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Workshop Schedule

Experiment Design Made Easy (EDME)
February 12-13, 2013: Minneapolis, MN*
March 11-12, 2013: San Diego, CA*
April 23-24, 2013: Minneapolis, MN
$1295 ($1095 each, 3 or more)

Response Surface Methods for Process Optimization (RSM)
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Mixture Design for Optimal Formulations (MIX)
February 14-15, 2013: Minneapolis, MN*
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May 7-8, 2013: Minneapolis, MN*
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May 9-10, 2013: Minneapolis, MN*
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PreDOE: Basic Statistics for Experimenters Online Course
Free (a $95 value). Learn more at: http://www.statease.com/clas_pre.html.

*Attend the EDME/RSM, EDME/MIX, or MIX/MIX2 workshops in the same week and save $395 on tuition!

Workshops limited to 16. Multiclass discounts are available. Contact Elicia Bechard at 612.746.2038 or workshops@statease.com.

Food Scientists Drink in a Cool Aid for Formulating Beverages: Mixture Design

Mark Anderson, Principal

For some years now I've been presenting a pro-bono webinar on mixture design for optimal formulation to North Carolina State University (NCSU) students of food-science professor Tyre Lanier. My talk ties in to a laboratory exercise Tyre runs to develop an artificial orange drink. The goal of this NCSU lab is to match these sensory attributes on a control—a commercially-available orange drink*:

Y1. Orangeness
Y2. Acidity
Y3. Sweetness
Y4. Intensity

The students scored their tastings on a 1 to 9 scale where 5 represented no difference between the experimental blend and the standard.

The components (ranges shown in milliliters) they varied were:

A. Flavor (5-25)
B. Citric (5-25)
C. Sucrose (200-400)
D. Water (remainder needed to 'top off' the mixing vessel at 500 ml total)

Entering these parameters into the optimal design-builder under the Mixture tab of Design-Expert® software produces by default a 20-blend, robust (including 5 lack-of-fit and 5 replicate points) experiment for fitting a second-order (quadratic) model (Scheffé polynomial). However, due to time constraints in class, Tyre opts for a 16-blend optimal design that provides only one replicated run. That's OK—as shown in Figure 1, this experiment gets the job done.

As you can see, the NCSU food-science students tasted their way to an orange drink that perfectly matched the sensory profile of the standard.

That's a great start, but I threw in another challenge—see if the cost can be reduced by using less of the most-expensive ingredient (by far)—the artificial flavor. Figure 2 shows the result of adding this goal.

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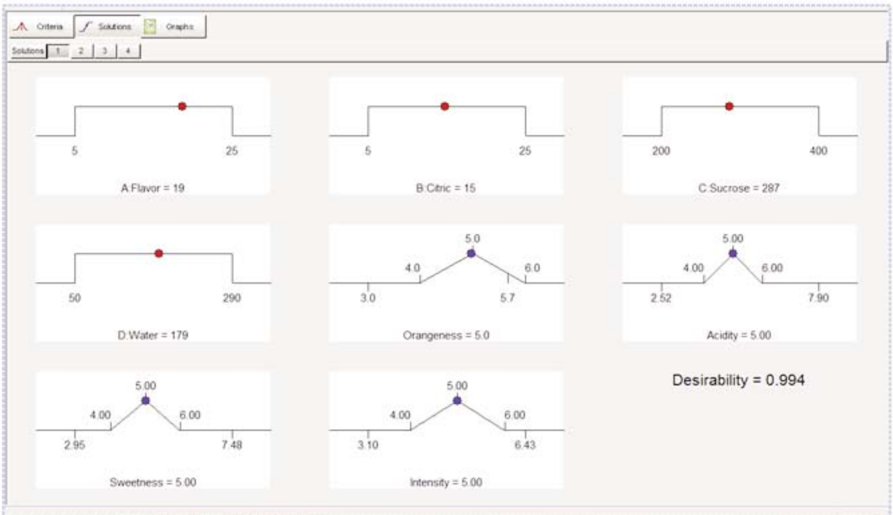

Figure 1: Most desirable results—a great match!

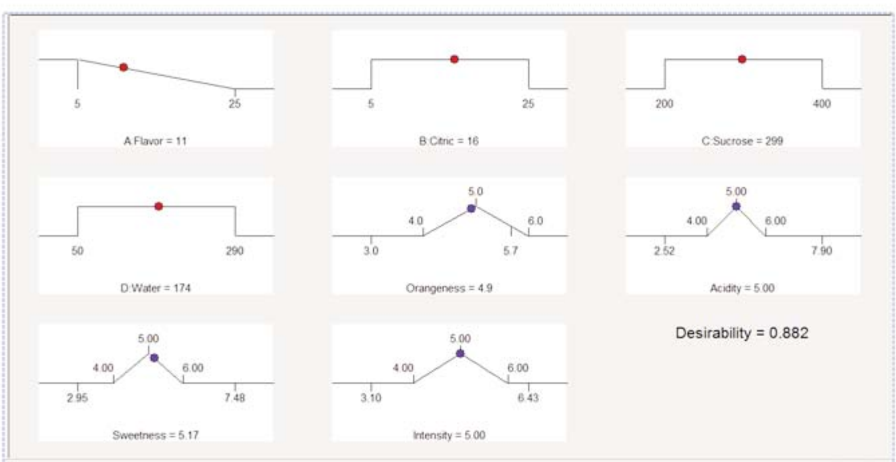

Figure 2: Reducing cost by minimizing the amount of flavor

Figure 3: Flavored orange drink

It turns out that a bit more citric and more sugar fools the palate for the most part. The match is not quite as precise, but perhaps this is a good trade-off for saving an estimated 20% off the original (high-flavor content) cost of ingredients.

That tells the main story. However, I discovered something else by including the standard deviation of the sensory ratings: As citric is increased, the results vary more and more on the perception of orangeness and overall flavor intensity. Thus if I were fiddling with this formulation, I would be a bit wary of cheapening it in this fashion—it could backfire due to some individuals not being fooled by the substitution of citric and sugar for the orange flavor. (See an example of an orange drink in Figure 3 above).

By the way, Tyre told me a trick of the trade that might make this whole cost-reduction thing work. He said all you have to do is add more orange color. These food scientists are sneaky! ;)

–Mark Anderson, mark@statease.com

*I do not know the brand they used but my ideal would be a staple from my youth called Tang. I liked it because that's what astronauts drank, at least John Glenn did.

PS. Stat-Ease now offers a specialized workshop on "Designed Experiments for Food Science." For more information, visit our web site at http://www.statease.com/clas_defsci.html. If you would like to bring this high-powered know-how into your enterprise via a private class, contact Elicia via workshops@statease.com.

Confirming the Optimal Ramen

In the last issue of the Stat-Teaser (Sept 2012), we presented the cure to the recession blues: a great tasting (by some accounts ☺) ramen noodle recipe. We found the optimal ramen noodle specifications as shown for the following four factors:

A. Water Amt (g)
B. Cooking Time (s)
C. Brand
D. Flavor

The optimum overall average taste was found at settings of 367 g of water and 250 seconds in the microwave. The chicken flavoring fared best with an "unnamed brand". As both brands were acceptable and competition will keep the price down for consumers of this economical food, we'll just let you choose your own favorite.

This optimum was found using the Numerical optimization tool in Design-Expert® software. We simply set the goal to Maximize the average taste. Once an optimum is found, it's important to confirm these results by performing a confirmation run (or runs). There is a great new tool in Design-Expert for exactly this purpose: the confirmation node.

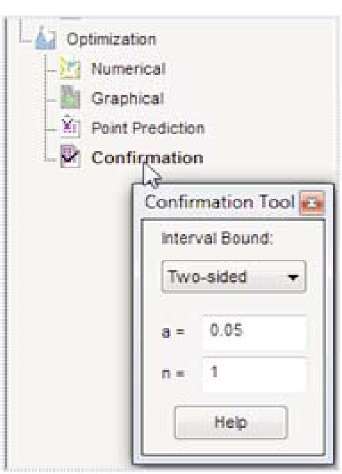

Figure 1: Confirmation Tool

Response	Prediction	95% PI low	95% PI high	Conf. Run Avg.
Noodle Weight Gained (%)	174.0	137.2	210.9	160.2
Avg. Taste	8.0	6.5	9.6	8.2
Avg. Crunchiness	4.0	2.2	5.8	4.0

Table 1: Results for confirmation

To confirm the model, you run an experiment at the optimum settings and then see if the results you get match what is predicted by the model. Design-Expert not only provides a point prediction, but it also gives you a statistical interval around that prediction to temper your expectations. After all, any good engineer knows that results vary every time a given setup is run.

The Confirmation node in Design-Expert calculates the correct interval for you to work within. If you've already run a Numerical optimization, your solutions will be pre-loaded. On the Confirmation Tool (Figure 1), you enter the number of confirmation runs you want to perform (we used n=3). The prediction interval that is reported is then adjusted to account for this number of confirmation runs.

Table 1 above shows the reported point prediction and prediction interval (PI) for the three confirmation runs we ran subsequent to our experiment. The average results were 160.2% for noodle weight gained, 8.2 for average taste, and 4.0 for average crunchiness. I added a column with these results to Table 1 for easy comparison. As you can see, the results fit well within the prediction intervals given by the confirmation node. Success!

It is interesting to note that the most quantitative response (noodle weight gained), was the farthest from the prediction. It was still close, but the Avg. Taste and Avg. Crunchiness ratings (which are subject to human estimation) actually hit the mark almost exactly. This may lead some to believe that the taste testers were biased, knowing that they were rating optimal tasting runs. Actually, we had a plan to prevent this from happening.

Knowing the potential for bias in the ratings, we couldn't just do the confirmation runs at the optimal settings. To keep the tasters honest, we randomly interspersed other points which produced bad- or mediocre-tasting ramen noodles. We actually completed seven confirmation runs, with only three at the optimum. The average of those three runs is what is presented in Table 1 above.

Even though we made sure to keep the tasters honest, they did a great job of hitting the predicted ratings. This can be attributed to the fact that we had 4 different tasters and averaged the results. We also had a defined rating scale which everyone had agreed on and tried out, and a strong predictive model. Having confirmed our model, we now can rest assured that even though we may decide to eat cheaply, we'll at least be eating the most optimal ramen noodles that money can buy.

–Brooks Henderson, brooks@statease.com

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