Wisconsin Center for Dairy Research

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TURBO CHARGING SPECIALTY CHEESE:

THE STORY OF A WORLD CHAMPION OAXACA

According to the United States Department of Agriculture (USDA), specialty cheese sales in the United States totaled approximately 4.9 billion dollars in 2015, which is equivilant to a 17.6% volume share for the year. Included in that total were cheese varieties such as Limburger, Havarti and Oaxaca, a soft, buttery and versatile cheese named after the southern state of Mexico where it was first manufactured. Once a fairly rare cheese in the U.S., Oaxaca cheese production and sales have steadily grown. In fact, the USDA estimates that the U.S. volume sales for Oaxaca cheese were around 2,342,724 pounds in 2014, an increase of around 111,321 pounds since 2011. This growth has been an international effort, but thanks to a partnership between the CDR Technology Transfer, University Research and Business Opportunities (TURBO) program and Chula Vista/V&V Supremo, Oaxaca cheese has found a new home in the dairy state.

"It was a little over five years ago when we first decided to develop our very own Oaxaca," said Tom Dahmen, the plant manager at Chula Vista in Browntown, Wisconsin, a partner of V&V Supremo, Chicago, Illinois. "We pursued making it, but ran into a few problems along the way, so we contacted John Jaeggi at CDR."

Having worked together on various projects over the years, Cheese Applications Coordinator John Jaeggi was aware of Chula Vista's needs and the challenges that can come with manufacturing Oaxaca, a variety of cheese that is fairly labor intensive. In fact, due to the cheese's unique set of attributes and its historical roots, pinpointing a make process that provided ideal function and historical accuracy created a unique challenge.

"Like many clients that work with CDR, we had provided Chula Vista with guidance, tech support and troubleshooting over the years," said Jaeggi. "But, it was during one particular meeting with Chula Vista that we had the opportunity to discuss various options for their Oaxaca line. Chula Vista is very particular and they pay great attention to quality so we were very interested in helping them to extend their shelf-life while maintaining a smooth texture, buttery flavor and an ideal stringiness."

Jaeggi and Dahmen began working together, along with their respective teams, in order to develop a make procedure for Oaxaca that would pay tribute to the variety's historical roots while meeting consumer requests and expectations. The initial trials were performed in the CDR pilot plant at Babcock Hall because the multiple, small vat system allowed for many experiments to take place at one time.

"We have rather large vats at our plant, but coming to CDR to use their small vats allowed us to streamline our process," said Alan Hamann, Senior Manager of Quality Control at Chula Vista/V&V Supremo. "It's much more efficient and it allowed us to get to a solution quicker."

After the initial trials at CDR proved to be successful, Dahmen and Jaeggi worked together to scale up the make procedure at the Chula Vista plant. Some adjustments were needed, but soon the process was officially up and running.

After that it didn't take long for people to begin to take notice. In fact, the Chula Vista/V&V Supremo Queso

Oaxaca Ball received the Best of Class award in the Hispanic Melting Cheeses (Quesos para Fundir class) at the 2016 World Championship Cheese Contest, earning a 99.85 out of 100.

As the success of the brand's Oaxaca cheese grew, Chula Vista/V&V Supremo saw a need to expand production. Having previously made the cheese one or two days per week, the plant was now making the cheese five days a week in order to keep up with consumer requests. As such, new equipment and additional employees were needed, so the company reached out to the CDR TURBO program to see if there were any resources available to assist with the expansion.

The TURBO program, which is led by CDR's Vic Grassman, is a comprehensive business accelerator designed to increase the speed of commercialization for new products and technologies specifically related to the dairy industry. More recently, however, the program has started to offer fee-for-service economic development assistance to Wisconsin dairy product companies to support their business growth. This assistance includes site selection, real estate expansions, capital equipment expenditures, entrepreneurial support services and help with workforce issues.

After discussing the options, Grassman and Hamann began working together to apply for grants and in 2016, Chula Vista/V&V Supremo was able to secure a grant through the Wisconsin Economic Development Coorportation (WEDC) that allowed them to purchase some equipment needed to increase production. "This was really a collaborative effort," said Grassman. "Together we were able to successfully create a product, secure the WEDC funds and create new jobs in a rural area."

Oaxaca exiting the extrusion "fingers."

While the product has been launched and the equipment is in place, Chula Vista/V&V Supremo and CDR continue to work together.

"CDR has been great to work with," said Dahmen. "The relationship has been beneficial in both short and long term success. Between the hands on and the theory, we know we can always call CDR to talk cheese."

For more on the CDR TURBO program, please visit www.turbo.cdr.wisc.edu or contact Vic Grassman at vgrassman@cdr.wisc.edu

For more information on Chula Vista/V&V Supremo Oaxaca cheese please visit www.vvsupremo.com/products/semi-soft-cheeses

The Chula Vista/V&V Supremo Queso Oaxaca Ball can be purchased in Wisconsin at Woodman's, El Rey, Sendik's and at various retailers throughout the United States.

MICROBIOLOGICAL METHODS: HOW THEY WORK AND WHAT COULD GO WRONG

Contributed by: Adam Borger, Outreach Program Manager, UW Food Research Institute

Microbiological test methods are a bit like those rickety carnival rides that pop up every summer across random rural parks and mall parking lots – you don't really know what goes on behind the scenes; you definitely have a vague sense of unease that something could go very wrong; but you figure it's better to not think about it and hope for the best as that rusty, ¼ inch iron lap-bar is "locked" across your torso with a hitch-pin and off you go on what could be a very wild ride!

When things consistently go smoothly with your microbiological testing results (i.e., everything is "negative" or "in-spec") it is easy to forget that there are many factors that can adversely affect a test and cause a false-negative or false-positive. Unfortunately, now and again when such results arrive it is quite common for people to become confused, perhaps enraged, and direct their ire towards the lab or test method. Having a basic understanding of the potential pitfalls of microbiological testing won't help ease the pain of true "positive" or "out-of-spec" results but could help you avoid some erroneous test results in the future.

One of the first steps in truly understanding microbiological testing is to know what your final result should be. You might be shaking your head thinking "It should be negative for genus *Listeria*, genius!" That is not what I mean. One needs to understand whether a number of microorganisms is to be reported or, as is often the case in pathogen testing, whether a "negative", "presumptive positive" or "positive" result will be reported. Below I will discuss these different scenarios and what goes on behind the scenes at the laboratory.

Quantitative tests: Most food and ingredient quality indicator test results are reported as some quantity of microorganism colony forming units (CFU) per milligram of food sampled. These are called **quantitative** tests and are usually performed using agar or liquid culture media to arrive at an estimated count per gram of food or milliliter of liquid. Examples of quantitative tests include aerobic plate count (aka standard plate count), coliform, *enterobacteriaceae*, generic *escherichia coli*, *Staphylococcus aureus*, yeasts and molds.

Agar plate counts are an indicator of the bacterial counts and probably, the simplest quantitative microbiological tests to perform for food and environmental samples. Then using agar or similar methods the media chosen should be proven to allow for the growth of the bacteria and/or fungi that you wish to enumerate. In some cases media may be selective for

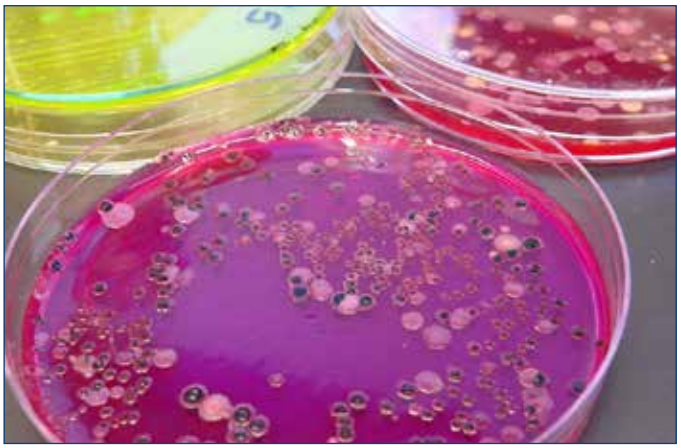
particular microorganisms and may even differentiate closely-related bacteria and fungi. For example, coliforms are gram-negative bacteria that ferment lactose to produce acid and gas. Coliform count tests are performed on media containing chemical constituents that select for gram-negative coliform bacteria while hindering the growth of gram-positive bacteria such as *lactobacilli*. The media also contains lactose and an acid indicator dye to differentiate coliform bacteria from other gram-negative bacteria that may also grow on the agar. Therefore, if a bacterial colony ferments lactose to produce acid, an accompanying color change of the dye within the agar differentiates this coliform colony from those bacterial colonies that do not ferment lactose. The production of gas is yet another differential indicator that the colony is a coliform.

Qualitative tests: In contrast to agar or liquid culture media testing that yields a quantity of microorganisms per gram or volume of sample, **qualitative** tests are used to detect the mere presence of a microbe in a sample. Many pathogen tests such as genus *Listeria, L. monocytogenes, Salmonella*, and *E. coli* O157:H7 are qualitative tests. If you are testing finished product for *Salmonella* you probably do not immediately care about the number of *Salmonella* cells present in a sample. ANY *Salmonella* is bad news – and you just want to know if it is there and act accordingly.

Presently, most pathogen test methods are either genetic-based testing, where a specific piece or pieces of a microbe's DNA/RNA are detected, or antigen-based testing, where specific antigens on the cell surface are detected. Pathogenic microorganisms should be present at much lower numbers than total aerobic bacteria or yeast and molds. Therefore, test kit manufacturers go to great lengths to develop their methods to be very specific and sensitive. Specificity is the ability of the test to correctly detect the microbes it should while not detecting those it should not. Sensitivity involves the level of microbes required at the point of testing to be detected correctly. These concepts will become clearer in a moment.

Since the numbers of pathogens present in foods, ingredients and environmental samples are often very low, trying to detect them can be like finding a needle in a haystack. Thus a step is required where a larger volume of liquid media is added to the sample which in turn helps resuscitate cells, increases their numbers and may select for the targeted microbe. After this enrichment step the cell level must be at a certain quantity (detection level) so that the test method has a fighting chance to detect the presence of the target microbe's genetic material or antigen structure. By raising the cell level with an enrichment step you are essentially still looking for the presence of a needle in a haystack – but there are now 100,000 needles in there and your chances of finding one are much higher.

The ability of a test method to sift through large amounts of proteins, carbohydrates, fats, spices, colors, other bacteria, yeasts and molds and correctly detect a pathogen is actually very impressive. These elements are not to be ignored as they can adversely affect the ability of a test to perform as intended and result in a **false-negative** or **false-positive** test result.



Selective and differential agars help distinguish Salmonella *(black colonies on plate) from other bacteria (everything else present).*

Here are just a few examples of how these may occur.

False-negative results: It is imperative that you know whether the pathogen test method chosen has been validated using your food product matrix or something very similar. Spices like onion and cinnamon are known to contain antimicrobial constituents and have been shown to prevent microorganisms from growing to the detection levels needed during some enrichment steps. Not all cheese is the same so while a method may be acceptable to test for *L. monocytogenes* in American cheese, it may not be applicable to Feta soaked in onion and cinnamon-infused oil which A) sounds awful and B) may restrict the *L. monocytogenes* present in the food from growing to the required detection level in the enrichment due to the presence of those spices. The result is a false-negative test result. Failure to investigate this potential pitfall could be disastrous for a manufacturer and their consumers.

As mentioned above, specificity involves the ability of the method TO detect the microbes it is supposed to detect and NOT detect the microbes that is shouldn't detect. As a food producer using (and paying for) these tests you should have some idea of the specificity of the tests. For example, if a test detects only some of the species within the genus *Listeria* you must ask yourself, is that good enough? Years ago I spent weeks in frustration attempting to validate a method by intentionally spiking laboratory samples with *Listeria* only to find out that the test method I used was not capable of detecting the particular species of *Listeria* that I was using! Thus, the specificity of the test was not inclusive for that particular species of *Listeria* and I suffered the consequences of a false-negative test result.

False-positive results: While enriching samples raises the level of the targeted bacteria, other microbes closely related to the target may on occasion grow to even higher levels in the same enrichment. If that happens a test method may be overwhelmed by the presence of great numbers of closely-related microbes' genetic material or antigens and yield a "positive" or "presumptive positive" result. This is actually a false-positive result. One example of such a phenomenon is when *Citrobacter*, a gram-negative coliform bacterium in the family *Enterobacteriaceae*, grows to very high levels

in an enrichment for *Salmonella* (also a member of the *Enterobacteriaceae* family). The presence of such a high number of *Citrobacter* may cause a genetic-based and/or antigen-based pathogen test method to indicate the presence of *Salmonella.* This is due to non-specific binding of the large amount of closely-related, but not identical, genetic material or antigens present in the enrichment, yielding a false-positive. Keep in mind that non-specific binding may be compounded due to poor laboratory techniques such as maintaining test kit reagents at the wrong temperatures during analysis and may also cause false-positives.

Microbiological Confirmation: Manufacturers of pathogen detection tests go to great lengths to prevent both false-positive and false-negative results but no test is perfect. Suppose a company claims a false-positive/negative rate of ≤0.05%. If you perform 10,000 genus *Listeria* tests a year, theoretically that could result in five false-positive or false-negative tests. In part because of this seemingly small potential for error, the results from initial genetic- or antigen-based pathogen detection tests are often reported as "presumptive positive". At this point the onus is on the food producer to determine whether to react to this "presumptive positive" result as their final result or go one step further and perform a **microbiological confirmation** of the result to achieve a final "positive" or "negative" pathogen test result. And what do most of these very specific and sensitive genetic- and antigen-based pathogen test methods use to confirm the results? Cultural methods like liquid media and agars.

The benefit of using cultural methods for confirmation of "presumptive positive" pathogen test results is at this point the enrichment media used should contain high levels of the specific, targeted microbe. By placing a sample of the enrichment media on an agar plate or in liquid media that selects and differentiates for the pathogen, the chances of an incorrect result are very low. Revisiting the example where *Citrobacter* tested as "presumptive positive" for *Salmonella*, by streaking that enrichment onto an agar which is very selective and differential for *Salmonella* should not yield any colonies that look like *Salmonella* on the agar – because there AREN'T any *Salmonella* there, it's *Citrobacter*. The lab would then report a final result as "negative" for *Salmonella* based on the lack of cultural confirmation from the same sample that yielded a "presumptive positive" before. Confused? You aren't the only one.

Conclusion: Many people become confused with the processes around microbiological testing of foods and mistakes occur when a food manufacturer and the laboratory are not on the same page. It is crucial that you establish a perfectly clear protocol for your facility and the testing laboratory addressing:

1. The type of result to expect (quantitative vs. qualitative).
2. The use of validated methods demonstrated to work for your food, ingredient and environmental samples.
3. The potential requirement for cultural confirmation of "presumptive positive" pathogen results.

You should also be sure to have a plan in place for dealing with a positive result. Doing so will help everyone better understand and interpret your microbiological results, but it probably won't alleviate that nauseated feeling folks still get, when those laboratory results arrive.

BIG ISN'T ALWAYS EASY – ISSUES TO CONSIDER WHEN MANUFACTURING 640 POUND BLOCKS OF CHEESE

Technical Contributor, Dean Sommer, CDR

History Of 640 Cheese Blocks

Popularity of 640s has steadily increased since the 1970s. Kraft Cheese is widely recognized as the inventor of the 640, but in some respects, the name 640 is a misnomer today, since most companies target a finished weight of around 700 pounds for these large cheese blocks.

In the early days 640s were manufactured by collating 16, 40 pound blocks into one large 640 pound block. The 16, 40 pound blocks were initially formed, then hand placed into a 640 pound box form, pressed and then vacuumed before being placed in a cooler. Over time, a lot of cheese factories switched to direct fill 640s. During this process either milled curd or granular curd was directly conveyed, by an auger or pneumatically, to a 640 fill station to fill the box. This system necessitated some specialized ways to subsequently drain the whey from the interior of these large cheese blocks. The two most common methods used were pressing the curd with a pair of perforated drainer screens, which provided a passage for the whey to be removed from the block. Or, alternatively, cheesemakers used a probe system where a series of stainless steel probes penetrated the box of curd and free whey was vacuumed out of the block.

The Benefits and Challenges of 640s

A lot of the early acceptance of the 640 was based on the ability to reduce trim by cutting the cheese into exact weight chunks at the conversion facility, but over time it was discovered there were additional handling advantages to 640s. For example, there were less pieces to handle at the conversion plants and it was much easier for workers to strip and load one 640 block on the feed line compared to opening and stripping 16, 40 pound block boxes. There was also less material waste of corrugated boxes, 40 pound box liners and plastic film. The wooden 640 box components and steel legs, springs and irons could be cleaned, processed and reused, making 640's sustainable long before we ever thought of using that word in our industry.

But, as the late Dr. Bob Sellers used to say, in this industry for every positive aspect of a choice there is also a negative, and that is certainly true of 640s as well.

One of the early negatives of the collated 640s was the presence of visible lines or seams on the cheese resulting from the exterior of the original 40 pound blocks. Additionally, the advent of

direct filling of the curd into the boxes brought about new struggles in regard to achieving a tight knit of Cheddar cheese. Since then, all too often Cheddar 640s have been plagued by mechanical openings, similar to what we've historically seen in Colby cheese. These unwanted mechanical openings can be the result of any number of issues. First, it's very likely that the curd pH was too high at filling, resulting in the curd being too firm and not fusing together. Another reason for this issue may also be very high salt content, which can cause the salt to form a hard shell on the exterior of the curd and thereby disrupt knitting. In addition, some plants may be overcooling their curd with a cold water rinse, or the air in the area of the open curd tables may be too cold. Either way, this temperature issue can result in a cold curd that can't knit properly.

Sampling a 640 block.

A natural reaction to this lack of curd knit is to press the curd harder. Unfortunately, that just makes the openness problem worse. Pressing the curd too firmly during initial stages of block formation actually seals the exterior of the 640 and locks air inside the block, resulting in too many mechanical openings. Vacuuming is also an important part of minimizing this defect. Some factories simply do not allow for a long enough vacuum time and vacuum depth to remove air from the 640 and assist in achieving a good curd knit.

To prevent the issues listed above, keep the curd warm, above 80 ^{0}F, and do not press the curd at all for the first 15 minutes after fill and press. Be sure to vacuum as close as possible to 28 inches for a minimum of one hour in order to prevent excessive openness in the cheese. Double vacuuming the blocks is even better yet. As Steve Krause, retired cheesemaker and 640 expert has said, it's impossible to vacuum a 640 too long or with too much vacuum.

Another issue that is seen in 640s is the presence of a whey taint flavor. To avoid whey taint flavors you need to develop sufficient acidity and allow for proper whey syneresis prior to filling the box. With such a large block mass it is often difficult to get all the whey out of the interior prior to filling, but keep in mind that the sooner the whey exits the cheese block, the better in terms of flavor. Despite your best efforts, it is likely that some whey will remain in the block after filling. Therefore, great care must be taken with the drainer press or probe system to remove sufficient quantities of whey. Also, be sure to allow for sufficient time for whey drainage (drainer blade system) or whey removal by probes. You will also need to allow sufficient time for passive whey drainage after vacuum treatment.

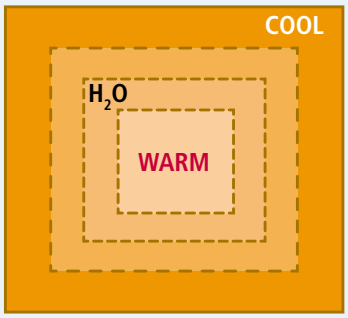
Gas production in the middle of the 640 blocks has also been a problem at times. If too much whey is left in the interior of the block, the contaminant heterofermentative *Lactobacilli* could ferment the lactose in the whey to form carbon dioxide gas. This creates gas holes in the interior of the block, which, when they are severe, have been described as cabbage heads. The most important prevention technique is the utilization of high quality milk that lacks microbial contaminants such as the one listed above. This defect can also be combatted by attempting to cool the 640s as quickly as possible to reduce the temperature and limit the growth of these gas producing bacteria. This rapid cooling can lead to moisture migration issues, so finding that sweet spot where cooling is not so fast that it promotes moisture migration but not so slow that it allows for gas production, is important, but ultimately an experiment.

Unwanted fermentations in a 640 block.

Moisture Migration

While the previous section listed a few issues with 640s, moisture migration in the block requires a deeper dive as it can result in both poor quality and negative financial consequences. At a very basic level, moisture migration results in a non-uniform cheese where the moisture levels differ significantly between the center and the exterior of the block. This large gap in moisture makes obtaining a representative sample for moisture determination problematic. For example, in a 640 of Cheddar the outer one inch of the block may contain 43 percent moisture while the inner may contain 36 percent. With 39 percent being the legal maximum moisture level, this difference means that the 640 cannot be cut into chunks and sold at retail as each chunk would not meet the legal moisture levels. With such a huge moisture differential, the inner core of the block is brittle, which would lead to poor machinability in shreds so this cheese is likely headed for processed cheese, resulting in a lower value price for the cheese.

Moisture Migration in 640 Blocks



Serum will move from the center of the block to the outside. As a result, the moisture content will be highest on the outside and the % fat and % casein content will be lower on the outside.
Outer 1 inch = ~21% of the weight
Outer 2 inches = ~39% of the weight

Keep in mind that moisture migration is driven by rates of cooling and the inability of the curd to strongly hold the moisture and keep it from migrating when the curd is young. Moisture moves from warm areas (the center of the block) to colder areas (exterior portions) of the block. Reportedly this movement of moisture is driven by physical principles such as differences in vapor pressure, hydraulic pressure, as well as the ability of the casein molecules to bind water. With such a large curd mass it takes up to 10-12 days to cool the center of the 640 block to 42 ^{0}F, which is the temperature most customers require upon delivery. This is further complicated by the fact that initially the casein network is not conditioned to strongly absorb moisture or restrict moisture movement. When the cheese is very young too much of the calcium is still insoluble and binds the casein molecules tightly together, but when the cheese is warm inside the unbound water is free to migrate to the colder exterior. Over a few days, however, the acid in the curd solubilizes more of the calcium that is binding the casein together, loosening the casein structure and allowing the free moisture to be trapped more tightly within the casein network. This concept can be easily demonstrated in pasta filata

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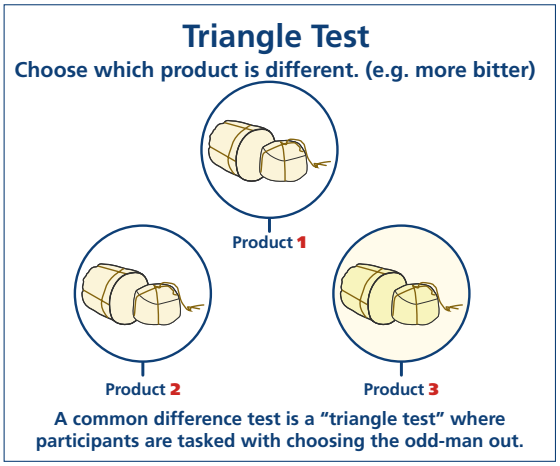
SENSORY ANALYSIS: THE TOOLS OF THE TRADE

Contributed by Pat Polowsky, Sensory Coordinator, CDR

Sensory analysis is using the human senses to evaluate products. When used appropriately, it is a valuable tool that allows for quick and meaningful information. Employing the human senses is the oldest form of product quality control and still serves an important role in today's dairy industry. The use of licensed graders, quality control panels, trained descriptive panels and consumers' insight all have their place in the current sensory landscape.

The various methods used in sensory analysis often take the form of different sensory tests and evaluation protocols. Based on the overall goal for your product, some sensory tests may be overkill while others might not give actionable information. It is important to choose a test based on the questions you want answered. When used correctly, sensory analysis can be an extremely effective and efficient form of testing for various products. The following is a brief explanation of a few basic tests that exist in the sensory evaluation toolbox.



What are you looking for?

PRODUCT FOCUSED

IS THERE A DIFFERENCE? **Discrimination Tests**

Product Insight

WHAT IS THE DIFFERENCE? **Descriptive Tests**

PEOPLE FOCUSED

HOW MUCH IS IT LIKED? **Affective Tests**

Consumer Feedback

IS THERE A PREFERENCE? **Preferences Tests**

We changed an ingredient. Is there a noticeable difference? (Discrimination Tests)

Changing an ingredient in a product can be a risky venture. Ingredient substitutions are usually done due to cost reduction measures, improving the label, or supplier changes. Answering the question "Are these products different?" is addressed by a realm of sensory methods know as discrimination tests (also called "difference" tests). These tests are designed to aid in determining if there is a noticeable difference between products.

In most cases, discrimination tests use around 25-40 respondents who may or may not be screened for acuity. Using semi-trained or trained respondents can be an option if the expected difference is very slight or the product makes it difficult for the average consumer to evaluate. In these tests, statistical analysis is used to determine if there is in fact, a significant difference between products. Examples of difference tests include: triangle tests (pictured), duo-trio tests and many more.

A downfall of discrimination testing is not being able to determine what the difference is if one exists. Since panelists are asked to evaluate products as a whole, their responses can't give much insight as to what particular part of a product is different. In some cases the product developer can assume what the difference is (e.g. lowering the amount of sugar). In other cases, further testing must be conducted in order to determine what the different is between the products. [See descriptive test section]

Overall, discrimination testing can be a useful tool to aid in decision making if changing a product line is a viable option. This type of testing is one of the cheapest and most rapid sensory testing options available. For substantial changes and critical projects, further consumer testing is often needed.

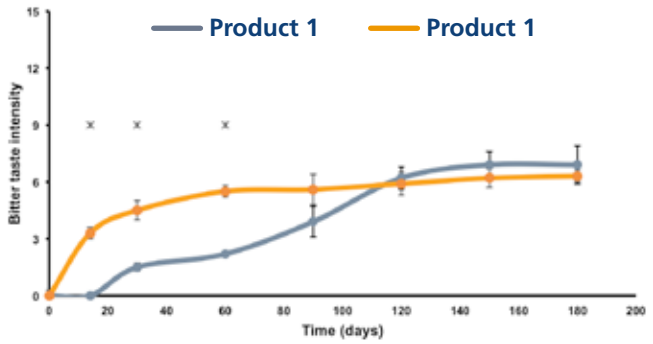
How did changing an ingredient affect the overall flavor of my product? (Descriptive Tests)

When a product developer wishes to profile the flavor and texture of their product they will often employ descriptive analysis. While discrimination testing and consumer testing can shed light on whether products are different and if one is liked more than another, descriptive testing is necessary to measure how the products are different and by how much.

Descriptive analysis utilizes panelists who have been trained for many hours on how to detect and quantify various product attributes. They will often measure attribute intensities on a 15-point scale based on standardized flavor/aroma references. Since the panelists have been trained on a common scale for each attribute, their responses can be used to compare across products or for the same products over time.

This type of testing can be very costly and time consuming due to the amount of training that is needed in order to get consistent results. Panelists must be trained for each

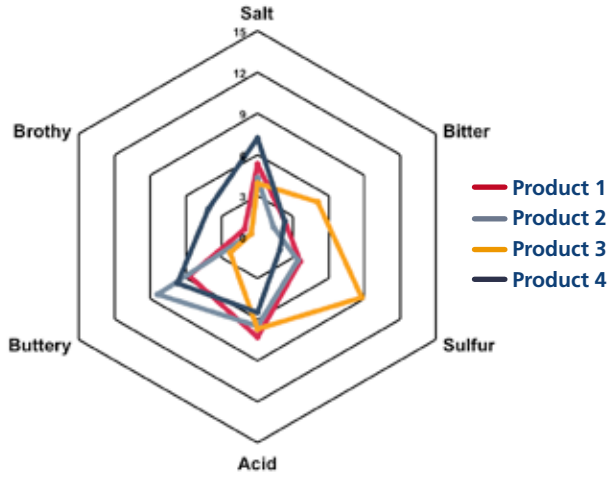
Example of descriptive test results.



Changes in bitter taste over six months (180 days). Error bars show panel standard deviation. Asterisks above data points indicate statistically significant differences between products (<0.05).

product and each attribute that is of interest. However, once a standing panel has been established and trained, they can be used to reliably measure the overall sensory profile of various products.

Example of descriptive test results.



Flavor descriptive analysis comparison across four products.

There is a noticeable difference do people still like my product? (Affective Tests)

As discussed above, changing a product usually first involves determining if there is a perceptible difference. If a difference is detected, then it is necessary to determine if that difference affects how much consumers like the product. These types of tests are known as acceptance or affective tests. A term often used in conjunction with this type of testing is "hedonics," which is another way of saying how much people like something ("degree-of-liking").

This type of testing involves presenting consumers multiple products and gathering their input using basic questions. Consumers will rate how much they like certain product characteristics on a 7 or 9-point scale. From there, statistical analysis can be used to determine if the products are liked differently.

This type of testing can be costly and time consuming, but gives valuable information since consumer opinions are being polled directly.

Do consumers prefer my product or my competitor's? (Preference Tests)

Preference testing is used to establish if consumers prefer one product over another. The most common form of preference testing is presenting a consumer with two products and having them choose the one they prefer. This is called a paired preference test.

It is important to realize that you can't necessarily draw the same conclusions from an acceptance test and a preference test. It is entirely possible that consumers, on average, like two products to the same level (e.g. 6 out of 9 on a hedonic scale), but still prefer one product over another. Since preference is a holistic decision in many cases, it can be difficult to get reliable answers from consumers as to why they preferred one product over another.

Conclusion

We've just scratched the surface of the numerous sensory tests available to measure product-specific and consumer-specific insights. Many more tests exist that often blur the boundaries between what we discussed here.

Overall, the first step in choosing any sensory test is to understand the goal(s) and what question you want answered. With that information in mind, choosing a sensory test that will give useful and actionable information is much easier.

For more information contact the CDR Sensory Program at: sensory@cdr.wisc.edu

To view an informational video about the CDR Sensory program go to www.cdr.wisc.edu/sensory

SALTING OF CHEESE: SIMPLE OR NOT?

Technical Contributors: Dean Sommer, CDR and Nicole Durch, Senior Technical Service Representative, Cargill Salt

At first glance it would appear that salting of cheese is a simple process. Throw a little salt on the curds, or soak a block of cheese in a salt brine for a few hours and all should be well.

Unfortunately, with respect to the salting of cheese, things are not quite that simple. Proper salting requires a thorough knowledge of the best storage, handling and application practices. In fact, having this knowledge is one of the most important things a cheesemaker can do to achieve a safe, uniform product. Uneven salting of the curd inevitably leads to cheese defects. One of the main effects of salt on the curd is to attenuate the acid producing activity of the starter culture. If some parts of the curd in a block of cheese have less salt than others, due either to lumping of the curd or simply to uneven distribution of salt on the curd, more lactic acid will be

produced in those areas and acid spots will develop in the cheese. Therefore, knowing how to maximize salt absorption and attain uniform concentration is key to maintaining quality. Without this knowledge cheese flavor, texture and shelf-life can suffer and ultimately the industry is worse for it. Therefore, this article provides the background knowledge every cheesemaker needs in order to achieve the desired product and maintain safety.

Back to Basics: Salting

There are three main ways to salt cheese: dry salting; brining; and dry surface rubbing.

Dry salting is the direct addition of salt crystals to the surface of fresh curd. For cheese varieties like Cheddar, Colby, and Monterey Jack, traditionally dry salt can be applied in one of two ways. First, it can be weighed to get the desired amount of salt to add to the curd, then manually spread on the curd by an operator who allows the agitation of the curd table to uniformly mix the salt into the curd. Alternatively, with some of the larger plants today using enclosed finished vats or salting belts, filtered, dehumidified air can be used to pneumatically convey the salt to the salting vat or belt and automatically distributed onto the curd.

Dry Salting

Brining is another common salting technique utilized in cheese variates such as low moisture part skim or whole milk mozzarella, wheel Parmesan, wheel Gouda, wheel Swiss, Gruyere, Muenster, Brick and others. It essentially involves the immersion of the cheese in a concentrated salt solution for a specific period of time. Maintaining consistent salt levels in the brine can be a challenge. As salt is being taken up by the cheese from the brine, the cheese releases water into the brine. This results in a reduction in the salt concentration in the brine. Replenishing the salt in the brine at an appropriate level is, therefore, critical to maintaining salt levels in brined cheeses. Monitoring the brine strength is easily accomplished with a brine hydrometer or salometer, which is a weighted bobber-like device with a calibrated narrow neck in a shape similar to a Babcock fat test bottle. The more salt that is dissolved in the brine the higher the salometer will ride in the brine, and the calibrated salometer neck allows the operator to directly read the current brine strength.

Brining

Another version of brining is used in a few varieties, such as Feta or fresh Mozzarella. In this case, the pieces of cheese are packaged in containers or buckets that are filled with salt brine. The trick with this method is to use a brine with the correct amount of salt in it so that the cheese will ultimately absorb just the desired amount of salt from the brine as the cheese works its way to your customer.

For brined cheeses, brine concentration, temperature, pH and cheese composition affect salt absorption. In general the higher the salt content of the brine, the more salt will be absorbed by the cheese. However, the rate of salt uptake increases at a diminishing rate as the salinity of the brine increases. Therefore, higher salinity brines result in less depth of penetration of salt into the cheese. The lower the cheese pH and the warmer the cheese going into the brine, the faster the uptake of salt.

Lastly, for a few varieties, including Swiss, Baby Swiss, some blue and Brie cheeses, and Limburger, dry salt can be rubbed on the surface of the blocks and wheels in order to salt the cheese and form a rind. For more on each method, please also see The Dairy Pipeline, Vol. 17 #1.

Dry rub salting – Limburger

Selecting a Salt

As we noted in the beginning, when it comes to salt, the goal is always to choose a salt that allows for maximum salt absorption and the creation of a uniform cheese. Therefore, it's important to know which type of salt works best for each application and cheese variety. The type of salt and crystal size and shape used will be dependent on two main factors: the specific needs of the cheese variety and the type of equipment that will be used to salt the cheese. Salts with different crystal shapes and sizes have different surface areas. Often the more surface area a salt has the more quickly it will dissolve. Smaller salts usually have greater surface area compared to larger salts of the same crystal shape. To clarify this issue, please see Table 1.

Table 1.

Type of Salt Application	Size	Type
Pneumatic Conveyor	Larger size salts (30 x 70 mesh)	Cubic, granulated as they are more durable
Hand/Manual	Any salt size, avoid very fine salt if dusting is a challenge	Any crystal shape as this is a gentle process
Brine	30x70 mesh is commonly used but many sizes and shapes will work depending upon the rate at which you want the salt to dissolve	Use salt larger than 100 mesh if dusting is a challenge. Also, consider installing a 100 micron filter prior to the salt entering the brine production system
Dry Rub	Depends on the rate at which the salt needs to dissolve	Salts with larger surface areas dissolve faster while salts with smaller surface areas will dissolve slowly

A special note about the pneumatic system

While each method of salting has its unique challenges, pneumatic systems need proper design and attention in order to limit the breakdown of salt. The breakdown f salt results in the creation of salt fines that can lead to plugged filters and inconsistent salt application. Cheesemakers tend to think of salt crystals as indestructible. Unfortunately, this is not the case. The pneumatic conveying of salt, if done improperly, can result in significant breakage and crystal damage which results in wide variations in salt crystal size when salting the curd. This, in turn, can dramatically influence uniform salting of the curd and the overall quality of the finished cheese.

Pneumatic system piping is one area that needs to be monitored in order to avoid breakage. Short, straight, horizontal runs of salt pipes will minimize crystal damage. The more elbows there are in the pipes the more the salt crystals will slam against the sides of the pipes and be broken up. The system must be designed to limit damage to the salt crystals so that large amounts of small salt fines aren't created, leading to poor uniformity in salting of the curd.

Table 2. Salt in moisture for slected cheeses

Cheese	S/M (%)
Cottage	1.0-1.2
Swiss	3.0-4.0
Cheddar	4.5-5.5
Provolone	5.0-6.0
Blue	8.0-10.0
Feta	10.0-12.0

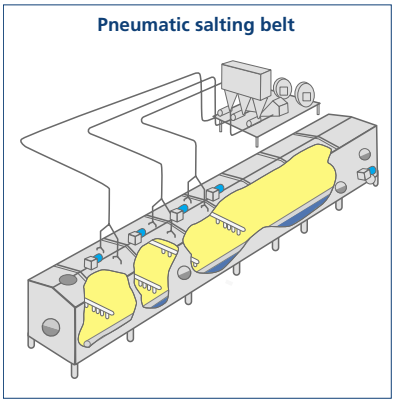
Table 3. S/M % Impacts water actavity (A_w)

Cheese	(A_w)
Camembert	0.982
Brine	0.980
Emmenthaler	0.972
Edam	0.960
Cheddar	0.950
Parmesan	0.917

While there are many things to consider when using a pneumatic conveyor system, perhaps the most important thing any plant can do is to create and maintain a positive relationship with an expert consultant or engineer. Explain to this professional that salt integrity is important to making a quality cheese and this person can assist with proper design and modifications.

Finally, in regard to the actual application of salt using the system, care must be taken to ensure that the salt is evenly applied to the curd on the belt and that the stirring mechanisms adequately mix the salt uniformly onto the curd. This requires the proper salt distributor at the end of the pneumatic conveying system that evenly spreads a fine layer of salt over the surface of the curd in the table or on the belt. It also requires the correct agitation system and the correct time to uniformly stir the salt onto the curd and provide enough time for initial salt absorption. Keep in mind that whey is drawn out of the curd by salt. If salt is applied too rapidly to the curd, you will end up with lower salt absorption. This is due to the curd's inability to absorb salt fast enough before the whey rinses away the salt, making it unavailable for absorption.

Pneumatic salting belt



Moisture, Temperature and Crystal Size

In addition to this knowledge, a cheesemaker should also be aware of the role curd temperature and curd moisture content play in salt retention. The moisture content of the curd plays a key role in salt retention. For example, curd at 90 ^{0}F retains less salt than does colder or warmer curd, likely because at 90 ^{0}F fat coats the surface of the curd and slows salt absorption. At higher temperatures, the fat on the curd surface liquefies and goes into the whey; at lower temperatures, less fat is released to the surface of the curd. Higher moisture curd also results in less salt retention, likely due to the rinsing effect of more whey syneresis. Therefore, depending on the specific needs of the cheese variety, curd temperature should be taken into consideration prior to salting.

Crystal or grain size should also receive special considerations as research shows the flake size does affect retention rates. In fact, Professor Bill Wendorff, Ph.D., did a study on Alberger (Cargill) salt retention and found that fine flake salt displayed the highest salt recovery percentage at 51 percent. Other salts, including special flake, flake and coarse salts showed 45 percent, 45 percent and 48 percent retentions, respectively. For more on this particular issue see The Dairy Pipeline, Volume 14 Number 4.

Kaufman and Olson (1985) also did a more general study on salt retention and found that a finer crystal size facilitated absorption better than a coarser grade of salt.

Storage and Handling of Salt

Correctly utilizing salt is essential, but maintaining the quality and integrity of salt is equally important. Therefore, it's imperative that cheesemakers remember that the transport and delivery of salt to the cheese plant plays a major role in the overall quality of the salt. Before transportation even begins, be sure that you are purchasing salt that is packaged in a multi-walled bag to prevent moisture from caking the salt. Also, the bags should be designed to be stripped prior to emptying, meaning the outer paper layer of the bag should be removed prior to emptying the bag so that any dirt or foreign material or microbes on the exterior of the salt bags do not contaminate the salt during emptying of the bag. During transport pallets of salt bags should be stretch wrapped to prevent dust and dirt from contaminating the exterior of the bags in the first place and the tops of the palletized salt should be covered with plastic film for the same reason. Keep partial pallets of salt covered by a top sheet to keep them clean. Pallets used for salt transportation should also be clean and should not have nail heads or wood splinters sticking up that might puncture the bags of salt. Use a first in, first out (FIFO) process when utilizing the pallets of salt to prevent salt from clumping due to long storage times.

Once the bags have arrived at the facility the salt should be

stored in a room that is dry and separate from the cheesemaking area where moisture is often present. To limit clumping of the salt, the humidity should be maintained below 75 percent and salt should be stored on racks, not stacked on other pallets of salt. One of the worst things a cheesemaker can do in regard to salt storage is to allow the temperature, and as a result the humidity, of the storage room to change on a regular basis. Fluctuations above and below 75 percent humidity will result in caking. An increase in fluctuations will decrease the amount of time the salt will remain free flowing. Keep in mind that if caked, lumpy salt is added to the curd you will end up with a localized area of high salt cheese which will be high in pH due to the high salt concentration snubbing the action of the starter culture.

When a cheesemaker is ready to move the bags of salt from the rack storage system to be emptied into a salt bin, a couple of additional options should be considered. First, a coarse screen or grizzly bars can be used to prevent lumps from getting into the bin which could result in plugging or bridging in the bin. This may also help to prevent larger pieces of the storage bag from entering into the salting system. Second, rare earth magnets can be installed prior to salting. It is best to install the magnets close to where the salt is applied to the cheese. This provides an opportunity for metal that may have been picked up in the process to be removed by the magnets. The magnets should be inspected on a regular basis, at least daily. This is a proactive approach to metal detection and removal, versus relying on metal detectors after the cheese has been made. Operators should also routinely monitor the visual purity of the salt by observing the salt for excessive amounts of brown and black specks that can sometimes contaminate the salt during manufacture, storage and handling.

For cheesemakers buying salt in bulk, keeping bulk tanks clean is important as well. Therefore, it is best to have two separate tanks and alternate their usage. This can also help to keep different lot of salt separate from each other. When one is not in use, utilize vibration or other dry cleaning methods in order to keep salt particle build up on the sides of the tank at bay. If two tanks are not possible, be sure to empty the tank on a scheduled routine basis and do a dry cleaning. Ideally this should be preformed 3-5 times a year but at a minimum once a year depending on salt usage. Also note that if you are using plastic tanks, it's ideal to electrically ground them in order to avoid static which can result in finer salt particles clinging to the sides of the tank. These fines can form chunks that break off causing the tank to plug or larger chunks of salt to be applied to the cheese.

Special Note about Anti-Caking Agents

Anti-caking agents are commonly added to salts as clumping is a frequent issue that creates a lot of headaches for cheesemakers. A common anti-caking agent used in salt is yellow prussiate of soda (YPS) but others include tri-calcium phosphate (TCP) and magnesium carbonate. Yellow prussiate of soda is known to be the most effective salt anticaking agent. It is added to food salts in miniscule (not to exceed 14ppm) amounts to prevent caking. It is classified as GRAS (Generally Recognized as Safe) and is classified by FDA as a food additive for the direct addition to food for human consumption, and is allowed by the FDA as an anti-caking agent in salt in 21 CFR 172.490. For more on this reference Food Chemical Codex, FCC Sodium Chloride Monograph.

Conclusion

Salt is one of the most important factors in terms of cheese functionality. Too little salt and the cheese will have a flat flavor, too much acid development and a short shelf-life. Too much salt and the cheese will have a salty flavor, poor acid development and significant moisture issues. Therefore, the main takeaway from this article is that maintaining consistency during the salting process is key to manufacturing a safe and delicious cheese product. Take each element discussed here into consideration and develop a salting procedure that will leave you with a product that meets the legal requirements and exceeds consumer expectations.

References and additional resources:

The Dairy Pipeline: Vol. 12 #3, Vol. 12 # 4, Vol. 14 # 4, Vol. 15 #2, Vol. 17 #1

Kaufman, S.P, and N.F. Olson. 1985. Salt crystal dissolution rate relative to salt recovery and other factors in Cheddar cheese. Final project report to Diamond Crystal Salt Co, St. Clair, MI.

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Mozzarella cheese. For example, on day one, when the mozzarella is cut in half, free moisture often pours out of the cut surfaces. But, if you allow the same Mozzarella block to sit for a few days and then cut it, no free moisture escapes. This is proof that the casein structure has opened up and that the calcium has been solubilized by lactic acid thereby trapping the water more tightly.

If you are manufacturing higher moisture cheeses, like Monterey Jack or Colby, note that these cheeses typically experience larger moisture differentials than, a Cheddar, especially a lower moisture aged Cheddar which is started at a lower moisture from the beginning. This is due to the inherently higher moisture content of a Monterey Jack or Colby cheese variety. Granular curd typically has significantly higher moisture migration than does milled curd, likely because there is much more openness inside the block with granular curd and the free moisture can more freely move within the block.

Limiting Moisture Migration

In order to minimize moisture migration, it is important to solubilize some of the bound calcium in the casein matrix and make it more conducive to holding onto water. This can be done by generating more acid production prior to renneting or performing preacidification of the cheese milk. Adjusting the cheese make procedure to achieve a drop in pH and increased whey syneresis before filling the 640 will also help.

One of the most significant ways to limit moisture migration in the 640, however, is to reduce the pressures driving the moisture to move. Those pressures are generated by temperature differentials within the block during cooling, so slower cooling of the block will reduce temperature differentials and reduce moisture movement. One way to achieve this is to simply increase the temperature of the cooler where initial cooling occurs. Keep in mind that this must be balanced by the potential risk of unwanted fermentations and gas production in the centers of the 640.

The material used in the 640 box is another means to slow

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MARK JOHNSON, PHD EARNS THE CALS AWARD FOR EXCELLENCE IN SCIENCE

Please join us in congratulating CDR Assistant Director and Distinguished Scientist Mark Johnson, Ph.D. on his University of Wisconsin, College of Agriculture and Life Sciences (CALS) Award for Excellence in Service.

Given to only one staff member per year, this award honors those who go above and beyond the normal call of duty while showcasing outstanding service and dedication to their area of expertise. Thanks to letters of support from members of the industry as well as academic peers, Dr. Johnson received this honor at a ceremony on May 4, 2016.

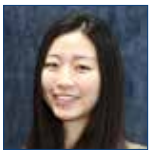
Kathryn VandenBosch, CALS Dean & Mark Johnson, CDR

Letters of support touted Dr. Johnson's creativity, tenacity and curiosity as some of his most defining characteristics. As one supporter wrote, "Mark's generosity is admirable but he also displays initiative and great creativity when approaching a problem."

CDR is proud to have Dr. Johnson on staff and we are honored to have so many staff that show dedication and outstanding service on a daily basis. We thank the industry for their support and appreciate the opportunity to use our skills and expertise to serve the dairy industry.

CDR WELCOMES FOUR NEW STAFF MEMBERS

Hong Jiang • Research Specialist



As a research specialist, Hong Jiang assists the Dairy Ingredient and Beverage group as well as the Cultured Products group with a wide variety of requests. Using knowledge she gained while working towards her B.S. in Food Science from Purdue and a M.S. in Food Science from UW-Madison, Hong is able to help with everything from basic research to product formulation. She is particularly passionate about protein and has spent several years investigating solubility of conjugates and the general scientific principles of dairy proteins. Hong is excited to work with the dairy industry to develop new products and she is driven by the thought of helping companies to create products that will bring consumers joy and satisfaction.

Jeremy Johnson • Research Cheesemaker

Growing up, Jeremy spent a great deal of time working at his Great-Grandfather's farm in Westfield, Wisconsin. The experience sparked Jeremy's passion for the dairy industry which has led him to pursue a career in cheesemaking. Previously employed as a curd processor and later as an ice cream maker, Jeremy is proud to contribute to CDR's mission. Through his work as a CDR research cheesemaker, Jeremy hopes to make a difference in the lives of farmers.

USDEC AND CDR PARTNER TO BRING YOGURT BARLEY SOUP TO IFT

The CDR Dairy Ingredient and Functionality program is pleased to once again be partnering with the United States Dairy Export Council (USDEC) in developing a unique, dairy-based prototype for the Institute of Food Technologists (IFT) Annual Meeting to be held July 16-19, 2016 in Chicago at McCormick Place.

This year IFT, USDEC and CDR will be mass sampling yogurt barley soup, developed by Applications Lab Coordinator, Sarah Minasian. Inspired by an Armenian soup called Tanabour, yogurt barley soup contains 13 grams of protein and only 190 calories per cup. While the product was showcased at last year's meeting via a handout, 2016 attendees will have the opportunity to taste the soup and discuss its development with Minasian, who created the product under the direction of CDR Ingredients and Functionality Coordinator KJ Burrington.

Yogurt barley soup.

In developing the soup, Minasian used Greek yogurt and low-sodium chicken broth as the base before boosting the protein content to an excellent source level with milk protein concentrate 85 (MPC 85). Whey permeate was also added to further reduce the sodium level. The inclusion of barley, onion and spinach created a healthy savory soup that is finished off with melted spearmint butter.

IFT participants interested in trying this dish and discussing its development with Minasian should plan to visit the USDEC booth (#1931). In addition to the mass sampling, Minasian and other CDR staff will also be available to answer questions about U.S. dairy ingredients.

Beth Rettenmund • Financial Specialist Senior

Growing up on a dairy farm gave Beth a great deal of appreciation for the dairy industry. As such, she is honored to utilize her financial skills to assist CDR in its mission. With more than 20 years of experience as a UW-Madison financial specialist, Beth brings a great deal of knowledge and skill to CDR in regards to reconciling accounts, grant management, billing, purchasing, tracking and more. With a passion for the clear-cut and precise nature of numbers as well as the challenges associated with contracts and grant management, Beth deeply enjoys her work and looks forward to working with the dairy industry.

Daniel Turner • Associate Research Specialist

As an associate research specialist Dan is responsible for carrying out analytical work as it relates to CDR research projects. Whether it is an internal research project or a request from industry, Dan enjoys working in the lab and experiencing the ever-changing aspects of his analytical work. With a background in genetic research and a B.S. in Biochemistry from UW-Madison, Dan is equipped to handle a variety of analytical requests.

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cooling and minimize temperature differentials within the block. Wood has traditionally been a popular choice for 640s and as it turns out wood is the best material for minimizing moisture migration because it is a relatively good insulator. Plastic is another popular choice for dealing with moisture migration. Stainless steel 640 boxes, on the other hand, have a high thermal conductivity which leads to rapid cooling rates of 640s and consequently the largest moisture movement and differentials.

Utilizing the old system of 40 block forming towers followed by a collator may also reduce moisture differentials. Some plants have converted to a re-crumbling system where 40 pound blocks made in block towers are re-crumbled and the curd is then evenly filled into a 640 box in an effort to remove excess free moisture prior to final block formation. This is a promising method because block forming towers are more effective in removing free moisture from the curd than drainer blade or probing systems are for the large direct fill 640 blocks. Still, each plant is different and the solution for one plant may not work for another. Therefore, consider all of these options carefully and apply the solutions as needed.

Conclusion

Making cheese in 640s has in many ways been positive for our industry. Nevertheless, challenges remain in making this cheese as consistent as possible. Biochemistry, microbiology and physics ultimately determine the end product. New technologies in manipulating cheese milk composition offer some promising opportunities to improve 640 cheese consistency. Further work is needed however, to allow us to keep the positive aspects of 640s while further minimizing some of the negative aspects.

References:

Reinbold, R.S., & Ernstrom, C.A. (1988) J. Dairy Sci. 71, 1499–1506
Reinbold, R.S., Ernstrom, C.A., & Hansen, C.L. (1992) J. Dairy Sci. 75, 2071–2082 & 2637–2647
Reinbold, R.S., Ernstrom, C.A., & Hansen, C.L. (1993) J. Dairy Sci. 76, 909–913
Barbano, D.M. (2001) J. AOAC Int. 84, no. 2, 613-619
Barbano, D. M. Uniformly Moist Cheese. Cornell University, assignee. Patent US8609164B2. 17 Dec. 2013.
Blathner, T.M, N.F. Olson, and D.W. Wichem. (1985) Sampling Barrel Cheese for Moisture Analysis: Comparison of Methods." Journal of Association of Official Analytical Chemists, V68, no.4 , 718-721

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