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# Low-Sugar Bread Formulations Using Alice, A Hard White Winter Wheat

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## ABSTRACT

Alice white wheat is a new cultivar of white wheat that has many desirable attributes for the baking industry. Its main appeal is the reduction in bittering compounds and pigments. White wheat is in demand in the booming Asian noodle market. The purpose of this study was to analyze rheological properties of white wheat flours using the Mixolab, a state of the art dough rheology instrument. Additional objectives included sensory testing of various reduced-sugar bread formulations and the determination of physico-chemical properties of flours and of bread made with them. Experimental baking using standardized methods revealed that sugar levels could be reduced by half and yet yield acceptable loaves of bread. This was possible owing to the reduced levels of phenolic compounds in white wheat. Such compounds mask the sweetness perception of breads made when hard red wheat is used. Acceptable loaves of bread were produced with Alice flour and Alice whole wheat flour as judged by evaluation of bread characteristics. Loaf height, crumb structure, crust color and other bread characteristics were also acceptable by objective and subjective standards.

## INTRODUCTION

Alice is a new variety of Hard White Winter wheat developed by wheat breeder Dr. Amir Ibrahim, South Dakota State University. This variety shows promise for use in bread baking and noodle production. It is named to honor Alice Wright, an Administrative Assistant for the South Dakota Wheat Commission. This new variety of wheat is derived from the cross 'Abilene'/'Karl' grains. It has the following desirable traits: white grain color, earliness, good bread baking qualities, good pre-harvest sprouting tolerance, and high yield in rain fed systems.

Hard red wheat is the primary choice for loaf breads in the United States. White wheat lacks certain pigments found in red wheat that are bitter tasting. Baked goods made with white wheat appear to exhibit enhanced sweetness. Sugar levels in recipes need to be adjusted to compensate for the lowered bitter tastes. Reduction of sugars may show a potential for lowered caloric content if bread-baking functionality is not adversely affected.

In testing a new economic class of wheat for bread baking qualities, it is necessary to address the quality factors of interest to the commercial baker. The quality factors involved in bread baking include water absorption, mixing time, dough characteristics,

fermentation tolerance, and physical appearance in the baked loaf (i.e., volume, crust color, and crumb). Use of the Mixolab provides information on the dough such as water absorption, dough stability, optimal mixing time, and tolerance to over-mixing.

A traditional test for the protein quality in a wheat variety is the measurement of a bread density or loaf volume to loaf weight ratio. Wheat contains gluten proteins, which contribute to the formation of the dough upon addition of water and physical manipulation. During the process of bread baking, the gluten matrix traps carbon dioxide produced by the yeast and allows the dough to expand. This expansion is translated into “oven spring” and measured as loaf height. Comparing the height to volume ratio against breads made with standard flours will give a good indication of protein quality.

The Mixolab is also able to determine protein quality by measuring the mixing tolerance. It is a tool that allows the analysis of the quality of the protein network, starch behavior, and enzyme activity of flours. In addition, the instrument measures and records the resistance of the dough to mixing in real time while at the same time monitoring bowl and dough temperature as well as mixing torque. The dough is manipulated between blades and mixing torque is monitored. The parameter is monitored through kneading and heating. Peak time is the optimal dough development time and mixing tolerance is the resistances of dough to breakdown during continued mixing (Wheat and Flour Testing Methods, 2004). Both parameters are functions monitored by the Mixolab. The instrument is thus a valuable tool for the determination of grain quality and prediction of baking functionality. Baking functionality in turn determines end products that can be produced. Protein content is a major nutritional constituent that dictates water absorption, texture, appearance, and gluten strength. Gluten is developed when flour is moistened and physically manipulated. The gluten imparts elasticity and extensibility characteristics to the dough. Weak gluten results in shortened peak times and less mixing tolerance than strong gluten flour. White wheat (7-10% protein) is one of five wheat classes which includes hard red spring wheat (11-18% protein) used for bread and blending; hard red winter wheat (10-15% protein) used in bread products; soft red wheat (8-12% protein) used in cakes, cookies, and crackers; and durum (11-16% protein) used in pasta products (D'Appolonia, 1987). Lower protein contents are good for tender products such as snack cakes, while higher protein content provides a chewy baked product like French breads (Wheat and Flour Testing Methods, 2004).

## **MATERIALS AND METHODS**

### *Experimental Baking*

A straight dough baking procedure was employed where all ingredients were mixed in one stage. Ingredients were added to the bread maker in the following order and amounts: distilled water (180 ml); vegetable oil (14.18 g); egg (50 g); salt (14.29g); sugar (28.5 g); Alice flour or Alice whole wheat flour (300 g), bread flour or all-purpose flour (270 g). The vegetable oil, eggs, sugar, bread flour and all-purpose flour were commercial products that were locally purchased. Alice wheat and Alice flour were acquired from the South Dakota Foundation Seed Stocks Division (Plant Science Department, South Dakota

State University, Brookings, SD). Alice whole-wheat was ground to produce whole-wheat flour using a laboratory mill (Retsch Centrifugal Mill, ZVM-1, 0.5 mm mesh). One pound loaves of bread were baked in a West Bend Bread Maker (The West Bend Company). Bread loaves were baked in duplicate for each treatment. The treatments were given the following labels: Alice Flour Standard Sugar (AFSS), Alice Flour Low Sugar (AFLS), Alice Whole-Wheat Flour Standard Sugar (AWSS), Alice Whole-Wheat Flour Low Sugar (AWLS), All-Purpose Flour Standard Sugar (APSS), and All-Purpose Low Sugar (APLS). A loaf using a standard sugar recipe and bread wheat flour was utilized as the control. Low sugar formulations and standard formulations employed one and two tablespoons of sugar, respectively.

### *Measuring Bread Height*

Bread loaf height was measured using a standard metric ruler and read at the loaf peak. Loaf volume did not need to be calculated since the cross-sectional area of all loaves was uniform and conformed to the dimensions of the same loaf pan used for all loaves. The use of the same bread machine and bread pan removed variability due to baking technique.

### *Sensory Tests*

A triangle test of difference was used panelists to discern sweetness differences. In this test three samples (two similar and one dissimilar) were administered to determine if panelists were able to pick out the odd sample. Preference tests were conducted to evaluate overall liking of breads. Samples were ranked by preference in the latter test.

### *Moisture Analysis*

The Moisture Air Oven Method (AACC 44-16) was followed for moisture content on each flour sample. Samples were dried for 1 hour at 130°C.

### *Protein Analysis*

Protein determination was completed using the CE Elantech Flash EA 1112 (ThermoFinnigan Italia S.p.A., Rodano, Italy) following the Dumas combustion method (AACC 46-30). Percent nitrogen was converted to percent protein using a factor of 5.7 specific for wheat flour ( $\% \text{ Protein} = \% \text{ Nitrogen} \times 5.7$ ).

### *Mixolab*

Dough rheology tests were done using manufacturer's instructions. Flour water absorption or optimal water needed to make the dough was determined from the mixolab curve. The Mixolab was programmed to simulate a mixing profile similar to the Farinograph (Brabender Instruments, New Jersey) for the first eight minutes of each sample run. Key pieces of data relevant to dough mixing requirements such as water requirement, dough mixing time, dough stability and mixing tolerance were derived from the Mixolab curves. Beyond 8 minutes the heating and cooling phases were designed to bring out the differences between flours under real world baking conditions. Such tests that exaggerate differences between flours serve to provide explanations for baking performance differences. Such differences are due to starch-protein interactions, enzyme

activity and other varietal and environmental factors. Five distinct phases have been identified by the manufacturers of the instrument. These will be discussed in a later section.

## RESULTS AND DISCUSSION

### *Bread Height*

The control (bread machine flour) produced loaves with the highest height (18.0 cm). AFSS produced a loaf slightly lower in height (17.1 cm). The reduced sugar loaves contributed to smaller loaves. AWLS loaf produced the smallest loaf height (12.8cm). This is likely due to the inclusion of the bran and germ. Alice flour produced a shorter loaf height when compared to the bread flour loaf. This is most likely due to a lower amount of protein in the Alice flour. Table 1 below shows the compilation of loaf heights.

Flour type	Loaf Height in centimeters	
	Standard	Half Sugar
Alice Flour	17.1 cm	15.3 cm
Alice Whole Wheat Flour	14.0 cm	12.8 cm
Bread Machine Flour	18.0 cm	--
All-Purpose Flour	15.0 cm	14.5 cm

**Table 1.** Bread loaf height

### *Sensory Tests*

A triangle test is a discriminating test that presents the sensory panelist with three coded samples. Two of the three samples are the same product; therefore it is the panelist's job to pick out the odd or dissimilar sample. In the triangle test between bread samples made from AFSS and AFLS, the panelists were unable to determine a difference in sweetness as only 12.5% of panelists correctly identified the different bread sample (Table 2). This is valuable as it illustrates that differences in sweetness is not perceived in bread made with Alice flour using one or two tablespoons of sugar in the formula. In a triangle test using bread samples made from AWSS and AWLS, the panel was once again unable to determine a difference in sweetness because only 25% of panelists correctly identified the different bread sample (Table 3). This test showed the same inability of panelists to discern the differences when regular and low sugar recipies were tested. A preference test allows the panelists to rank in order of most liked to least liked sample products. In a preference test between bread made with AFSS, AFLS, and bread machine flour, half of panelists preferred AFSS and half preferred bread machine flour equally (Table 4). Preference test panelists chose standard sugar bread when they were presented

with a choice. Alice flour and bread machine flour were equally liked by the sensory panelists. The sensory panel consisted of 3 males and 3 females with backgrounds in food science.

Code Number	Recipe	Number of times chosen
543	Standard Sugar	2
921	Standard Sugar	5
722	Low-Sugar	1

**Table 2.** Triangle Test results for Whole Alice Flour Bread

Code Number	Recipe	Number of times chosen
305	Standard Sugar	2
281	Low-Sugar	1
947	Low-Sugar	5

**Table 3.** Triangle Test Results for Alice Wheat Flour Bread

*Alice Flour vs. Bread Flour Preference Test Results*

Bread	Alice flour Standard Recipe	Alice flour Low Sugar	Bread flour Standard Recipe
Code Number	642	875	563
Most Preferred	4	0	4
Middle	4	1	3
Least Preferred	0	7	1

**Table 4.** Preference Test Results

*Moisture Content*

Alice flour was found to have the lowest moisture content (10.4%), although there was very little difference between the remaining flours (Alice whole wheat 11.3%; bread flour 11.7%, all-purpose 11.6%). The moisture content of the flour was necessary for the determination of total water requirements of the dough.

*Protein Analysis*

Commercial bread machine flour contained the highest amount of protein (16.9%). Alice flour and Alice whole wheat flour were closer in protein content at 15.0% and 15.7%, respectively. All-purpose flour had significantly lower protein content than the other flours at 14.1%.

Flour	Moisture Content %	Protein Content %
Alice Flour	10.4	15.0
Alice Whole Wheat Flour	11.3	15.7
Bread Machine Flour	11.6	16.9
All-Purpose Flour	11.6	14.1

**Table 5.** Moisture and protein content of wheat flours

### *Mixolab*

The key principle of the Mixolab is that it examines the characteristics of the rheological behavior (hydration capacity, development time, etc) of dough as a function of mixing and temperature. Torque produced when the dough is kneaded between specially designed mixing blades is measured in real time. Other parameters measured included protein reduction, enzymatic activity, gelatinization, and gelling of starch.



**Figure 1.** Chopin Mixolab

Figure 2 shows a Mixolab profile of several different flours. Arrows illustrate bowl temperature curve and dough temperature curve. Three flour curves are superimposed and color contrasted onto one graph allowing for easy comparison.

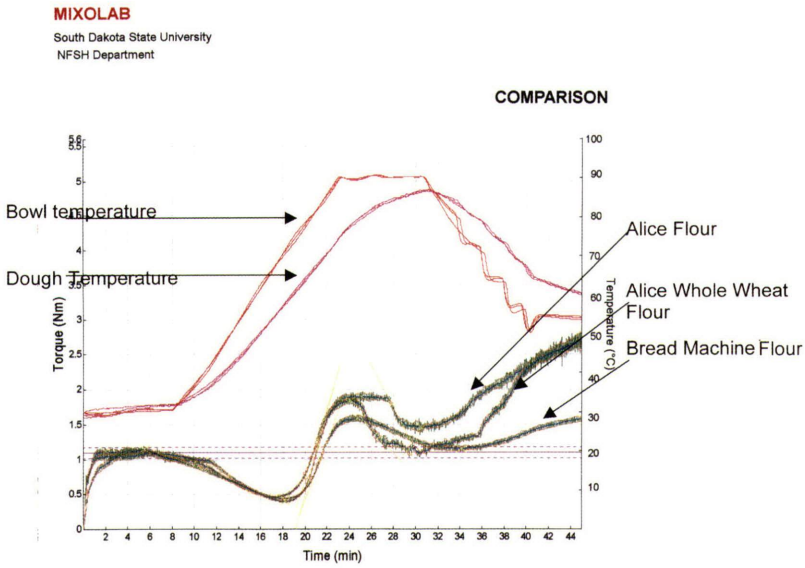


Figure 2. Mixolab Curve

**MIXOLAB**  
South Dakota State University  
NFSH Department

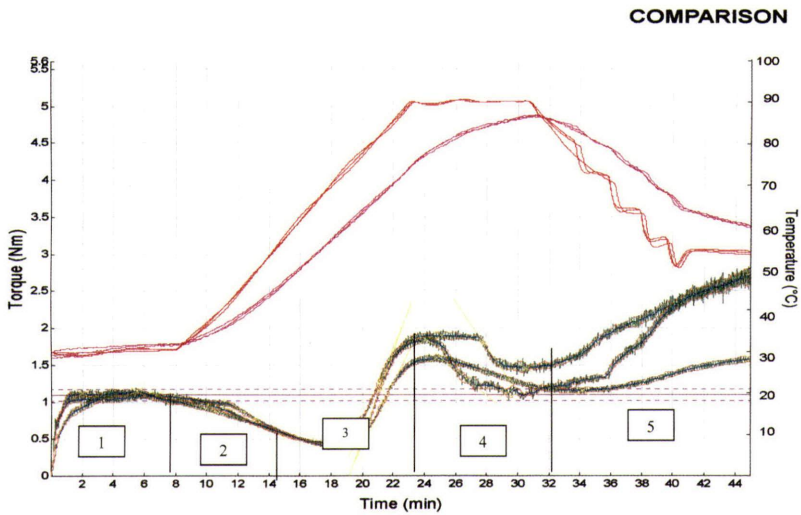


Figure 3. Breakdown of steps in Mixolab curve



Type of Flour	Alpha Nm/min	Beta Nm/min	Gamma Nm/min
Alice Flour	-0.04	0.514	-0.304
Alice Whole- Wheat Flour	-0.06	0.588	-0.172
Bread Flour	-0.132	0.424	-0.066

**Table 6.** Rheological Dough Comparison. Units are expressed as torque.

Information provided in Table 6 above shows that for protein reduction (alpha), bread flour had the greatest decrease in slope, indicating a higher protein quality when compared to Alice Flours. Based on starch gelatinization (beta) qualities, Alice Whole-Wheat had the greatest increase in slope indicating greater gelatinization and consistency in the starch. Analyzing amylasic activity (gamma) revealed that Alice Flour had the sharpest decrease in slope indicating greater amylasic activity. Implications of gamma values are the subject of basic research and will reveal additional functional traits that are yet to be exploited in wheat flour evaluation.

Bread machine flour had the highest water absorption (62.4%) followed by Alice Whole-Wheat (60%) and Alice Flour (57.8%). Higher amounts of protein in flour result in increased water absorbance and higher moisture requirements in the dough. Water is a relatively inexpensive ingredient that is maximized in bread formulations.

Mixolab results were presented in the form of a graph that provides five important pieces of information. Figure 3 provides a visual image identifying the various phases.

- 1.) Development: water absorption capacities are determined and dough mixing characteristics are measured
- 2.) Protein reduction (alpha): As dough temperature increases, consistency decreases; protein quality is determined by the intensity of the decrease of consistency.
- 3.) Starch gelatinization (beta): In this phase gelatinization becomes dominant and an increase in consistency is observed
- 4.) Amylasic activity (gamma): The value at the end of the plateau depends on the endogenous activity; a decrease in consistency represents a greater amylasic activity
- 5.) Starch gelling: At this stage, cooling starch retreats and increases product consistency. (Chopin Mixolab Manual 4/2005)

## CONCLUSION

Alice white wheat is a new wheat variety of white wheat that has many desirable characteristics such as white grain color, earliness, decreased quantity of bittering compounds, and good baking functionalities. One major appeal of this grain is the reduced quantities of sugar that can be used in bread loaf formulation, thus resulting in a lower calorie and carbohydrate-containing product. This would be ideal for individuals who require dietary reduction of sugar.

Sensory analysis panelists were unable to discern differences in sweetness between breads made with Alice wheat and other wheat flour when sugar was cut back in the formulation. Sugar levels did contribute to greater expansion of loaves made with

standard sugar (even Alice flour) in the formula than those with reduced sugar. This aesthetic difference in loaves and bread slices appears to have influenced panelists who ranked their preference for the various breads.

Objective and subjective evaluation of bread made from standard sugar and reduced sugar formulas revealed that bread produced with Alice flour has many desirable baking attributes as judged by crumb structure, crust color, loaf volume, oven rise, symmetry and internal texture.

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**Variety "Expedition"**  
**Hard Red Winter Wheat**



**Variety "Alice"**  
**Hard White Winter Wheat**