



by
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Part I – Cheese Control Charts

You are employed by a small artisan cheese company in their quality assurance team. They have been having trouble with the cheddar cheese line. Some of the cheeses have significant flavor and texture defects and the company is not sure why. They are careful about sanitation and they have confirmed that microbial contamination (e.g., spoilage bacteria, molds, yeast) is not the cause of the defects. A diagram of their cheddar cheese production process is shown in Figure 1.

The company employs a dedicated sensory team that tastes 50 samples total out of every batch and rates the cheeses in terms of flavor and texture. The results from the last 20 batches of cheese are shown in Table 1 (next page). Note that the company has made process changes between the batches on 10/18/12 and 10/19/12, and between the batches on 10/27/12 and 10/28/12 to try to reduce the number of defects. Unless otherwise stated, each defective sample has one defect.

As recorded in the last column of the table, some samples have more than one defect. Therefore, the total number of defects in the samples would be greater than the number of samples with defects. For example, the batch on 10/13/12 has 6 samples with defects. Since one sample has 3 defects and two samples have two defects each, the total number of defects in that batch is $3+2+2+1+1+1 = 10$ defects.

The defects that are appearing in the cheddar cheese are shown in Table 2 (next page). The severity of a defect can range from hardly noticeable to a trained evaluator to noticeable right away by a general consumer.

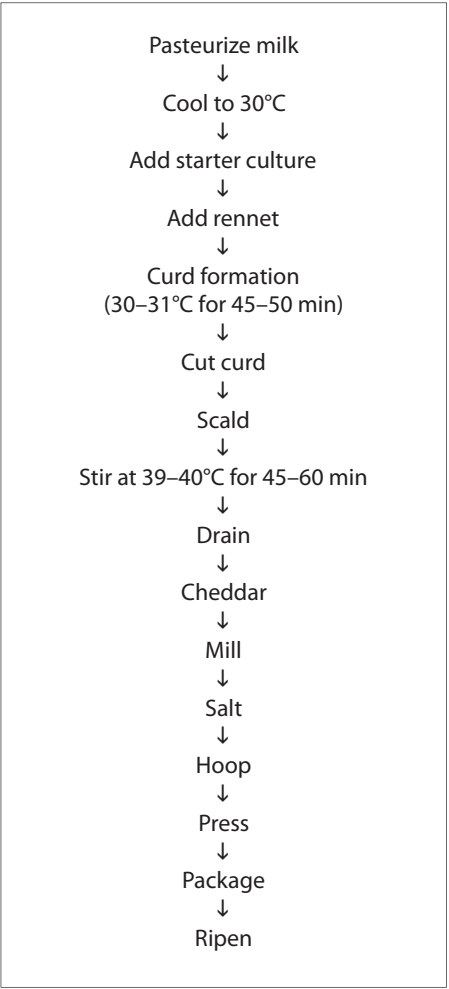


Figure 1. Cheddar cheese production process. Adapted from Varnam and Sutherland, 2001.

Table 1. Cheddar Cheese Sample Results.

<i>Batch Date</i>	<i>Batch Number</i>	<i># of Samples with Defects</i>	<i>Notes</i>
10/13/12	1	6	One sample has 3 defects, two samples each have 2 defects
10/14/12	2	5	One sample has 4 defects
10/15/12	3	5	Three samples each have 3 defects
10/16/12	4	3	One sample has 2 defects
10/17/12	5	5	
10/18/12	6	6	Three samples have 3 defects, one sample has 2 defects
10/19/12	7	0	
10/20/12	8	6	One sample has 4 defects
10/21/12	9	6	Three samples each have 2 defects
10/22/12	10	7	One sample has 3 defects, two samples each have 2 defects
10/23/12	11	4	
10/24/12	12	5	
10/25/12	13	6	Three samples each have 2 defects
10/26/12	14	3	Two samples have 2 defects each
10/27/12	15	6	
10/28/12	16	5	Two samples each have 2 defects
10/29/12	17	5	Four samples each have 2 defects
10/30/12	18	4	Two samples each have 3 defects
10/31/12	19	5	One sample has 2 defects
11/01/12	20	8	Two samples each have 2 defects

Table 2. Cheddar Cheese Defects.

<i>Body/Texture</i>	<i>Flavor</i>
Pasty Open Weak	Unclean Whey Taint Bitter High Acid

Definitions of the defects are as follows:

- *Body/Texture*
Pasty: cheese sticks to fingers when manipulated by hand.
Open: cheese shows small openings along curd lines.
Weak: cheese deforms easily when compressed between the first two fingers and thumb.
- *Flavor*
Unclean: unpleasant/dirty flavor with lingering aftertaste.
Whey taint (*in young cheese*): slightly sweet, brothy flavor that does not linger in the mouth.
Whey taint (*in aged cheese*): sour, bitter, fermented flavor that lingers in the mouth.
Bitter: bitter taste or aftertaste.
High acid: sour, sharp taste, especially during the first few chews.

Questions

1. What could be the source of the flavor and texture problems? Consider the process, the raw ingredients coming in, and what can happen during the aging process. (Remember, microbial contamination is not an issue in this case.) Use the supplemental resources if you need more information.
2. Make a p-chart, an np-chart, a c-chart, and a u-chart with the data from the quality control team. You may not use a control chart generator (e.g., Minitab, QIMacros) to complete your calculations, but you can perform your calculations and create your graphs in Excel or a similar program.
3. Select *one* of the charts and analyze it for out-of-control behavior. Based on the chart, did either of the changes made to the process (between the batches on 10/18/12 and 10/19/12, and between the batches on 10/27/12 and 10/28/12) improve the quality of the product? Explain your answer.
4. Of the four charts you made, which one would you suggest the company use to monitor their cheese quality? Explain your answer.
5. Assume that the cheese company has figured out the problem(s) causing the defects and is taking steps to improve the cheese quality. Why might they need to revise their control chart central line and control limits for cheese defects once they see a consistent improvement in their cheese quality? What could happen if they don't revise the control chart?
6. Would you recommend that the company continue to monitor cheese quality with a chart for attributes or switch to a control chart for variables (e.g., Xbar and R)? Explain your answer.

Part II – A Closer Look at Process Control

The quality assurance team has tested cheese samples over several weeks and has identified a potential cause of the flavor and texture defects. They think that the cheddaring and pressing processes may not be expelling enough whey from the curd. The excess whey left in the curd results in a cheese with a moisture content that is higher than expected. In addition, the flavor and texture defects identified by the sensory group are typical of those present in cheese that has undergone insufficient pressing and contains excessive whey.

You have gathered moisture content data for 30 batches of cheese. The data are shown in Table 3. The company wants their cheese to have an average moisture content of 37%, and will allow a maximum deviation of 0.3% above or below this average.

Questions

1. What are the specification limits for the moisture content of the cheese? How do they compare to the Code of Federal Regulations for cheddar cheese?
2. What is the average moisture content of the cheese? How does it compare to the desired average and the specification limits?
3. Calculate the process capability for moisture content. Use the standard deviation of all the moisture contents from the data given. What does the process capability tell you about the moisture content of the cheddar cheese?
4. Calculate the capability index (C_p) and the capability index that accounts for the process center (C_{pk}). What do these values tell you about the process?
5. Does the process need to be adjusted to change the average moisture content based on your results for C_p and C_{pk} ? Explain your answer.
6. Would you recommend evaluating the process to reduce variation based on your results for C_p and C_{pk} ? Explain your answer.
7. It costs \$5.75 per pound for the company to produce cheddar cheese. They sell the in-specification cheese to distributors for \$8.50 per pound and the out-of-specification cheese to a company that makes process cheese for \$4.00 per pound. What is their current net profit for their cheddar cheese? What would the company's profit on each pound of cheese be if all of their product met specifications? You may assume that the mean and standard deviation from the data are indicative of population statistics.
8. Aside from profit loss from not being able to sell the cheddar cheese to the intended consumers, what other problems can arise from producing out-of-specification product? Explain your answers.

Table 3. Moisture Content Data.

Sample Set	Moisture Content (%)	Standard Deviation (%)
1	36.91	0.07
2	37.00	0.07
3	37.18	0.08
4	36.90	0.10
5	36.96	0.12
6	37.13	0.12
7	37.12	0.11
8	37.10	0.10
9	37.18	0.09
10	36.96	0.09
11	36.98	0.10
12	37.18	0.08
13	36.96	0.10
14	37.18	0.11
15	37.04	0.09
16	37.17	0.11
17	37.12	0.09
18	37.15	0.07
19	36.95	0.11
20	36.93	0.07
21	36.96	0.10
22	37.03	0.11
23	36.97	0.08
24	37.01	0.07
25	36.96	0.08
26	37.17	0.10
27	37.01	0.09
28	37.18	0.08
29	37.19	0.10
30	37.06	0.11

Executive Summary Assignment

Prepare a one-page executive summary of your findings for the head of the artisan cheese company. Include in your summary:

- The current problems the cheese company is having with their cheddar cheese and the probable causes of these problems.
- An overview of the trends (if any) you observed in your control chart and whether the process changes had any effect on the number of defects in each batch of cheese.
- An explanation of the process capability and capability index, and how it relates to the quality problems.
- The current net profit and net profit if no defective batches were produced.
- Your recommendations for altering and monitoring the process to correct the quality problems in the cheddar cheese.

When you are writing the summary, assume that the owner of the company is not very familiar with quality management principles. The owner may not understand technical terms used in quality management, so be sure to clearly define and explain all terms you use.

Attach your selected control chart from Part I and your process capability and capability index calculations from Part II as an appendix. These attachments do not count towards the one page limit, nor should they appear in the executive summary itself.

