

Statistics to Improve the Taste of Bread Dough

By Jerry Fireman

Nearly all frozen bread dough products use chemicals such as oxidizers, emulsifiers and reducing agents to maintain strength after being frozen, thawed and baked. A few frozen bread doughs have been introduced with all natural ingredients but they have not been successful because consumers were not happy with the quality of the product. They also suffered from short frozen shelf life. Rich Products set out to develop an all-natural bread dough that would meet the same quality and taste standards as the company's popular conventional bread doughs. The company identified a number of possible natural ingredients and then faced the difficult task of optimizing the amount of each of these ingredients in order to meet specified requirements for flavor, appearance, softness, etc.

Conventional one-factor-at-a-time (OFAT) experimental methods were not used because they would have taken an enormous amount of time. New optimal values would have had to be found for each variable whenever another variable that interacted with it was changed. Instead Sachin Bhatia, Research and Development Scientist for Rich Products Corporation, used design of experiments (DOE) to simultaneously optimize the values of all factors. This statistical method helped Rich Products identify four different recipes that best met the company's requirements. Bhatia tested each one before picking the best recipe for the final product. The result is far superior to previous natural bread doughs and will soon be introduced to the market.

Challenge of developing natural bread dough

Rich Products Corporation (also known as Rich's) is a privately-held international food products corporation headquartered in Buffalo, New York. Rich's initial products were non-dairy whipped topping, creamer, cake icing and cooking cream. The company now also has product lines in the bakery, frozen seafood, frozen appetizers, snacks and breakfast areas. Rich Products faced a major challenge in extending its popular bread dough line with an all-natural product.

"A number of food companies have tried to replace chemicals with natural ingredients," Bhatia said. "They have generally used a trial-and-error approach based on experience and instinct to develop their recipes. These recipes are tested by freezing, thawing and baking them and then performing a taste test on the resulting samples. Up until now these products have not met with considerable success. Most importantly, the taste of previous natural bread dough products has not appealed to consumers. In addition, the cell structure has been too open. For example, white or wheat breads made with earlier natural bread dough have sometimes had the open cell structure normally associated with French bread. Lastly, the shelf life of these products has been short."

DOE streamlines design process

Bhatia felt that the development methods used contributed to the lack of success with the earlier products. The amount of time required to make and test each recipe meant that there is typically only enough time to test a relatively small number out of the huge universe of possible formulations. He felt that it might be possible to create a substantially better product by using a more scientific approach to fully explore the recipe space and optimize the formulation.

“DOE drastically reduces the number of runs required to determine the optimal value of each factor by varying the values of all factors in parallel,” said Mark Anderson, Principle and General Manager of Stat-Ease Inc., a major developer of DOE software. “This approach determines not just the main effects of each factor but also the interactions between the factors. As a result, DOE makes it possible to identify the optimal values for all factors with far fewer experimental runs than the traditional one-factor-at-a-time (OFAT) approach.”

“I used Design-Expert® software from Stat-Ease to design an experiment to optimize the natural bread dough recipe,” Bhatia said. “I originally selected the software because it is designed for use by subject matter experts who are not necessarily experts in statistical methods. The software walks users through the process of designing and running the experiment and evaluating the results.” Bhatia selected the D-optimal design because it provides the minimal number of blends ideally formulated to fit a given predictive model. He picked four different natural ingredients to include in the formulation of the new bread dough. The minimum value of each ingredient was set at zero so that the experiment could explore the option of removing each ingredient from the recipe. Bhatia selected a quadratic model which includes the non-linear blending terms for detection of component combinations that may be significantly antagonistic (detrimental) or synergistic (beneficial).

The factors and levels for the experiment were:

- A) Ingredient A, 0 to 2
- B) Ingredient B, 0 to 4
- C) Ingredient C, 0 to 0.04
- D) Ingredient D, 0 to 2

The unit for each factor is flour percent or Baker’s percent which measures the weight of the ingredient relative to the total weight of the flour. The total of the level of the factors was fixed at 4.

“One of the nice things offered by Stat-Ease is a consulting service in which they assist with designing the experiment and interpreting the results,” Bhatia said. “Since this was one of my first DOE projects, I decided to take advantage of this service. The design space looked unusual to me because the enzymes are used at very low concentrations in the parts per million range. They looked over the design and confirmed that although the design space looked narrow everything was correct.”

Bhatia asked the lab to produce all of the samples in a single day in order to reduce variability. Each sample was evaluated based on 10 different responses. Four of the responses were objective:

- 1) Volume
- 2) Length
- 3) Height of the bread after baking
- 4) Width of the bread after baking.

The other responses were subjectively evaluated by a panel of taste testers:

- 5) Overall likeability
- 6) Crust flavor
- 7) Crumb flavor
- 8) Softness
- 9) Cell size
- 10) Crumb density

Bhatia entered the responses into Design-Expert and the software generated a series of statistical analyses.

Optimizing the bread dough recipe

Bhatia used the analysis of variance (ANOVA) results to verify the significance and accuracy of the model. The normal plot of residuals showed a high level of correlation between each of the data points, indicating that the results were internally consistent. Bhatia then developed a desirability function that provided weights and constraints for the responses, which he used to optimize the factors. The predicted response values for a most desirable formulation is shown in Figure 1. It depicts settings and resulting predictions in the form of number lines superimposed on desirability scales—the higher the better. For example, overall liking achieves a highly desirable outcome. A 3D rendering of the desirable region is shown in Figure 2.

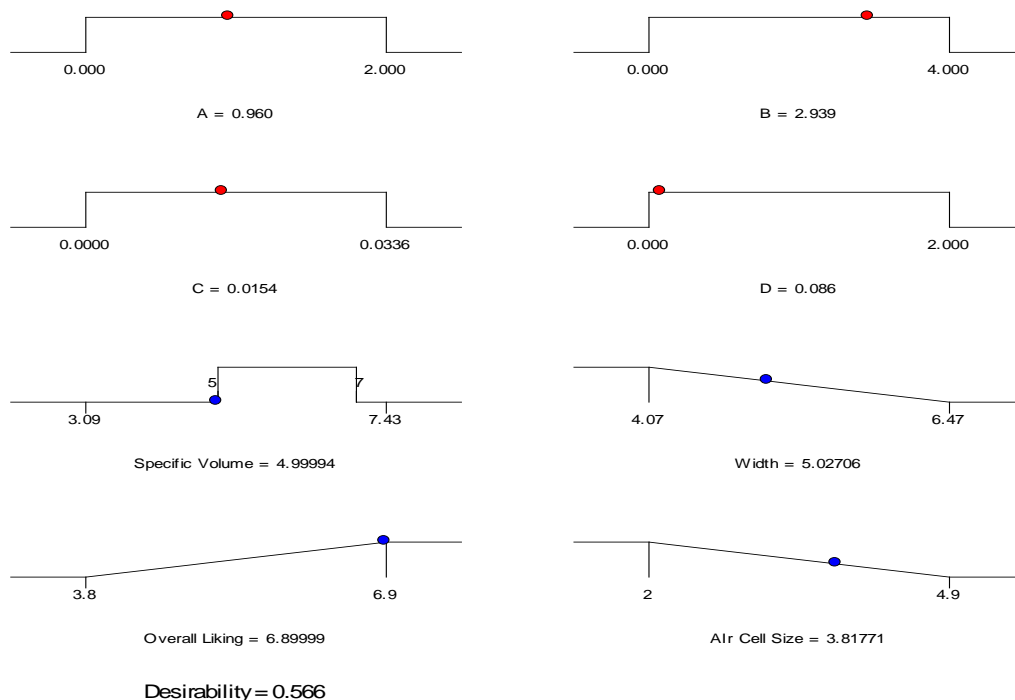


Figure 1: Predicted responses for one of the desirable formulations

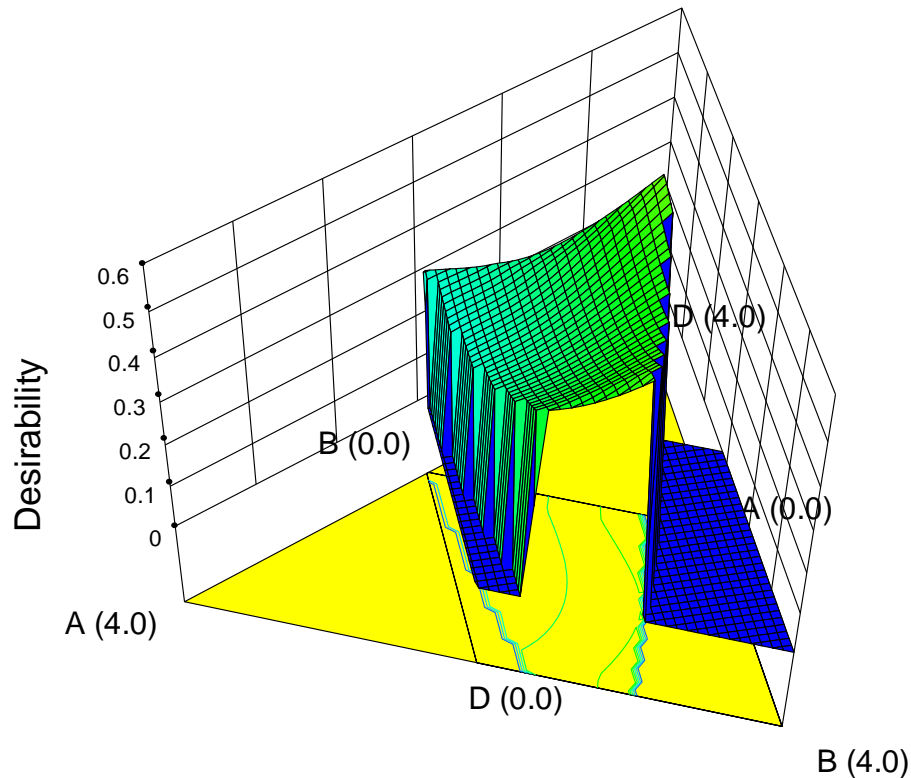


Figure 2: 3D rendering from the region found to be desirable

“I examined other desirable formulations to evaluate their distinctness and robustness as well as their overall likeability, which is the most important response,” Bhatia said. I eliminated several because they were very close in the recipe space to other formulations that had higher overall likeability. I also evaluated the robustness of the recommended formulations in order to account for manufacturing variability. I ordered samples of four selected recipes and did a followup sensory testing. Two of these samples scored very highly. I then tested both of these formulations in the manufacturing process. Based on manufacturability and cost, one of these recipes was selected and it forms the basis of our new line of bread doughs. Our new natural bread dough will hit the market soon and is far superior to any other natural bread dough in terms of taste and shelf life.”

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