for the results). Analysis by LS means, comparing the two treatments by volume showed significant differences at the 5% level. The actual LSD means value was $4\frac{1}{2}\%$ which just barely made the arbitrary 5% significance level cutoff. These results include the fine granulation white bran versus coarse granulation white bran that were substituted for the natural reds of both the Eagle and Triumph varieties.

The differences between fine versus coarse loaves with the same percentage of whole wheat flour was usually only 15-25 cc. This is a barely perceptible difference in volume when the loaves are visually compared without the volume meter. If these were pound loaves, an equivalent difference would be 60 cc which, again, is nearly imperceptible.

It should be stressed that the fine granulation of this study is not typical of a commercial fine whole wheat flour. The commercial fine is an intermediate granulation between our two extremes.

It may not be worth the added cost to the baker to have the miller regrind the bran for such a small improvement in volume if that were the only improvement. There is a much more apparent advantage to a finer granulated whole wheat flour, however. The grain, as first observed by Lyman and

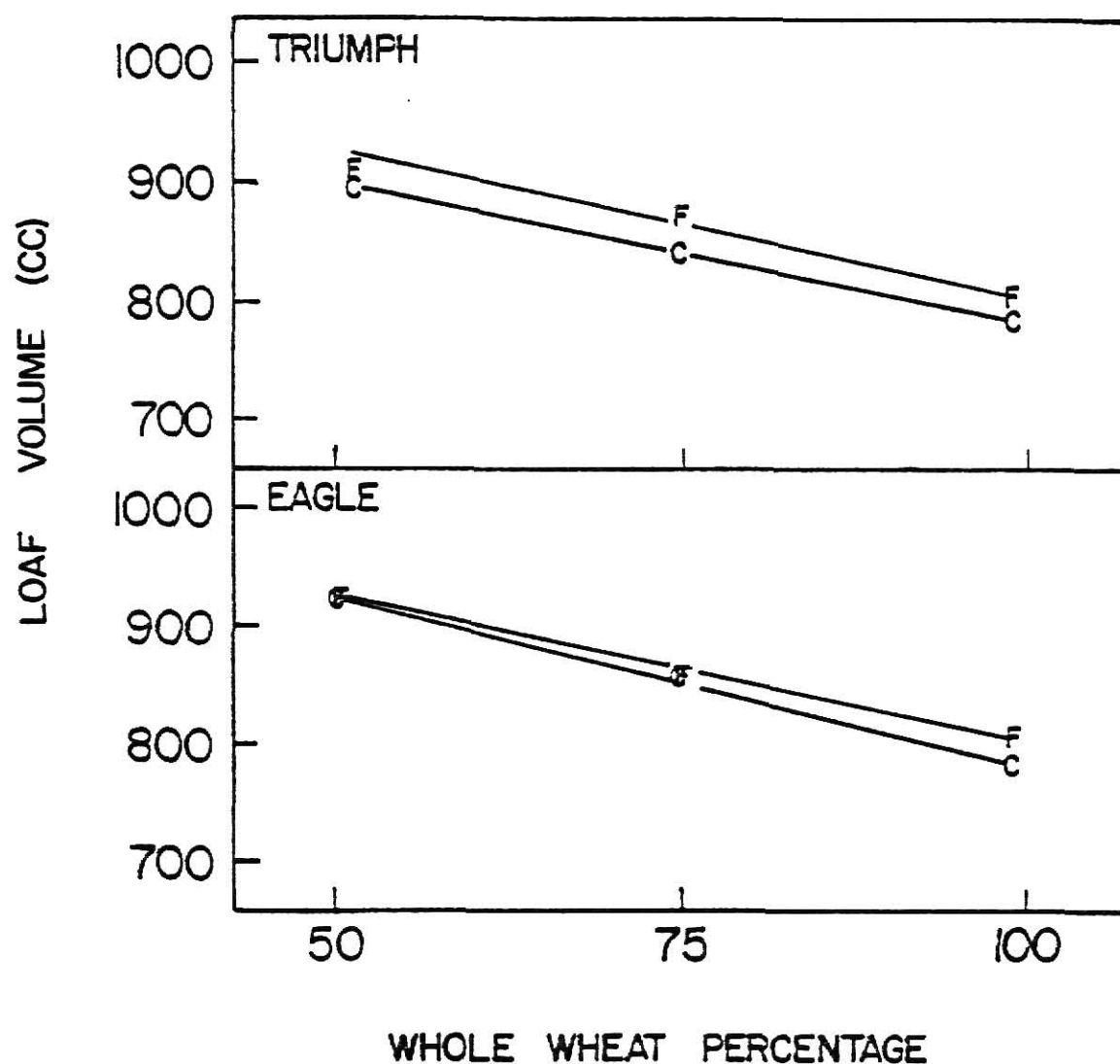


FIGURE VII. The Relation Between Whole Wheat Percentage and Loaf Volume in Loaves Containing Fine Granulated Whole Wheat Flour (F) Versus Coarse Granulated Whole Wheat Flour.(C).

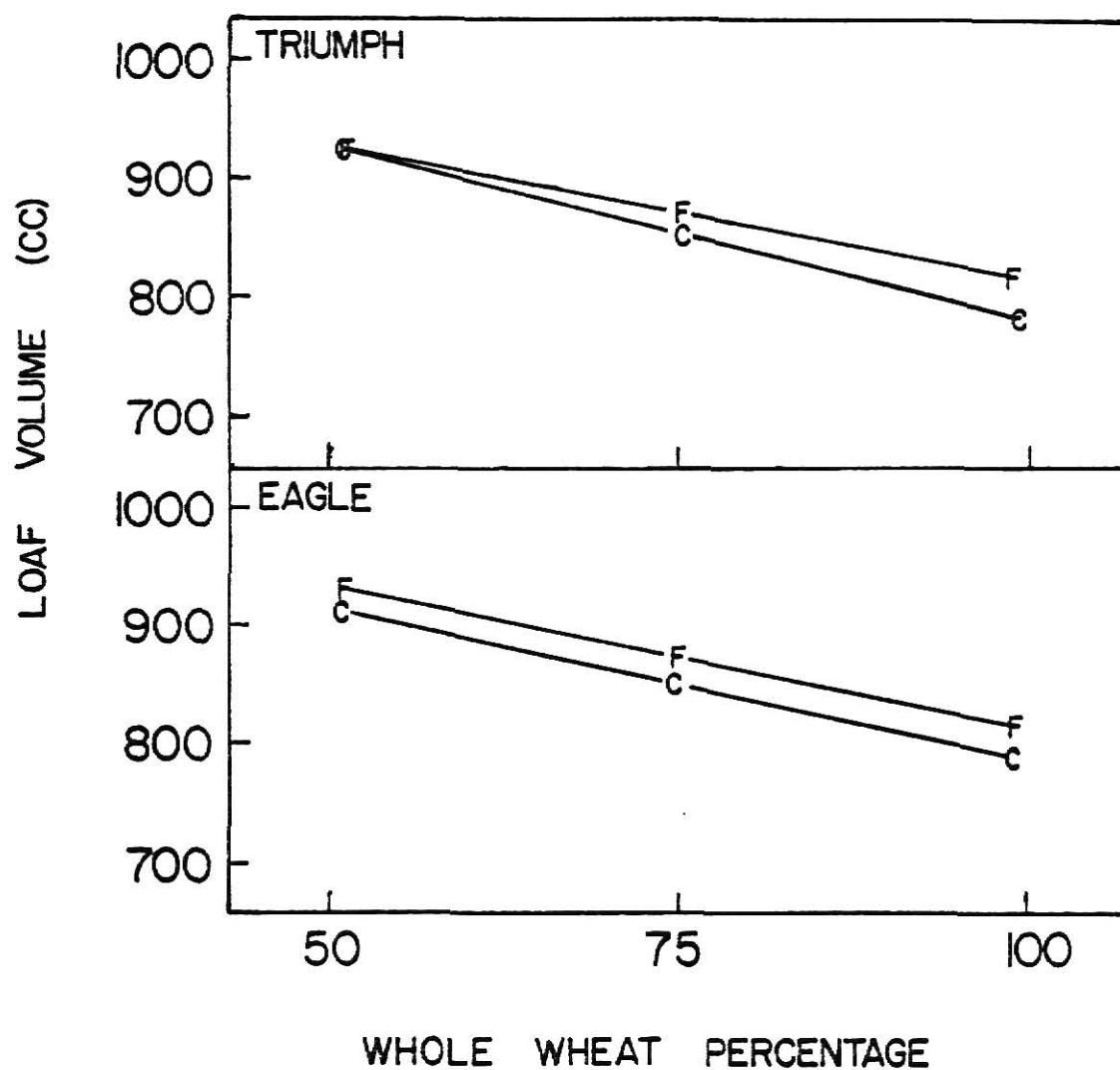


FIGURE VIII. The Relation Between Whole Wheat Percentage and Loaf Volume in Loaves Containing Fine Granulated Wheat Flour (F) Versus Coarse Granulated White Wheat Flour (C).

TABLE IV

Agtron readings on bread crumb with
white bran versus red bran,
coarse bran versus fine bran

Variety	Bran Color	Whole Wheat Percentage	Granulation	Average Agtron Reading*
Eagle	red	50	coarse	39
Eagle	red	50	fine	28
Triumph	red	50	coarse	38
Triumph	red	50	fine	31
Eagle	white	50	coarse	52
Eagle	white	50	fine	50
Triumph	white	50	coarse	56
Triumph	white	50	fine	54
Eagle	red	100	coarse	15
Eagle	red	100	fine	7
Triumph	red	100	coarse	12
Triumph	red	100	fine	6
Eagle	white	100	coarse	30
Eagle	white	100	fine	29
Triumph	white	100	coarse	33
Triumph	white	100	fine	34

* Average readings of eight actual readings using Agtron discs #24 and #63. Lower numbers represent darker color values.

Shetlar (1944), were much better with bran and shorts at a finer granulation. The cells were more numerous and uniform and the crumb had a stronger body. In general, the appearance of the finer granulated whole wheat bread was more like that of white bread except for the color. Coarse granulated whole wheat made bread with a lighter crumb, readily seen by visual inspection. Since we weren't sure whether this was due to greater degree of contrast between the large bran and the light background structure in the coarse granulated crumb, we compared the colors of the two crumbs objectively using the Agtron. The results are available in Table IV. The Agtron consistently showed darker readings for the finer granulations of whole wheat with the natural red brans present, even though the coarse granulated flour contained the same amount of brany material in each case. Unexplicably, a similiar difference was seen by visible inspection of whole wheat breads made with white wheat bran materials in place of red, the Agtron was unable to verify the difference between fine and coarse granulation crumbs.

HRW versus HWW

Figures VII and VIII can be used again to illustrate yet another comparison using Eagle and Triumph. Both varieties were baked with their natural red (HRW) brans, shorts and red dog fractions and then with the bran, shorts and red dog of a hard white winter (HWW) substituted for the natural red. Analyses by LS means for color and whole wheat percentage

versus volume indicated that color does not significantly effect volume, which was expected. The appearance of the crumb of the loaves was dramatically different with white bran in place of red. White bran loaves were much lighter in color giving the impression of having less whole wheat flour than a corresponding whole wheat percentage with red bran. The white bran did not give the bread a white bread appearance, however. The crumb color was more akin to tan or yellow. In loaves with white bran at a coarse granulation the bran particles were easily seen though not as easily as in loaves with red coarse bran. The grain characteristics of loaves with white bran displayed the same kinds of differences compared to their corresponding fine bran loaves. Coarse bran loaves were more open grained, had a lower volume and appeared to be lighter in color than their fine bran counterparts. White bran substitution for red gave no significant change in loaf volumes, as would be expected. Table IV also shows that the white bran was measured as being lighter than red bran but whereas with the red bran there was a difference in readings between fine and coarse, with the white bran loaves there was no measurable difference.

Taste Panel: HRW versus HWW

For the taste panel comparisons of HRW versus HWW, the bran of Eagle and Triumph were mixed together in equal proportions to give a composite for the HRW. The shorts, red dog and flours of Eagle and Triumph were handled similarly. The half and half blend of Eagle and Triumph flour was also used

for the HWW sample but in this case white bran shorts, and red dog fractions were used.

Tables V and VI summarize the data obtained from a triangle taste panel in which participants were prevented from observing the differences in crumb color. The results showed a very significant number of people able to perceive a difference in the texture and flavor of the breads made with the two different brans. Over 50% of the participants correctly identified the odd sample when the law of chance stated that only one-third should have been able to correctly guess the odd sample. Figure IX provides an example of the score sheet presented to the panel.

When, on a later date, a taste panel was asked to state a preference and grade the breads overall, crumb color differences were visible to the panelists when making their judgments. A sample questionnaire is included in Figure X. Again, coarse granulation loaves and fine granulation loaves were compared separately. The results analyzed by a binomial test and summarized in Tables V and VI indicated that the panel liked both types of whole wheat bread. There was no preference for whole grain breads made with white bran over those made with the more common red bran. From the overall ratings of the breads taken from the hedonic scale and analyzed by the Wilcoxon sign test, there also was no difference in the average scores between fine bran loaves and coarse bran loaves with either red or white bran.

FIGURE IX
Triangle Taste Test Panel Score Sheet

BREAD

GROUP I

Two of these three bread slices came from the same loaf and one came from another loaf.

_____ # _____ # _____

EXAMINE THE SLICES OF BREAD LEFT TO RIGHT ORDER AND TAKE OUT ONLY ONE SAMPLE AT A TIME:

A.) Answer the following questions:

1.) The odd sample is # _____

2.) What was the difference? _____

GROUP II

Two of these three bread slices also came from the same loaf and one came from another loaf.

_____ # _____ # _____

EXAMINE THE SLICES OF BREAD LEFT TO RIGHT ORDER AND TAKE OUT ONLY ONE SAMPLE AT A TIME:

A.) Answer the following questions:

1.) The odd sample is # _____

2.) What was the difference? _____

FIGURE $\bar{X}$
Preference Taste Test Score Sheet

Please taste the breads given to you. Place an X in the box that best describes your opinion.

	610		469
Excellent			
Very Good			
Good			
Fair			
Not so good			
Poor			

Which product do you prefer?

610 _____

469 _____

Comments - Please give any comments you may have.

610 _____

469 _____

TABLE VCoarse Granulation Whole Wheat

General Preference Findings:

	<u>Number of Participants Preferring</u>	<u>Percent of Total</u>
#469 (red bran)	29	58
#610 (white bran)	21	42
Totals	<u>47</u>	<u>100</u>

Binomial test gives $P = 0.16$ that any difference in preference can occur purely by chance. No significance.

Ratings; The Hedonic Scale

	<u>Poor</u>	<u>Not so Good</u>	<u>Fair</u>	<u>Good</u>	<u>Very Good</u>	<u>Excellent</u>	<u>Total</u>
#469	0	1	12	14	20	3	50
#610	0	3	8	22	16	1	50

Wilcoxon sign test gives $P = 0.16$ that any difference in overall ratings can occur purely by chance. No significance.

TABLE VI

Fine Granulation Whole Wheat

General Preference Findings:

	Number of Participants Preferring	Percent of Total
#913 (red bran)	24	51.1
#804 (white bran)	23	48.9
Total	47	100.0

Binomial test gives $P = 0.50$ that any difference in preference can occur purely by chance. No significance.

Ratings; The Hedonic Scale

	Poor	Not so Good	Fair	Good	Very Good	Excellent	Total
#913	0	0	15	12	18	5	50
#804	0	5	5	22	15	3	50

Wilcoxon sign test gives $P = 0.25$ that any difference in overall ratings can occur purely by chance. No significance.

In the general comments, thirteen panelists indicated that for coarse loaves the color of red wheat is identified with a coarser, more brany or grainy product when compared to white versus two panelists with the opposite view. Also, in those that favored the red, a few commented that white had a flavor that was too bland.

In the fine granulation bread, ten panelists commented that the white wheat bran loaf was more bland while the red was grittier, more bitter or less sweet. Again, two panelists stated the opposite view. Still, as in the coarse bran loaves, there was a fairly even split on preference.

CONCLUSIONS

The physical dough characteristics of the Triumph blend used in this study was established to be typically "mellow". In contrast, the Eagle-Plainsman $\bar{V}$ blend was found to represent a typically "strong" variety in physical dough character.

The use of five levels of whole wheat flour in the bake tests graphically illustrated that the loaf volumes decrease with increasing percentage of whole wheat flour. This is a direct response to the corresponding decrease in functional protein as whole wheat percentage increases. A whole wheat bread product, in contrast to white bread, is a compact loaf for two reasons: A low functional protein content and a relatively large amount of slightly deleterious material to be carried.

The whole wheat percentage formed a linear relationship with loaf volume and these lines were the basis for comparing Eagle and Triumph. With no shortening present, Eagle showed a significantly higher volume than did Triumph. There was no significant difference between Triumph and Eagle with 3% shortening present or with 1% DATE as the treatment. This is strong evidence that under normal to optimal conditions the physical dough characteristics of a variety, with their respective labels such as "strong", "mellow", or "weak", do not correlate to that variety's ability to carry bran, shorts, and red dog as evidenced by the loaf volumes. The regression lines of loaf volume on protein content for each variety are the best indicators to predict an individual variety's loaf volume

potential rather than its physical dough properties.

There is a minute improvement in loaf volume when the particle size of the bran and shorts fractions are decreased by re-grinding. However, there is an obvious improvement in crumb grain and the number and relative size of cells. There is a darkening of the crumb color with a finer granulation that, some may feel, detracts from the crumb appearance.

Finally, the question of whether the general consuming public would prefer to have white hard winter wheat (HWW) bread in preference to red hard winter wheat (HRW) bread has not been answered conclusively. There was an even split in the number of people in our taste panel who preferred red bran whole wheat products to white bran whole wheat products. Although a highly significant number of people could taste the difference between the two, there is not a strong consensus for either in a whole wheat bread product as there may be in a breakfast cereal product.

BIBLIOGRAPHY

- Anon. Bakery Trends '79 Facing the New Consumer, Bakery
June, 35-47 (1979)
- Anon. Bakery Update on Variety Bread Boom, Bakery
May, 80-84 (1980)
- Carlin, G.T. Fat in Bread Dough, Bakers Digest 21(4):22
(1947)
- Finney, K.F. and Barmore, M.A. Flour Blends and the Question
of Complementary Effects, Cereal Chem. 25(1):65-74
(1944)
- Finney, K.F. and Shogren, M.D. A Ten-gram Mixograph for
Determining and Predicting Functional Properties of
Wheat Flours, Bakers Digest 45:32 (1972)
- Finney, K.F. and Shogren, M.D. Quality of Kansas Wheat Vari-
eties, Report to 7th Annual Wheat Marketing Field Day,
USDA Grain Marketing, Manhattan, KS (1979)
- Finney, K.F. et. al. Soy Product Variables Effecting Bread-
making, Cer.Sci.Today 8:166-168,183 (1963)
- Finney, P.L. et. al. Short-time Baking Systems, Inter-
dependence of Yeast Concentration, Fermentation Time,
Proof Time, and Oxidation Requirement, Cereal Chem.
53(1):126-134 (1976)
- Hoseney, C.R. et. al. Diacytl Tartaric Acid Esters of Mono-
glycerides in Breadmaking, Bakers Digest 50(2):28
(1976)
- Hoseney, C.R. and Finney, P.L. Mixing a Contrary View,
Bakers Digest 48(1):22 (1974)
- Larmour, R.K. The Relation of Wheat Protein to Baking
Quality, Cereal Chem. 8:179-189 (1931)
- Sandstedt, R.M. and Ofelt, C.W. A Varietal Study of the
Relation between Protein Quality and Protein Content,
Cereal Chem. 17:714-725 (1940)

Shetlar, M.R. and Lyman, J.F. Effect of Bran on Bread-making, Cereal Chem. 25:295-303 (1944)

Shogren, M.D. et. al. Counteracting the Deleterious Effects of Fiber in Breadmaking, Cereal Chem. In Press

BREADMAKING POTENTIAL OF STRAIGHT GRADE AND WHOLE WHEAT
FLOURS USING VARIETIES HAVING CONTRASTING PHYSICAL DOUGH
PROPERTIES

by

GREGG J. MODER

B.S., University of Wisconsin, 1974

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Grain Science and Industry

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1981

The consumption of whole wheat and other variety breads in the U.S. is increasing at the expense of white pan bread. Triumph and Eagle wheat varieties were chosen to represent varieties with contrasting physical dough properties in an experiment designed to judge whether they had equal potentials in whole wheat breadmaking. Eagle-Plainsman blend and Triumph, hard red winter (HRW) wheat varieties that varied from strong to mellow in physical dough properties, were each milled to give a straight grade flour, bran, shorts, and red dog. We evaluated the potentials of the two wheat types to make bread from whole wheat flour, straight grade flour, and their blends. They were found to be equal in their ability to carry bran and shorts and make a whole wheat bread product.

In another phase of the study a fine granulated whole wheat was compared to a coarse granulated whole wheat. There was a significant but slight increase in volume with finer granulated whole wheat flours but the bread grain was improved substantially. Crumb colors were darker with the finer granulation bread crumbs, however.

Finally, we used taste panels to test whether a hard white winter (HWW) variety might be preferred in breadmaking to a HRW. The bran, shorts and red dog of a Newton (HWW) were reconstituted with the straight grade flours of Eagle-Plainsman blend and Triumph in a 75% whole wheat blend. The results of the taste test panel comparison, using both a triangle taste test and a preference test, showed that there was no strong preference for HWW type whole wheat bread products over HRW breads.