The Company's Best Yogurt: The Importance of Statistics in Food Product Development

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Part I – Quality Attribute Selection

It was Monday morning and Andrew was looking forward to another week of research. He had recently been hired into the research and development department at *DairyWow!*, a large dairy company that produced many dairy products. *DairyWow!* prided themselves on producing high-quality value-added products that appealed to health-conscious consumers who still wanted that indulgent feeling in their product. Andrew was currently working on improving a low-fat Greek-style yogurt formulation, trying to give it the sensory qualities of a higher-fat yogurt.

Andrew spotted his coworker, Becca, in the lab, sighed, and decided to get a cup of coffee before heading into the lab. "She's probably been here an hour already," he thought. Becca typically came in early, left late, and always seemed to be busy with at least three projects.

"Andrew, have you taken a look at the yogurt survey data that Marketing just sent us?" Becca called out, having spotted him heading to the coffee machine.

"No, I just got in and haven't checked my e-mail yet," said Andrew, pouring coffee into his cup. "What did they say about what our ladies want?"

"They said our *target market* wants a smooth, thick yogurt that doesn't have an overly sweet taste," said Becca. "They also want fruit flavors like strawberry and blueberry."

"Well, that's not surprising, considering that's pretty much what every consumer of yogurt ever wants," mused Andrew. "Except maybe for my sister: she's crazy about plain Greek yogurt with about a case of Splenda dumped in. Hates fruit yogurt, though."

"Our target market is also interested in sustainability, prefers a clean label, and doesn't like excessive packaging," continued Becca, apparently deciding to ignore Andrew's comments. "So we need to figure out how to give our target market what they want."

"But do they really want *all* that?" asked Andrew. "I mean, how many people actually want everything they check in those little boxes on the survey and how many of them just think it sounds good to say that? I bet you'd get a lot of different results if you just asked someone what good yogurt tasted like without providing all of the options like packaging and sustainability."

"Andrew, has it occurred to you that women between the ages of 25 and 50 who quite possibly have children don't think like a 23-year-old male right out of college?" Becca asked tartly. "Besides, the people in marketing know what they're doing with these surveys. How many successful products have we launched in the last year?"

"At least half a dozen…okay, fine," said Andrew. "We still can't work on all of this though. Like the sustainability thing. How are the two of us supposed to make the entire company sustainable?"

"We can make a *product* that's sustainable by selecting ingredients from suppliers who are concerned with sustainability. And we can limit the amount of material we use in our trial formulations. We don't have to make a huge vat of yogurt to test one formulation," Becca replied.

"Okay, but I still think some of these things that our ladies want are more important than others. How are we going to decide what we're going to work on?" Andrew asked. "We only have a month or so to come up with a good low-fat yogurt formulation. We just don't have time to fiddle with every tiny detail."

Questions

1. Consumers often have one or two quality attributes that they think are most important, regardless of how many attributes they list as important on a marketing survey. Discuss the attributes listed by the consumers in terms of their relative importance. Think about current food trends as well. Are there any attributes that you think would be more or less important to the target consumers? Why?

2. Based on your answer to Question 1, what quality attributes could Becca and Andrew investigate as product R&D team members?

3. Pick one quality attribute that Becca and Andrew could investigate and discuss how they could investigate the impact of different formulations on that attribute. What tests would they run to see if the formulation changes made a noticeable difference to the target market?

Part II – Experimental Design

"So here's the plan," Andrew said to Becca, ready to end the seemingly endless discussion about what was and was not important about Greek-style yogurt eaten by women between the ages of 25 and 50. "You work on yogurt thickness and I'll work on how much sugar should go into it."

"What about the interaction between sugar and thickness?" asked Becca. "Don't you think there will be some kind of effect of one on the other?"

"Let's not complicate this any more that we have to," said Andrew with a sigh. "That makes me think of that statistics workshop we went to a couple weeks ago. All that ANOVA…I don't know if I want to get into that."

"Andrew, how on earth are we going to figure anything out if we don't have an experimental design?" demanded Becca. "You can't be lazy or sloppy with research designs! You could work on this for years and not figure anything out if you just keep trying random formulations! We need an experimental design so we can analyze the data properly."

"Oh, all right, fine," Andrew said. "Let's get something set up, then. I want to go make yogurt, not sit and play with numbers for three hours. And let's not get too fancy with how many formulations we make or how many, umm, *interactions* we look at. I know you'd stay here all night testing 25 formulations, Becca, but I like to go home at a reasonable time. Besides," Andrew said with a smile, "less formulations means less trial product we have to make, and didn't you say something about using less trial product and being more sustainable?"

Questions

1. Develop experimental designs for the variables that Becca and Andrew want to investigate. Becca and Andrew should have separate designs. In your experimental design, consider the following:

   a. What changes can Becca and Andrew make to a base formula to investigate their target quality attributes? Is there anything they should NOT change? Explain your answers.

   b. How many formulations should Becca and Andrew investigate? Justify your answer.

   c. What tests should Becca and Andrew perform on their formulations to investigate how differences in formulation affect their quality attributes?

   d. How many samples (replicates) should they make for each formulation? Justify your answer.

2. Explain what Becca was referring to in her comment about interaction between thickness and sweetness. Can the experimental design you developed in Question 1 test for this interaction? Why or why not?

3. If you wanted to test for interactions between thickness and sweetener level, would you need to change your experimental design? If so, what changes would you make? If not, why not?

Remember that Andrew and Becca only have 4 to 6 weeks for this project!

Part III – Data Analysis

"There, I think this is reasonable," said Becca, reading over the Excel spreadsheet she was using to record her experimental design. "Come take a look, Andrew."

Andrew, who had been lining the dry ingredients for the yogurt formulations up on the lab bench, hurried over. "Great, we have a design," he said, looking over Beeca's shoulder. "Does this mean we can make some yogurt now?"

"It does, after you take more than one second to look at the experimental design," Becca responded. "Make sure I didn't forget anything."

"Looks fine to me," said Andrew. "You're testing four different starches and I'm testing three different sugars. You've even got a control formula: 5% dairy solids nonfat with 13.5% sugar and 1% fat. Pretty straightforward."

Becca sighed. "No, look here. I'm testing four different starches, one starch per new formulation, at the same level of addition. You're testing one artificial sweetener at a different level of addition for each of your formulations. And we both have to make a control."

"All right, I get it. Just print me the formulas I have to make and let's get to it!" exclaimed Andrew.

Several weeks later, Andrew and Becca were both finished with their experiments. Becca had measured viscosities of her yogurts, while Andrew had used a trained sensory panel to evaluate the sweetness of his yogurts.

"Let's take a look at the results," said Becca. "This data is pretty interesting. Each of the starches I used resulted in a different viscosity. And it looks like each sweetener addition level affected perceived sweetness. The panel measured sweetness on a scale of 1 to 15, right?"

"Yeah, with 15 being super-sweet and 1 being not sweet at all," said Andrew. "Here's a question for you: since every formulation came out with different results, how are we going to pick the best one?"

"We should do some data analysis," replied Becca. "I think ANOVA would be good to start. That should help us narrow down our options."

Becca's and Andrew's experimental data are given in the tables below.

Yogurt formulation	Viscosity (mPa s)			Total of Samples	Average of Samples
	Sample 1	Sample 2	Sample 3		
Control	825	720	885	2430	810
Thickener 1	900	780	945	2625	875
Thickener 2	1650	1830	1725	5205	1735
Thickener 3	1320	1140	1155	3615	1205
Thickener 4	1230	1275	1335	3840	1280
All samples				17715	1181

Yogurt formulation	Sweetness					Total of Panelists	Average of Panelists
	Panelist 1	Panelist 2	Panelist 3	Panelist 4	Panelist 5		
Control	9	8	8	7	9	41	8.2
Sweetener level 1	7	6	7	7	6	33	6.6
Sweetener level 2	10	9	10	9	11	49	9.8
Sweetener level 3	8	7	8	8	10	41	8.2
All samples						164	8.2

Questions

1. Part of Becca's experimental design was that both she and Andrew needed to make a control yogurt. This control yogurt can be considered a starting prototype product. Discuss the pros and cons of each researcher making their own control samples versus using a common control.

2. Experimental design involves determination of null and alternative hypotheses.

   a. What is the null and alternative hypothesis for Becca's design?

   b. What is the null and alternative hypothesis for Andrew's design?

   c. What distribution should be used to test these hypotheses when using ANOVA?

   d. What does it mean when you reject the null hypothesis?

3. Explain how to perform an ANOVA analysis on these data.

Part IV – Next Steps

"There are a lot of numbers here," said Andrew, scanning the results of the ANOVA analysis. "I'm trying to remember what they all mean. Maybe I should get my notes from that statistics seminar."

"Good idea," said Becca. "I could use a reminder myself, just to make sure I'm reading this right."

Andrew headed over to his cubicle and, after a brief search through the stacks of paper on his desk, found his statistics notes. "Here we go," he said, heading back over to Becca. "Let's see…here's the section on ANOVA. Okay, our table matches the sample one here. Now we just have to look at this number and this number."

"Which number and which number?" asked Becca, adjusting her glasses. "Can I see those notes?" Andrew handed them over. "Oh, I see what you mean; you were talking about the test statistic and the critical value." Becca looked over the data again. "Hey, look at that! We both got some interesting results." Becca smiled up at Andrew. "Now we can start weeding out the formulas we don't want to use."

"We do that by comparing the numbers to our targets, right?" asked Andrew. "Let me think; the ladies liked yogurts with a viscosity of about 1100 and a sweetness of about 7 or 8, at least according to the consumer survey."

"That's what I remember," said Becca. "We'll look at formulations in a minute. Let's get the ANOVA run first."

Becca's ANOVA results

	Sum of Squares	Mean Squares	F_o	F_α
Treatment	1645710	411428	58.5	3.48
Error	70350	7035		
Total	1716060			

Andrew's ANOVA results

	Sum of Squares	Mean Squares	F_o	F_α
Treatment	25.6	8.533	11.8	3.24
Error	11.6	0.725		
Total	37.2			

Questions

1. Can an ANOVA analysis tell you which specific treatment is significantly different? Why or why not?

2. Assuming a value of $\alpha=0.05$, what can Becca and Andrew conclude from their data?

3. Discuss how Becca and Andrew can continue their statistical analysis and determine which specific treatment(s) is/are different.

4. Once Becca and Andrew determine which treatment(s) is/are different, what should they do? Discuss the next possible steps they could take and remember that their end goal is to produce a yogurt that is highly appealing to their target market.

5. Andrew was resistant to using an experimental design for this project, preferring to jump in and start making samples. Discuss the pros and cons of this approach.

6. Is there a time where just jumping in and trying formulations without an experimental design is appropriate? If so, when? If not, why?

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