

# Concentrating on Whey: The Use of Statistics in Process Control

by

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## Part I – Under Control?

Kenny was feeling increasingly uncomfortable. He thought that he had done at least a halfway decent job managing the quality of the whey protein concentrate produced on his line. But after showing the process and process records to Cheryl, he was having second thoughts. Cheryl was a quality management specialist, who had been contracted by his company to help implement their new quality management system.

“Looks like your records are in decent shape,” Cheryl said with a smile. “Do you do anything with the data after you record them or does it just sit in a file somewhere?”

“I think it gets stored on this computer for several years; then we send it off to a warehouse somewhere for long-term storage,” Kenny said. “Is that okay? I guess we should be doing something with it, what with this new quality initiative that management is all excited about, but I usually just check it against what I know it should be to make the WPC—whey protein concentrate, I mean—come out right. If it looks off, I take another look at the QC data from that batch.”

Cheryl frowned slightly. “If it looks off? How can you tell?”

Kenny gave her a small smile. “Well, I’ve been on this process for about 12 years now, so I kind of have an idea of what numbers are good and what aren’t.”

Cheryl smiled back. “Nothing like experience to give you a feel of what’s good or what isn’t! But what about the other people here? Do they know the process like you do? How about your boss, and your boss’s boss?”

“No, I’m the one that’s been on the process the longest,” Kenny said, “and I’m the head operator, so I’m really the go-to guy for any problems we have.”

“Okay, I see,” said Cheryl. “In that case, you’ll be a big help getting a control chart started for this process. You’ll know what quality problems the product can have, what variable should be monitored, what the rational subgroup and sampling method should be...”

“Whoa, wait a minute!” Kenny held up a hand to slow the stream of jargon. “I know all that’s probably part of that quality management program, but I haven’t been to any of the training yet and I’ve never heard of half the stuff you’re talking about. Is this control chart thing going to be really complicated? I don’t remember much from the statistics class I took in college, and I bet it has something to do with that.” Kenny sighed. “Never did like statistics much.”

“Oops, didn’t mean to get ahead of things,” Cheryl smiled apologetically. “I was just a little excited because you know this process so well and that can really help with quality management. Let me back up a little bit. I’ll give you a quick rundown on control charts and their uses. I think you’ll be pleasantly surprised how easy they are to use, and they’re not too bad to set up, either. We can look at a sample control chart together while I go over them.”

*Questions*

1. Provide a brief summary of control charts, their parts, and how they can be used for monitoring process control that Kenny can share with the other operators on the process.
2. Cheryl is trying to determine what type of control chart to use for the whey protein concentrate process. Kenny tells her that one of the most important quality factors in the whey protein concentrate is percent protein content. Their specs for protein content are  $75 \pm 0.5\%$  protein. Is this a variable or an attribute? Explain your answer.
3. What kind(s) of control chart(s) should Cheryl recommend to monitor protein content? Explain your answer.

## Part II – A Little Math

“So the math for the control chart isn’t really that bad,” said Cheryl. “And there’s software available that lets you set up a chart automatically, but I like to teach people how to construct one by hand. I think it’s important to know how they’re put together so if something gets put into the software wrong, it’s easier to catch it.”

Kenny looked skeptical. “I don’t know, I’d rather just have a program do it for me. The program’s a lot less likely to mess it up than me. Heck, I can barely add two and two without a calculator anymore! I just don’t do math much.”

“Oh, it’s not so bad,” Cheryl smiled encouragingly. “Here, we’ll take some of this data you have and make a chart right now.”

Kenny thought for a moment. “All right, if you’re the one doing the math.”

“Sure,” Cheryl said. “And you’ll probably have software to do this; I just want to show you how the control charts for your data are set up. That way it’ll be easier for you to understand what the software is asking for and how all the lines on the chart got there. And it’ll make it easier for you to figure out what’s an entry error and what’s an actual point of concern. Now, since you already have data, the first step is to figure out your subgroup size ...”

### *Questions*

1. The data that Kenny and Cheryl are using is shown in Table 1 on the following page. What control chart(s) can you construct with this data. What is the subgroup size?
2. Establish the centerline and control limits for your chart(s).
3. Are there any out of control points? If so, which ones?
4. Do the centerline(s) and control limits need revision? If so, revise them and explain how and why you revised the limits. If not, explain why the limits do not need revision.

Table 1. Data Log for WPC. Whey protein contents measured for 30 days of whey processing. Sample data are % protein content. Average and range are average and range of each row.

Day	Date	Operator	Sample 1	Sample 2	Sample 3	Average	Range
1	1/21/14	AAJ	74.2	74.7	75.3	74.7	1.09
2	1/22/14	MKD	75.5	74.2	74.2	74.6	1.33
3	1/23/14	CBL	74.0	73.0	73.2	73.4	0.99
4	1/24/14	KMW	75.0	75.8	74.2	75.0	1.57
5	1/25/14	AAJ	75.6	75.2	75.0	75.3	0.64
6	1/26/14	MKD	75.3	75.5	74.3	75.1	1.26
7	1/27/14	CBL	72.7	74.6	75.8	74.4	3.13
8	1/28/14	KMW	74.9	75.0	74.9	74.9	0.06
9	1/29/14	AAJ	74.3	75.3	75.0	74.9	1.07
10	1/30/14	AAJ	75.0	75.3	75.3	75.2	0.33
11	1/31/14	MKD	74.6	75.8	75.5	75.3	1.28
12	2/1/14	CBL	74.3	74.6	73.2	74.1	1.43
13	2/2/14	KMW	74.7	75.1	75.1	75.0	0.41
14	2/3/14	AAJ	74.7	75.5	75.9	75.4	1.22
15	2/4/14	KMW	75.2	75.1	74.3	74.9	0.92
16	2/5/14	MKD	75.8	75.6	74.2	75.2	1.60
17	2/6/14	KMW	75.0	74.8	75.4	75.1	0.62
18	2/7/14	CBL	74.1	72.9	73.2	73.4	1.23
19	2/8/14	KMW	74.8	74.5	75.6	75.0	1.14
20	2/9/14	MKD	74.4	74.4	75.6	74.8	1.26
21	2/10/14	KMW	75.6	75.2	74.2	75.0	1.42
22	2/11/14	AAJ	75.3	74.9	75.7	75.3	0.85
23	2/12/14	MKD	75.6	75.7	74.9	75.4	0.80
24	2/13/14	KMW	75.1	74.6	75.6	75.1	1.06
25	2/14/14	CBL	72.7	73.4	73.3	73.1	0.72
26	2/15/14	AAJ	74.6	75.5	75.7	75.3	1.14
27	2/16/14	KMW	74.6	75.2	75.5	75.1	0.87
28	2/17/14	KMW	74.5	75.6	75.1	75.1	1.10
29	2/18/14	CBL	76.4	73.1	73.2	74.2	3.31
30	2/19/14	KMW	75.3	74.9	74.7	74.9	0.62

## Part III – State of Control

“You’re right, the math isn’t so bad,” Kenny admitted. “It’s just keeping track of those dang constants. Does the software do all that for me?”

“Yes, the software will automatically calculate the centerline and control limits with the right constants...as long as you put your data in right!” said Cheryl. “So, now that you know how the control chart goes together, I’ll show you how to interpret it. Before I do, are there any problems that you saw when this data was collected?”

“Yeah, now that you mention it,” Kenny mused, “we’ve been having a little trouble with consistency lately. Seems like protein content has been fluctuating a bit, but we can’t seem to find anything wrong with the process.”

“Well, maybe this control chart will help,” said Cheryl. “Let’s see if we can spot any out of control patterns.”

“What do they look like?” asked Kenny. “I’m guessing there are shapes to look for, since you said patterns, plural.”

“You got it,” Cheryl smiled. “I’ll draw them out for you first and then we can look at the chart we just made.”

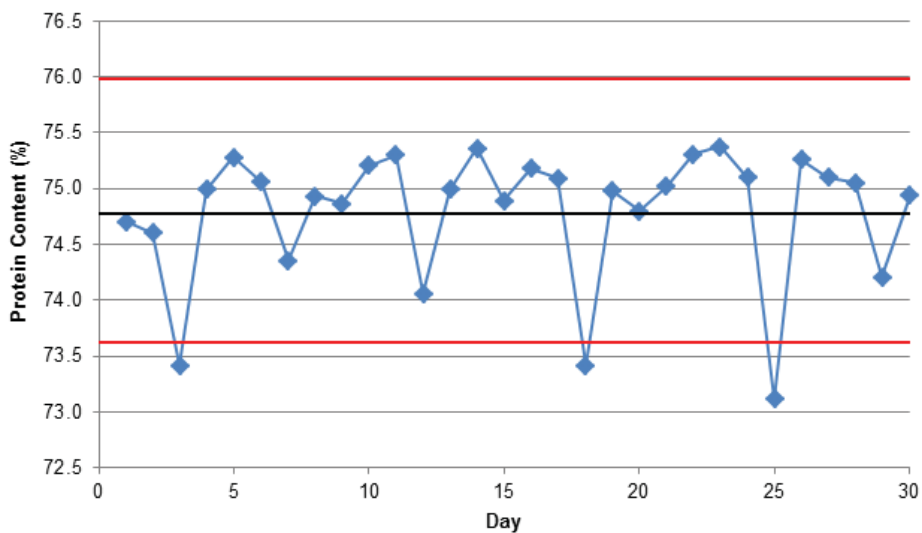


Figure 1. Kenny and Cheryl’s Xbar Chart for Protein Content.

### Questions

1. Provide a brief explanation of four types of out-of-control patterns that Kenny can share with his group. Include sketches of the patterns to support your explanation.
2. The unrevised control chart for the past 30 days is shown above (black centerline, red control limits). Are there any out-of-control trends in the data? If so, what are they?
3. Discuss possible causes for out-of-control trends in a whey protein concentrate manufacturing process.

## Part IV – Cause of Variation

“I knew there was something going on!” Kenny exclaimed. “That kind of up-and-down wiggle, that’s definitely not supposed to happen!”

“Now you can see why these charts are so helpful in improving process quality,” said Cheryl, pleased that Kenny was showing more enthusiasm for control charts. “So now that we found the out-of-control pattern, we have to figure out what caused it. This is where you come in. Do you know if there’s anything in the process that can cycle like this? Maybe temperature or something?”

Kenny shook his head. “No, no, it’s not temperature; we’ve got that monitored continuously and it’s fine. Let me take a look at these logs again.” He flipped through the logs quickly. “I don’t see anything here that looks like it would be the reason; it’s just the numbers for protein content, the QC tech’s name, and the operator on duty—wait a minute.” Kenny paged through the logs more slowly, then laid them out in a line on a nearby table. “Can I see the chart we just made?” he asked Cheryl, reaching for her laptop. “I think I may have figured out the problem.”

### *Questions*

1. Based on the data in the logs Kenny has (shown in Part II), what is a probable reason for the out-of-control pattern observed in Part III?
2. What are some steps that can be taken to correct the root cause of the out-of-control pattern?

## Part V – Capability

“That’s it!” Kenny was ecstatic. “That’s why we’ve been having quality problems for a month now! I knew Cory needed more training on the process and this proves it!”

“So Cory is the CBL in these logs, then?” asked Cheryl.

“Yeah, that’s him. Oh man, he’s on today! I need to go talk with him before another batch goes off. Thanks for showing me all this, Cheryl. I really appreciate it. And I’ll be sure to be at the training class you’re giving next week. Sorry, gotta run!” Kenny was out the door and down the hall before Cheryl had time to blink.

The next week, Kenny thanked Cheryl again after the quality management training class. “That control chart was right on. Turns out that poor Cory never did get decent training on the process, so he had to figure things out as he went. But we got him straightened out. And we’re going to keep that control chart going too. But can you show me process capability and capability index one more time? I keep mixing them up.”

“I’m glad I was able to help,” said Cheryl. “Let me grab my things and we’ll go over process capability and capability index in your office.”

### Questions

1. Provide a brief explanation of process capability and capability index that Kenny can share with his group.
2. Several weeks later, Kenny has figured out that the average range for the process is now 1.0. If QC measures protein in triplicate, what is the process capability?
3. Using the specification for protein content given in Part I, what is the process capability index?
4. Is it the process that is producing product that is out of spec? How do you know?
5. Discuss the advantages and disadvantages of using process capability and process capability index to monitor process performance compared to a control chart. Is one preferable to the other? Why or why not?
6. Management would like to tighten the specification on protein content to  $75\% \pm 0.2\%$ . Is the current process capable of meeting these specifications? Why or why not?
7. What are some things that can be done to reduce process variation for this whey protein concentration process?



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