STATeaser

ABOUT STAT-EASE® SOFTWARE, TRAINING, & CONSULTING FOR DOE

Workshop Schedule

Experiment Design Made Easy
February 1-2, 2011: Minneapolis, MN
March 7-8, 2011: San Diego, CA
May 11-12, 2011: Minneapolis, MN
$1295 ($1095 each, 3 or more)

Response Surface Methods for Process Optimization
February 3-4, 2011: Minneapolis, MN
$1295 ($1095 each, 3 or more)

Mixture Design for Optimal Formulations
February 15-16, 2011: Minneapolis, MN
April 12-13, 2011: Minneapolis, MN
$1295 ($1095 each, 3 or more)

Advanced Formulations: Combining Mixture & Process
February 17-18, 2011: Minneapolis, MN
$1495 ($1195 each, 3 or more)

Designed Experiments for Life Sciences
March 2-3, 2011: Minneapolis, MN
$1495 ($1195 each, 3 or more)

Basic Statistics for DOE
March 1, 2011: Minneapolis, MN
May 10, 2011: Minneapolis, MN
$595 ($495 each, 3 or more)

PreDOE: Basic Statistics for Experimenters (Web-Based)
Go back to the basics of statistics. See www.statease.com/clas_pre.html for more information. FREE (a $95 value)

Free Webinar: DOE Made Easy & Powerful via DX8 Part III —Multicomponent Mixture Design
Wednesday, January 27 at 10:30 AM
See www.statease.com/webinar.html.

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

Stat-Ease® statistics made easy®

Tumbler Rumbles with a Mugger

"Keeps Hot Drinks Hotter & Cold Drinks Colder Longer" is the claim by Tervis Tumblers (www.tervis.com) for their insulated drinkware. My son Hank, a programmer at Stat-Ease, decided to put this to the test with a tumbler I bought for him at the Tervis factory in Florida.

The Tervis Tumbler

While writing code, Hank likes to sip on hot tea, so that became the fluid of interest for a study on the heat-transfer from the double-insulated plastic container made by Tervis. Via a randomized experimental plan with 4 runs each, he compared its ability to keep hot drinks hot versus a ceramic mug (uninsulated). Using a digital thermometer good to about half a degree, Hank measured tea temperatures over a period of 25 minutes after bringing it to a boil. He noted the ambient conditions, which did not change much over the course of the experiment. You can see this and all the results in Table 1 below.

Focus your attention on the last column in the table: Do you see how much hotter the tea remained in the Tervis Tumbler? It's really obvious in the effects graph produced by Design-Expert® software (Figure 1 on page 2).

However, even more interesting is how at time zero (T0) the tea in the ceramic mug immediately cooled markedly relative to the Tervis Tumbler. Tervis makes their containers out of polycarbonate—a material that's far less dense than ceramic. Thus the ceramic mug exhibits far greater thermal inertia, that is, it takes a lot more heating just to

Run	Comments	Container	T0 deg f	T5 deg f	T10 deg f	T15 deg f	T20 deg f
1	29% H, 70.1 F	Ceramic	183.5	158.5	145	135	127
2	33% H, 69.6 F	Tervis	190.5	168.5	153.5	142.5	135
3	30% H, 71.7 F	Tervis	194	167.5	154	144	135.5
4	30% H, 70.1 F	Ceramic	184	158.5	146	135	127.5
5	32% H, 70.5 F	Tervis	197	171	155.5	145	136
6	34% H, 68.1 F	Ceramic	183.5	157.5	145.5	135	127
7	33% H, 68.3 F	Ceramic	183.5	162	146	135	127
8	33% H, 68.1 F	Tervis	198	168.5	154	143.5	135

Table 1: Temperatures in deg F at various time intervals (0 to 25 minutes)

—Continued on page 2

—*Continued from page 1*

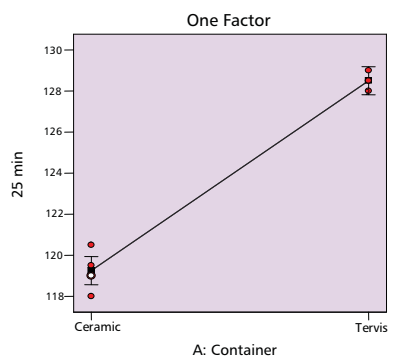

Fig. 1: Effects plot for temperature of hot tea after 25 minutes

bring it up from room temperature.

Stat-Ease Consultant Pat Whitcomb saw this also and reworked the results along the lines of time as shown in Figure 2 to the right. This shows that the ceramic mug immediately falls behind on temperature and never catches up with the Tervis Tumbler.

I'm happy with the results because the longer Hank sips at his tea the more he codes—good for Stat-Ease! In regard to this experience designing, conducting and analyzing an experiment, he said this:

"It was kind of a juggling act trying to get the water into the mug, measure it, and make a pot of tea at the same time—lots of room for error. I was really surprised at the consistency of the later readings. If I did it again I think I would use an immersion heater instead of boiling the water and then pouring it into the mug. Also, measuring the drastic difference in temperature on the surface of the mugs would be interesting. The Tervis Tumbler I can pick up by cupping my hand around it, which would probably burn my palm on the ceramic."

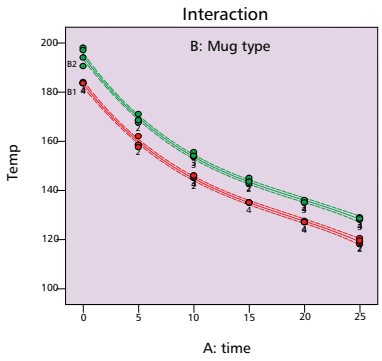

Fig. 2: Cooling profile for tea in Tervis Tumbler (green) vs ceramic mug (red)

—Mark Anderson, Principal
mark@statease.com

What is Mixture Design and What's In It for You?

A "teaser" for mixtures by Mark Anderson.

Perhaps you work with formulators who have not yet seen the light of DOE. They may be colleagues, suppliers or clients of yours. For their benefit, I've written (with help from Pat Whitcomb) a WIIFM, that is "what's in it for me," to encourage them to work through the more intense aspects of mixture design, response modeling, statistical analysis and numerical optimization. I call it "*A Primer on Mixture Design: What's In It for Formulators?*" Feel free to download this primer from www.statease.com/pubs/MIXprimer.pdf.

Here is the introduction:

"It's natural to think of mixtures as liquids, such as the composition of chemicals a pool owner must monitor carefully to keep it sanitary. However, mixtures can be solids too, such as cement or pharmaceutical excipients—substances that bind active ingredients into pills. The following two definitions of mixtures leave the form of matter open:

- 'Mixtures are combinations of ingredients (components) that together produce an end product having one or more properties of interest.'

—John Cornell & Greg Piepel (2008)

- 'What makes a mixture?

1. The factors are ingredients of a mixture.
2. The response is a function of proportions, not amounts.

Given these two conditions, fixing the total (an equality constraint) facilitates modeling of the response as a function of component proportions.'

—Pat Whitcomb (2009)

The first definition by Cornell and Piepel provides a practical focus on products and the interest that formulators will naturally develop for certain properties of their mixture (as demanded by their clients!). However, the second specification for a mixture provides more concise conditions that provide a better operational definition. Pat suggests that formulators ask themselves an easy question: 'If I double everything, will I get a different result?' If the answer is no, such as it would be for a sip of sangria from the glass versus the carafe, for example (strictly for the purpose of tasting!), then mixture design will be the best approach to experimentation."

Myopia on mixtures—some myth-busters

Here are several excuses often heard from formulators who only know factorial design and thus avoid applying tools more suited for mixtures. (We call this the "new hammer syndrome," that is, when one gets a new hammer, every-

—*Continued from page 2*

thing looks like a nail.)

1. Not putting all the ingredients into the same units of measure.*
2. Ignoring the impact of relative proportions.
3. Exempting components present only in tiny amounts.

To debunk these myths, let's consider two thought-experiments on a shamrock-shaped cupcake for St. Patrick's Day. The recipe starts with a mixture composed of 1 cup of flour, 1 jumbo egg, 1 stick of butter and 1 pound of sugar. Then, to provide color, we add a blend of two food dyes—yellow and blue.

In experiment 1 the four components are varied from 0.5 to 1.5 units of measure in a two-level full-factorial experiment with 16 runs (2^4). The responses are taste, texture and overall liking on a nine-point sensory scale. This seems promising until you consider that the two most extreme experimental combinations for making cupcakes are:
– – – – ½ cup flour, ½ an egg, ½ a stick of butter and ½ pound sugar
+ + + + 1½ cup flour, 1½ an egg, 1½ a stick of butter and 1½ pound sugar

All this does is scale up the recipe! The relative proportions remain the same. Here's what FineCooking.com expert Shirley Corriher says in her web-posting *For Great Cakes, Get the Ratios Right*: "Experienced cake bakers would never dream of trying to bake a cake without first 'doing the math' to make sure that the ingredients are in balance. Having the right proportions of flour, eggs, sugar, and fat makes all the difference."

The other thing a good baker or cook will do is weigh out the ingredients. Then the ratios can be computed precisely, for example for the eggs and butter, which Corriher recommends be kept in equal proportion. (She says that the contents of a large egg weigh 3.5 ounces, but why not measure this on a kitchen scale?)

Having done all this, one can then make use of mixture design and possibly produce a result like the following one extracted from the "*A Primer on Mixture Design*" (Figure 1).

The second thought experiment on the cupcakes involves the coloring. This involves two dyes—yellow and blue. With St. Patrick's Day coming up, we're hoping for a nice kelly-green. Knowing only how to do a two-level factorial, we try a range of 1 to 2 drops for each dye (more than enough to achieve color saturation) and run all 4 combinations (2^2—4 combinations of 2 dyes at 2 levels each). By now the message of proportions is at least received, if not understood completely, but our excuse for ignoring this is that for such a tiny amount of material in the mixture, this can be overlooked. The fallacy here is that the amounts are miniscule due to the tremendous potency of these ingredients. As you may have discovered as a child playing with stuff in your kitchen, a little bit of dye goes a long way! In any case, the same issues of proportionality come into play, as you can easily understand, when considering these two extreme combinations in the two-level factorial design:
– – 1 drop yellow, 1 drop blue
+ + 2 drops yellow, 2 drops blue

Both these combinations make essentially the same kelly green. Any differences cannot be detected by the naked eye,** so why waste time doing it twice?

I hope this provides food for thought to those of you who formulate mixtures. Instead of choosing a two-level factorial design, consider applying a mixture design. It's easy to set up with Design-Expert software. If there is a sweet spot, you will find it very quickly with your mixture experiment, presuming it produces results that are statistically significant.

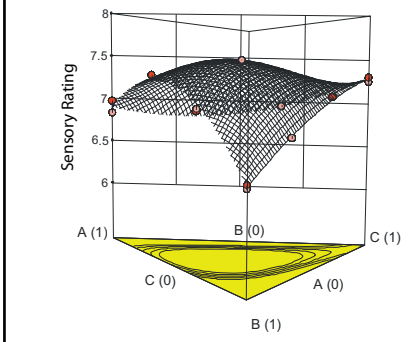

Fig. 1: Example of a response surface from a 4-component mixture design

*A traditional way to lay out a scaleable recipe is laying it out in terms of parts, for example, 100 parts of the main ingredient, plus 20 parts one additive and 10 parts of another. Although this does provide common units of measure, it is not a good basis for a mixture experiment. To see why parts are perilous, view the slides from a Stat-Ease webinar providing "An Introduction to Mixture Design for Optimal Formulations" which we've posted at www.statease.com/webinar.html.

**If amount does matter, then choose a mixture-numeric design from the "Combined" tab in Design-Expert. We cover mixture-amount experiments in our two-day workshop on Mixture Design for Optimal Formulations.

▪ *Note: Mark is doing an encore webinar on Design-Expert 8 features for mixtures in early 2011. Contact karen@statease.com for details and to signup.*

▪ *Check out the new "Advanced Formulations (MIX2)" workshop—next offered on February 17-18, 2011—The prerequisite is "Mixture Design for Optimal Formulations (MIX)" on February 15-16.*

Stat-Ease, Inc.
phone: 612.378.9449, fax: 612.746.2069
e-mail: info@statease.com, www.statease.com

Newsletter Preferences

12/10

Thank you for reading the Stat-Teaser newsletter. In the interest of helping the environment and to make sure we only send the newsletter to those people who are interested, we request that you take a moment to let us know your subscription preferences. Please indicate below whether or not you would like to keep receiving the *Stat-Teaser* newsletter by mail. If you would prefer instead to receive an e-mail, link to it via Mark Anderson's monthly e-mail newsletter, the *DOE FAQ Alert* (www.statease.com/doealert.html). Please check the appropriate box below.

Be sure to include this whole page, with your address and any changes, when you fax (612.746.2069) or mail us your response. If you prefer to e-mail your preference to marketing@statease.com, please include your full name, address, and the client code you'll find in the upper right corner of the address field. Thank you for your interest and your help!

☐ Keep me on the *Stat-Teaser* newsletter mailing list.

☐ Keep me on the *Stat-Teaser* newsletter mailing list. **In addition**, sign me up for Mark Anderson's monthly e-mail newsletter, the *DOE FAQ Alert*. My e-mail address is _____.

☐ Take me off the *Stat-Teaser* newsletter mailing list. **Instead**, send me an e-mail link to the *Stat-Teaser* via Mark Anderson's monthly e-mail newsletter, the *DOE FAQ Alert*. My e-mail address is _____.

☐ Please remove me from the *Stat-Teaser* newsletter mailing list.

☐ Please remove me from your database completely.

Address Service Requested

Stat-Ease, Inc., Hennepin Square
Suite 480, 2021 E. Hennepin Ave.
Minneapolis, MN 55413-2726

Stat-Ease®
statistics made easy®

Presorted
Standard
U.S. POSTAGE PAID
Minneapolis, MN
Permit No. 28684