Minitab®

FROM SOIL TO STORE:

Using Statistics to Improve Quality in Food Manufacturing and Keep Up with Food Demand

Overview

With the world population reaching over 7.7 billion people in 2019, there's one thing that unites us all— food. Whether raw, cooked, healthy, bitter, sweet, spicy or savory (the list goes on!) there are millions of foods being grown, bought, made and consumed every day. That being said by 2030, global food demand is expected to rise by 35 percent due to middle-class consumption growth from 10 to 40 percent in countries like India and China, and rise by 56 percent by 2050.

Individuals, organizations and companies around the world have been researching and finding all kinds of solutions to proactively handle the increase in food demand and reduce the food gap. While no one solution can entirely eliminate the problem, one of the best proposals is to become more efficient during the food manufacturing process to effectively reduce loss and waste. The World Resources Institute (WRI) and Food and Agriculture Organization (FAO) have found that by reducing food loss and waste 25 percent by 2050 alone would lessen the food gap by 12 percent. They also discovered nearly one-quarter of food produced for humans goes uneaten and it doesn't just happen in people's homes—waste occurs all along the food chain from farms, factories, stores and stoves.

Good news for food manufacturers—Minitab Statistical Software can help! Whether you're a veteran or newcomer to the food production and packaged goods industry or even in other more traditional types of manufacturing, let us show you how to become more efficient to reduce waste, improve quality and uncover savings with our three use cases.

Making Rice? Don't Dry Twice

Reducing Waste By Meeting Crucial Storage Conditions

Did you know that cereals are one of the most important staple foods for humans globally in 2019? Defined as any grass grown for its edible components, cereal is made up of grains including wheat, maize corn, rice, barley, oats, rye and sorghum. Believe it or not corn, rice and wheat together combine to make up 51 percent of the world's caloric intake.

Keeping that statistic in mind, it makes perfect sense that as we look to tackle the food gap that we explore how to increase the quantity of cereal grains available due to their massive impact on global diets. It turns out that 50 to 60 percent of cereal grains produced can be lost and wasted during the storage stage due to factors like humidity, moisture, air, pests, hazardous elements and more, so improving storage of grains can greatly increase the quantity available and help to reduce waste.

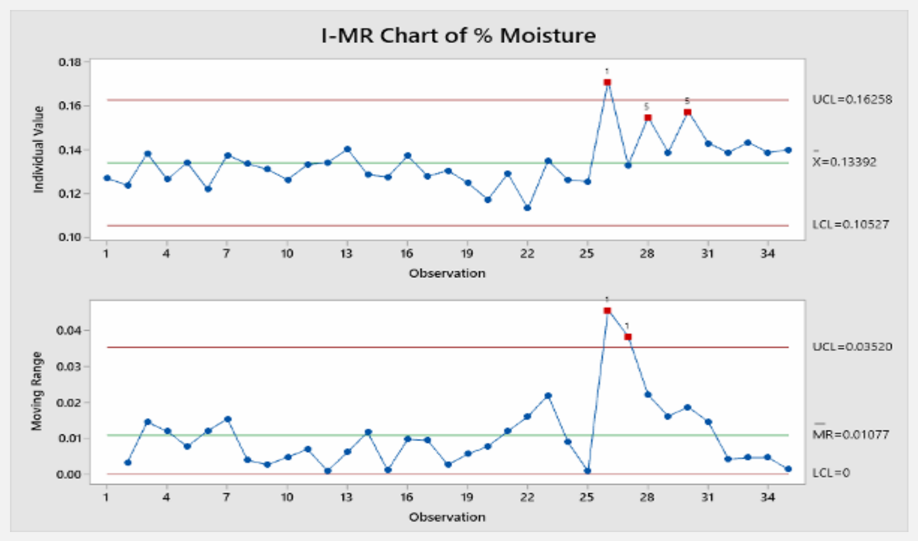
If we look at rice specifically, you see that storage containers vary in shape and size all around the world, but there is one constant element that needs to be met in all storage: moisture content. Naturally after harvesting, rice will contain up to 25 percent moisture, however optimal moisture content for rice storage from the International Rice Research Institute (IRRI) is 13 to 14 percent. If rice isn't dried to the optimal moisture content, it risks spoiling due to too much moisture however if the rice doesn't have enough moisture it won't mill well therefore exact moisture content is critical for proper storage. Given the above, moisture content easily becomes the critical variable for rice.

Consistency is key when it comes to drying rice and meeting that targeted 13 to 14 percent moisture content. There are two methods to dry rice: the primary method, which uses weight measurements and is considered more exact but takes longer, and the secondary method, which uses instruments that measure electrical resistance in just seconds.

Minitab Analysis Used

- Control Chart
- Gage R&R
- Capability Analysis
- Cause and Effect Diagram

The Analysis



Before beginning to try and meet the targeted moisture content for the rice, you need to take an initial snapshot to use as a starting point. This snapshot of the process behavior can be visualized using a control chart where individual measurements are plotted depicting the average percentage of moisture of rice samples taken over a period of 35 shifts. This chart also shows the trends and patterns of the measurements with respect to the average percentage of moisture as well as sample variation. Once the control charts have been made in Minitab, you will need to investigate the out of control instances, which are identified by the red dots and numerals, and find out the special causes that originated them.

Before jumping to conclusions and making process changes, however, you need to prove that you can trust the data obtained with your measurement system. This can be done by using gage repeatability & reproducibility (R&R) study in Minitab Statistical Software.

Gage Evaluation

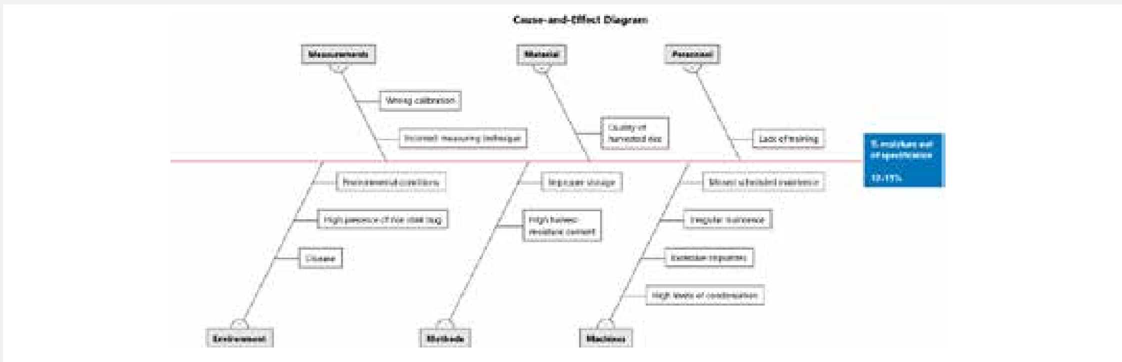
Source	StdDev (SD)	Study Var (6 × SD)	%Study Var (%SV)	%Tolerance (SV/Toler)
Total Gage R&R	0.0003821	0.0022926	23.71	22.93
Repeatability	0.0003821	0.0022926	23.71	22.93
Reproducibility	0.0000000	0.0000000	0.00	0.00
Part-To-Part	0.0015655	0.0093930	97.15	93.93
Total Variation	0.0016115	0.0096687	100.00	96.69

Number of Distinct Categories = 5

Up to 60% of cereal grains produced can be lost during storage

Due to the nature of the drying process, you randomly select 30 samples that represent the expected range of the process variation and give 10 random samples to 3 randomly selected food technicians (operators). The 3 technicians measure the percentage of moisture of the 10 different samples twice, for a total of 60 measurements. Each sample is unique to the operator and no two operators measured the same sample.

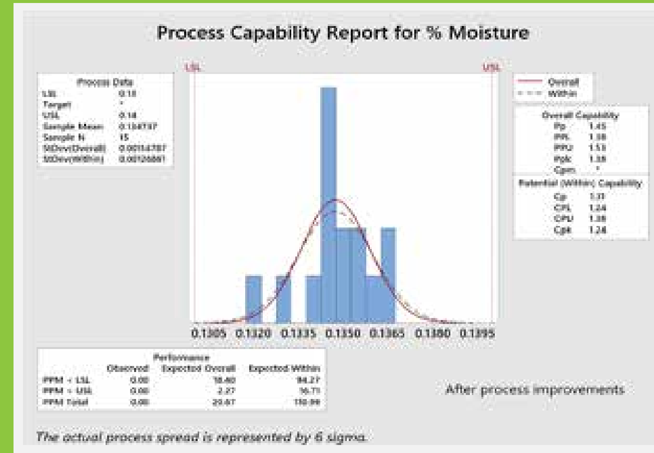
Because the measurements are unique to each technician, you would choose to perform a nested gage R&R study to assess the variability in measurements that may be due to the measurement system. This step will help you decide if the variation observed in the control chart is due to how the technicians measure the percentage of moisture in the samples or if there are other potential causes that need to be identified and addressed.



Once the gage R&R study has been done, you can begin to review the results in the gage evaluation section. For example, the %study var is useful to compare the measurement system variation to the total variation, while you find out that total gage R&R equals 23.71 percent of the study variation and the part–to–part variation equals 97.15 percent. As common industry practice, a total gage R&R variation less than 30 percent is acceptable. This measurement system can also differentiate between 5 distinct categories, indicating that the measurement system can distinguish between parts. According to the AIAG, you need at least 5 distinct categories to have an adequate measuring system. In this case, you can conclude that the data obtained with the measuring device and method used by the technicians is reliable.

Once the measurement data is validated, additional data shows that batches of rice aren't meeting the 13 to 14 percent moisture content specifications needed. This is when process capability analysis in Minitab can help you. An initial process capability can help you determine whether the process can produce the output that meets customer requirements and compare the overall capability of the process with its potential (within) capability to assess opportunity for improvement.

As shown in the process capability report, the Cpk is only 0.15 meaning that process is not capable of meeting customer specifications of 13 to 14 percent moisture content. Additionally, the expected process performance results show that over 580,000 batches out of every 1,000,000 batches produced are likely to fall out of the 13-14 percent range. Therefore, you'll need to identify the factors that affect the moisture levels through a fishbone diagram or idea map in Companion by Minitab.



The Results

By using a fishbone diagram, you are looking holistically at your rice drying process, making sure not to miss anything that may have an impact. After you identify all potential factors, narrow the scope and find key factors causing impact by running Multiple Regression in Minitab Statistical Software. The model can then be adjusted accordingly so you're able to consistently dry the batches of rice to meet optimal storage standards.

After key control characteristics of the process are identified, validated and mitigated you run a new process capability study in Minitab to measure the improved process performance. The new results and improved Cpk from 0.15 to 1.24, clearly show the process is more reliable at producing rice with 13 to 14 percent moisture content.

Great Guacamole for Great Times

Improving Quality & Quantity to Meet Customer Demands

We just learned that reducing waste is one way to decrease the food gap, but do you know another way? It's to improve food to meet consumer demands, both in quantity and quality, so the food being made is more likely eaten.

As you've probably noticed over the last few years, avocados have been popping up everywhere – from restaurants to cafes to beauty products even – these trendy, green fruits are in high demand. Although avocados have recently grown in popularity, guacamole on the other hand has been around for a long time. The creamy, avocado-heavy dip was created by the Aztecs and dates to sometime between the 14th and 16th centuries. Food manufacturers have been producing guacamole for years, but with the increased demand both on the avocado supply and from consumer need for products that use avocados like guacamole, these food manufacturers face a great challenge.

Luckily, guacamole manufacturers specifically may have a secret weapon: calabacitas. Found natively in Latin America, calabacitas are small, bright green squashes with similar characteristics to avocados so they can be easily mixed into guacamole. The question then arises for a guacamole manufacturer: would consumers notice if calabacitas are used into their favorite guacamole recipes?

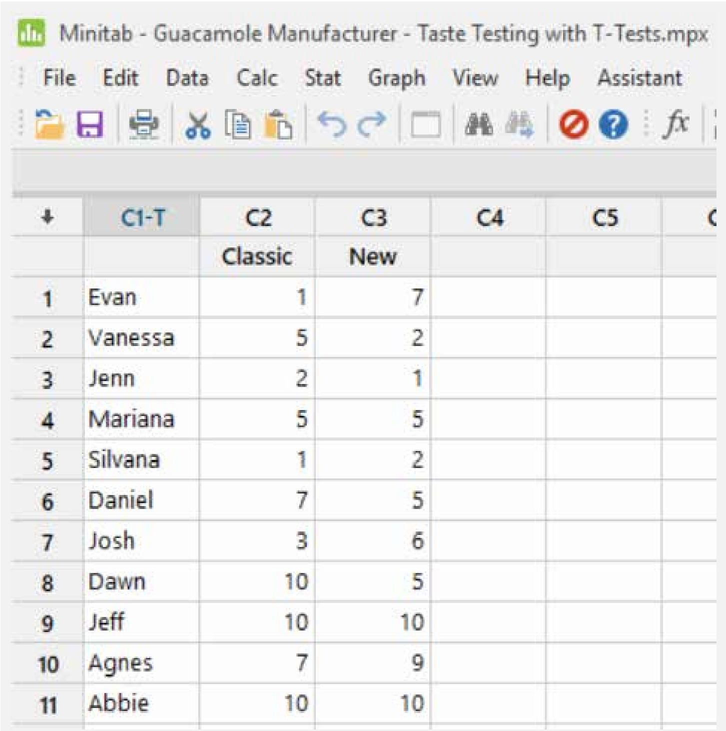
The Aztecs created guacamole as early as the 14th century.

To ensure consumers would be happy with the new guacamole mix and continue purchasing it so very little of the product goes to waste, the food manufacturer could develop and sample test the new product compared to their existing product before releasing it to the market.

Minitab Analysis Used

- Paired T-test
- Minitab Assistant

The Analysis



Minitab - Guacamole Manufacturer - Taste Testing with T-Tests.mpx

File Edit Data Calc Stat Graph View Help Assistant

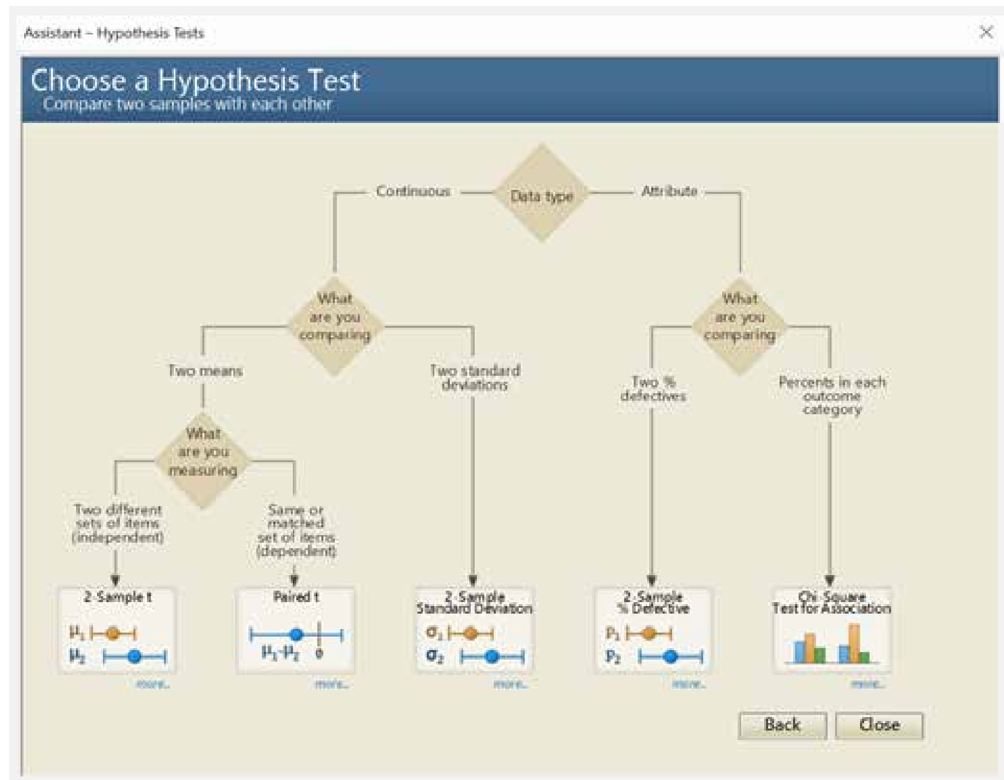
	C1-T	C2	C3	C4	C5
		Classic	New		
1	Evan	1	7		
2	Vanessa	5	2		
3	Jenn	2	1		
4	Mariana	5	5		
5	Silvana	1	2		
6	Daniel	7	5		
7	Josh	3	6		
8	Dawn	10	5		
9	Jeff	10	10		
10	Agnes	7	9		
11	Abbie	10	10		

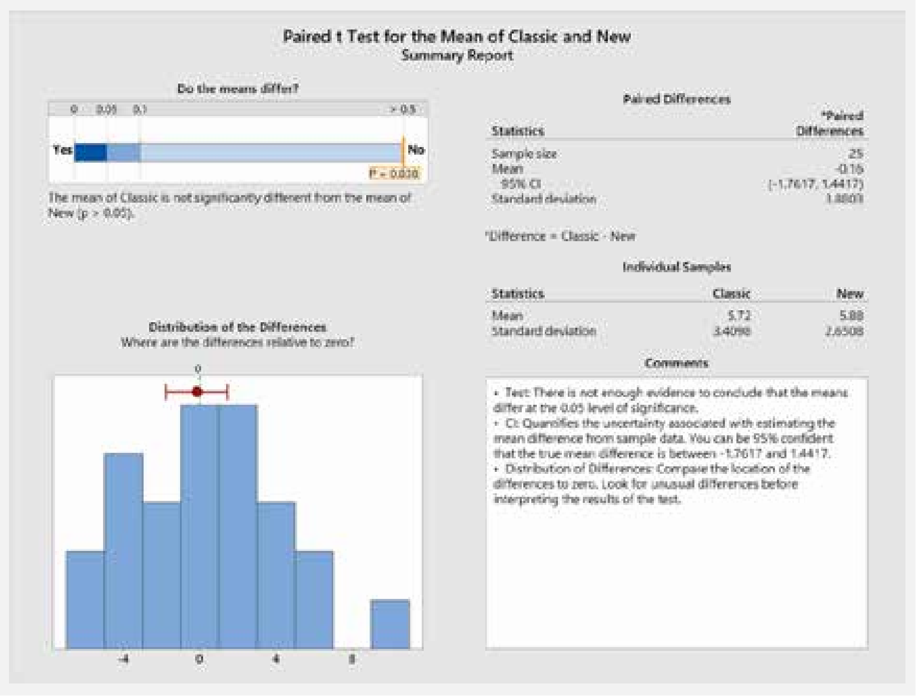
After all the sampling and tasting is complete, the collected data is then input into Minitab Statistical Software.

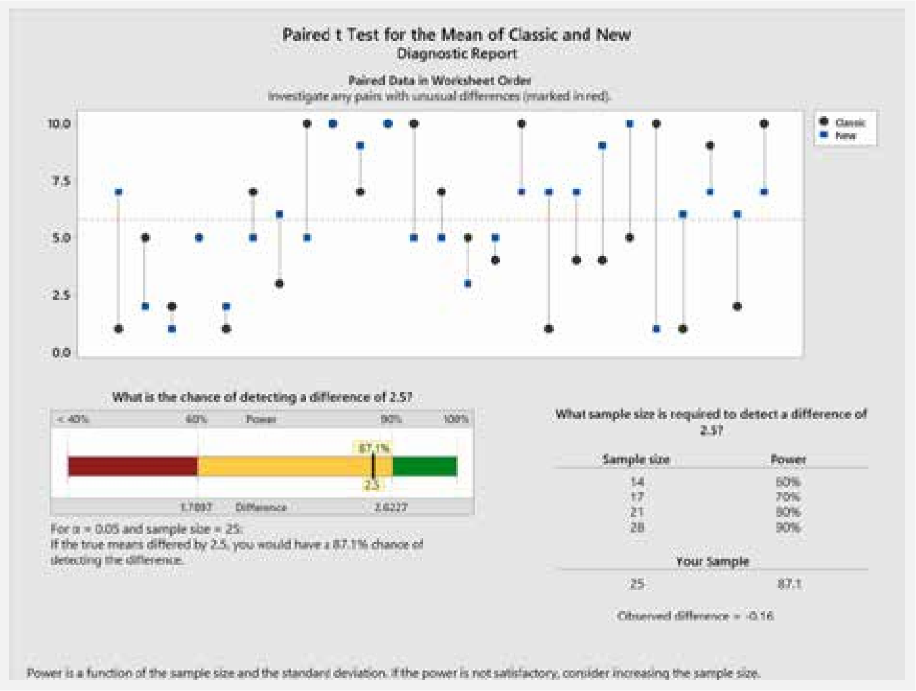
The food manufacturer can then use hypothesis testing under Minitab Assistant to guide their analysis and help explain their results. The food manufacturer knew they were comparing two samples against each other, however since the panelists each scored both recipes, Minitab Assistant helped the food manufacturer pick the paired T test as the most appropriate test to run.

Once the new guacamole recipe has been created, the food manufacturer can begin sample taste testing with T-tests. Simple but trusted, T-tests are ideal in any sampling scenario regardless of the manufacturers' size.

To accurately compare both guacamole formulations, the food manufacturer asked 25 panelists to try both the original and new recipes and score taste on a 1-10 scale, with 10 being the best flavor score. The food manufacturer also masked the panelists and randomized the order they tried the recipes, so half the group tried original first while the others had new first instead, to minimize any bias or preconceived notions.







The Results

Once the analysis was complete, Minitab's Summary Report appeared. Right away it displayed that the mean of original recipe was not significantly different from the mean of new recipe thanks to Minitab's quick calculations of the differences in each row. The average difference was very close to zero (-0.16) and the red interval showed the range for the true mean difference, so this told the food manufacturer that the two recipes are not different after all and the taste testers could not detect a recipe difference.

Before the guacamole manufacturer would begin to mass produce the new recipe however, they needed to verify that the experiment had adequate power and that they avoided the mistake of assuming there is no difference between the recipes due to a weak experiment. Statistical power is the probability of detecting an effect or practical difference, assuming it exists. Minitab easily helped them calculate that with the Diagnostic Report.

Given their sample size, they had an 87.1 percent chance of detecting the difference as shown above. This meant their test had adequate power to detect a difference between the recipes and therefore they could start mass producing their new guacamole recipe using calabacitas. Ultimately, this switch would not only keep their consumers happy with the quality and quantity available of their guacamole, but also lower their supply costs.

Hold that Beer

Streamlining Production for Savings and Conserving Resources

Now we've seen that food can be improved in quality and variety to appeal to more people and decrease the food gap, but then the next question arises: what about beverages?

As one of the oldest and most widely consumed beverages, beer has global appeal and power - the industry sold $661 billion worth of beer in 2017 alone. These days the brands and varieties available at stores and bars seem endless, but that is not the case: the top 50 biggest beer brands in the world account for 48 percent of all beer consumption. That being said, these big parent beer brands have a similar mentality to food manufacturers and work hard to offer the options and variety through smaller brands that customers are seeking.

Offering variety does come at a cost though in time, money and resources. Naturally beer manufacturers then need to look to streamline production, which in turn decreases resources needed (with a direct impact in the food gap), saves time throughout the entire production process and ultimately leads to savings.

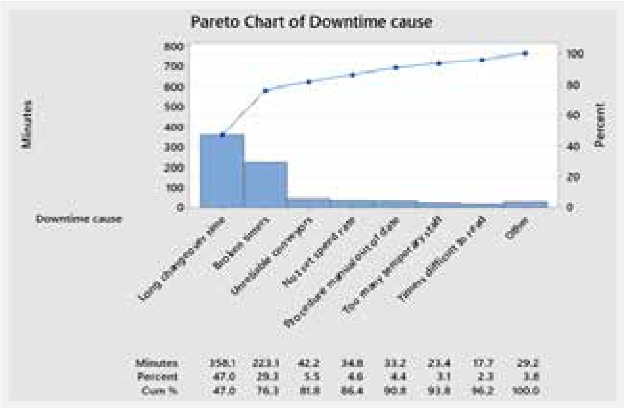
Over $660 billion worth of beer was sold in 2017

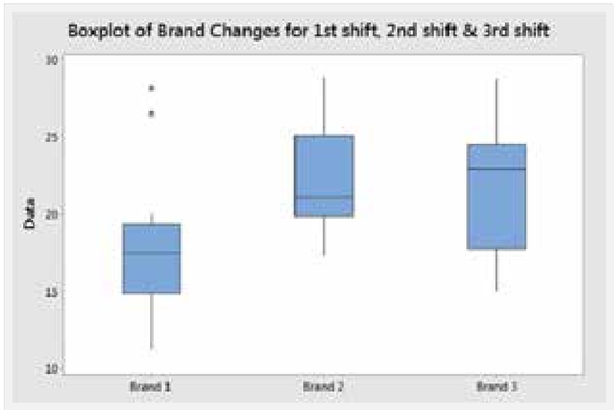
Beginning to streamline production starts by gathering data and completely understanding the beer production process for each beer being made. We often see reducing downtime between productions as the overarching best way to achieve a more streamlined beer manufacturing process while also reducing energy use, so we will narrow our focus on analyzing this piece going forward.

Minitab Analysis Used

- Pareto Chart
- Boxplot
- ANOVA
- Control Chart

The Analysis



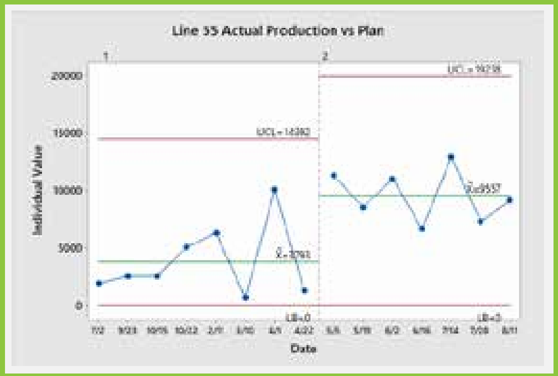


Once collected, the data is then input into Minitab Statistical Software where our broad set of tools can easily analyze the wealth of data and find those areas to streamline. To identify the biggest contributors to downtime, you will want to start with Pareto charts.

A Pareto chart is a special type of bar chart where the plotted values are arranged from largest to smallest; in this case it helps identify the most frequently occurring causes of excessive downtime. The Pareto chart was named after Vilfredo Pareto and his principle of the "80/20 rule" that states 20 percent of the people control 80 percent of the wealth meaning in beer production that 20 percent of the causes (long changeover time and broken timers) contribute to approximately 80 percent of downtime.

Once the causes with the most impact have been found, you can use histograms to understand overall process behavior, control charts to compare the multiple shifts for each of the brands and analysis of variance (ANOVA) and boxplots to visually show the differences in how the various shifts produce the different beers.

Finally, ANOVA can determine if each shift is running the production process differently. To deal with these differences, standard operating protocol is put into place so there are little to no discrepancies on the production lines when many unrelated beers are being produced.



The Results

These changes reduce planned downtime and reduce resources needed increasing savings for the beer manufacturer at this facility. In fact, we have seen that once implemented at other facilities across the globe, a beer manufacturer reduced planned downtime by over 30 percent, grow their savings by more than $400,000 and reduced their impact on natural resources worldwide.

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