Wisconsin Center for Dairy Research

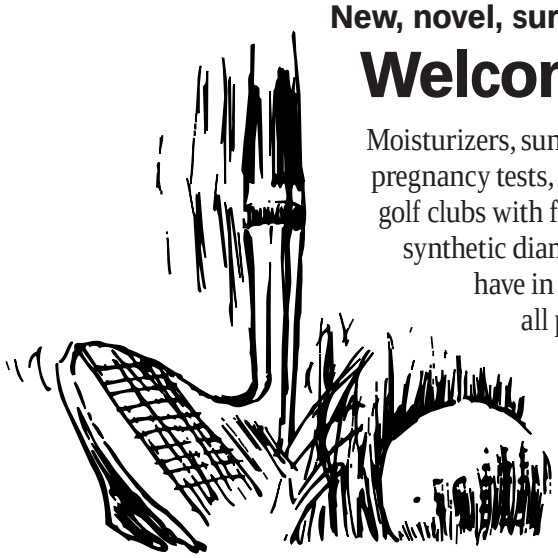
Dairy Pipeline

A Technical Resource for Dairy Manufacturers

Volume 18 Number 3 2006

New, novel, surprising—

Welcome to the nanoworld



Moisturizers, sunscreens, home pregnancy tests, stain resistant pants, golf clubs with flexible shafts and synthetic diamonds—what do they have in common? These are all products developed using techniques from the emerging field of nanotechnology. If you attended the 2006 International Food Technology (IFT) meeting in Orlando you might have noticed a sold out seminar titled the International Food Nanotechnology Conference. The agenda lists sessions on nanotechnology research in food science throughout the world, many focusing on practical problem-solving like virus recognition, prion detection, and using nanoparticles to find and identify food-born toxins.

According to a recent national poll commissioned by the Project on Emerging Nanotechnologies, only 1 in 10 Americans has heard a lot about nanotechnology and 42% of Americans have no awareness at all. If you don't know much about the field of nanotechnology then perhaps it is time to catch up and check it out. The nano world is small, the word itself is derived from the Greek "nanos," which means dwarf. However, it is possible this small world will have a huge impact relatively soon.

What's Inside:

Some researchers suggest that the market for nanotechnology will grow to 1 trillion dollars by 2010.

The nanoworld isn't new

The idea behind exploring the nanoworld isn't new. Richard Feynman, popular physicist and teacher, suggested the possibility of manipulating atoms back in 1959. It wasn't until the development of the scanning tunneling microscope in the early 1980's that scientists had an instrument they could use to "see" something as small as atoms. Then came more tools, improved electron microscopes and scanning probe microscopes. The field of nanotechnology has grown quickly since 1996, when federal agencies began to coordinate research efforts.

The scale of the nanoworld is hard to grasp, not only is it so small that we can't see it without a very special microscope, but most of us aren't used to thinking in nanoscale. Nano refers to 1 billionth (See table 1), which is somehow harder to imagine than a billion people, or billions of stars, or even a billion dollar deficit. Researchers try to help by telling us that a virus is 3 to 50 nanometers (nm) in diameter, or 10 hydrogen atoms stack up to 1 nm. Or even that your fingernails have grown 1 nm in the time it takes to read this sentence. But it is still difficult to picture.

Nevertheless, it is this very small scale that makes the nanoworld different, particularly when you consider the surface to volume ratio that occurs when atoms are lined up on a surface. Nanoscale particles do not behave the same as larger particles of the same material.

continued on page 4

Research Update

Metabolic studies of GMP are underway

GMP, or k-casein glycomacropeptide, is a whey protein produced when milk is coagulated with rennet to make cheese. It is unique and special because it is the only known natural protein that is free of the amino acid phenylalanine. To most of us, this unique aspect of GMP doesn't matter much. However, if you are one of the rare people with phenlyketonuria (PKU), then GMP may improve your life in the future.

In the United States, one in every 15,000 newborns is diagnosed with PKU every year. (For more background information see Dairy Pipeline, Vol. 12 #3) Since the 1960's, newborn screening tests have led to early diagnosis and treatment that prevents mental retardation, the most serious consequence of PKU. Treatment isn't simple or easy though; you can't take a pill to fix PKU. Instead, children and adults with PKU have to monitor everything they eat. All protein in the food we eat contains an amino acid, phenylalanine. This is the amino acid people with PKU need to avoid because they do not have the enzyme needed to break it apart. When phenylalanine, or phe, isn't broken down it builds up in the bloodstream, and it is this high concentration that is toxic to the brain.

People with PKU need small amount of phe

Phenylalanine is an essential amino acid, which means our bodies can't make it and we need to get it from food. Because of this, people with PKU also need phe, but only a small amount. Thus, they follow a rigorous diet, which excludes proteins like meat, cheese, eggs, milk, flour, fish, and soy—except for small measured amounts that supply a bit of needed phe. The rest of the amino acids, which we can't live without, are supplied to people with PKU in a formula that also contains vitamins and minerals. (See Table below.)

Sample menu for a typical 14-year-old girl with PKU

Breakfast
2 low protein pancakes*
2 pats butter and 2 Tbls of maple syrup
1/2 medium orange
8 oz. amino acid formula with vitamins

Lunch
Sandwhich made of tomato slices with Miracle Whip® on 2 slices of low protein bread
6 Ore-Ida® French fries
6 mini carrots
1 medium pear
8 oz. amino acid formula with vitamins

Snack
Diet Coke with Splenda®
12 apple chips

Supper
1 cup of low protein spaghetti
2 Tbls Ragu® sauce
1 cup chopped lettuce salad with Italian dressing
1/2 cup sherbet

Snack
1 medium banana
8 oz. amino acid formula with vitamins

*Low protein products are made from wheat starch and/or corn starch

You can imagine that developing a varied diet is a challenge for people with PKU. That is one reason why GMP is exciting, it offers a chance for more and different food choices and an alternative or addition to traditional treatment. Since 2002, a GMP Task Force has been meeting at the Waisman Center in Madison, WI to investigate this possibility.

The only domestic source of GMP is Davisco Foods, which isolates GMP from whey. However, this product still contains 0.4 % phe. Mark Etzel, Dept. of Food Science, University of Wisconsin-Madison, knows how to

From: Efficacy of Glycomacropeptide in the Nutritional Management of Phenylketonuria. Ney, D.M., Drexler, A. K., van Calcar, S. C., Gleason, S.T., Nelson, K. L., Lim. K., Etzel, M. R.in The Wonders of Whey...Catch the Power. Proceedings of the 4th International Whey Conference, Chicago, IL 2005. American Dairy Products Institute

process GMP even further, reducing the phe levels to about half of the Davisco product. This is significant since every bit of phe is accounted for in the PKU diet.

The next step was to try incorporating GMP in food. What did it taste like? How much phenylalanine did it add? CDR's Dairy Ingredients Application program took on the challenge, and Kathy Nelson began to evaluate the possibilities. Due to its low water binding properties, GMP works better in some products than others. Baked goods were not a good option but several GMP-fortified foods turned out to be pretty tasty, which was confirmed by sensory panels. The winners included strawberry pudding, fruit leathers, and a chocolate beverage.

A unique group of subjects, mice with PKU

The GMP Task Force moved on to the next issue, would a diet based on GMP as a protein source be safe? Not only is GMP free of phenylalanine, but it also varies from average dietary proteins in a few other amino acids. For example, GMP has more threonine, isoleucine and leucine than the average dietary protein. To answer this question the scientists turned to a unique group of subjects, mice with PKU. A common technique used to study the effects of genes is to "knock out" the gene and make it inoperable. PKU mice lack the gene for the missing enzyme, which means the PKU mice have the same genetic deletion that causes PKU in humans. This makes them ideal subjects for a preliminary study of GMP in PKU.

The GMP mouse study was done at the Dept. of Nutritional Science at the University of Wisconsin-Madison. Analysis of the results were encouraging; comparing PKU mice treated with GMP to PKU mice fed an amino acid diet showed similar gains in body weight and food intake. The mice fed GMP did have higher blood levels of threonine, but they also had levels of phe that were 10% lower than the mice on the amino acid diet.

GMP in the human PKU diet

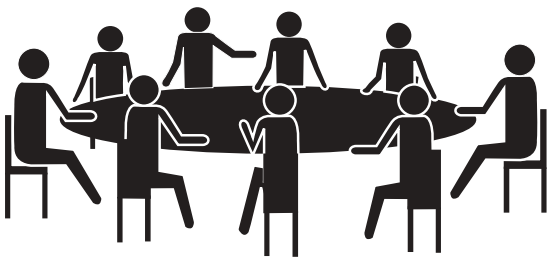
Will this higher threonine level associated with the GMP diet be a problem? The Task Force has started the next phase of research to find out. The National Institute of Diabetes and Digestive and Kidney Diseases funded a study to determine the safety, efficacy and acceptability of GMP in the human PKU diet. Research subjects begin the study on their regular amino acid based diet and then switch to the GMP based diet. All food is weighed to assure constant calorie, total protein and phenylalanine intake during the study. Since March, 2006, 5 young adults with PKU have spent several days in a research unit at University Hospital in Madison to be poked, prodded, and scanned with an MRI in order to compare how the 2 diets affect phenylalanine levels in blood and brain tissue. The study is continuing, the data is being analyzed and folks with PKU and their families are hoping for some dietary help.

The National Institute of Diabetes and Digestive and Kidney Diseases funded a study to determine the safety, efficacy and acceptability of GMP in the human PKU diet.

continued from page 1

According to Don Savage, materials science researcher at the University of Wisconsin-Madison, an interesting story behind the field of nanotechnology is the remarkable cooperation and collaboration it has spawned. Like the interdisciplinary effort that produced a map of the human genome years before it was expected, collaboration among engineers, biologists, mathematicians, and physicists is leading nanotechnology into the present.

Here on campus, the National Science Foundation recently awarded a three-year, $300,000 grant to a team of UW-Madison researchers to develop a system to aid clinical diagnosis of botulism. Led by Electrical and Computer Engineering Assistant Professor Hongrui Jiang, Chemical and Biological Engineering John T. and Magdalen L. Sobota Professor Nicholas L. Abbott , Biomedical Engineering Professor David J. Beebe and Food Microbiology and Toxicology Professor Eric A. Johnson will devise an integrated micro-sensing system to detect very low concentrations of botulinum neurotoxins. The team will also develop a coherent interdisciplinary program integrating high quality teaching and outreach activities.



Electrical, optical, or magnetic properties can follow new rules in the nanoworld. Consider the example of ordinary gold. Formed in jewelry or blocks, gold is always predictable: it is the same color, it is shiny and it has the same melting point no matter the volume. Not so at the nanoscale. According to Dr. Arden L. Bement, Jr., director of the National Science Foundation, gold nanoparticles are no longer inert but can be reactive and may even enter cell membranes. Scientists are taking advantage of these new behaviors and properties attributed to the nanoscale to design new materials.

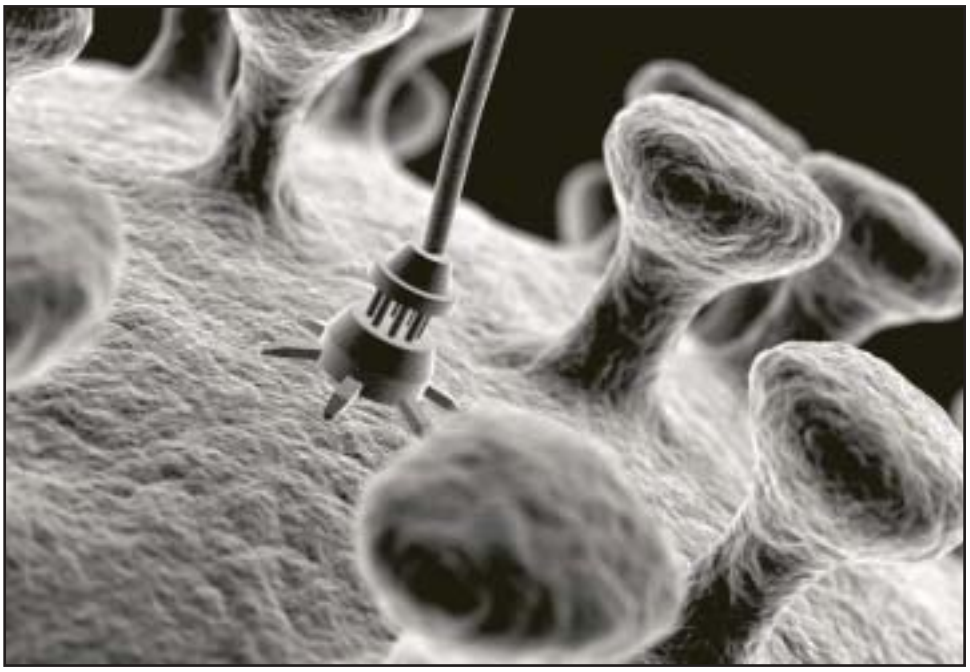
Most people running a food processing operation are aware of the potential for biofilm formation in processing equipment. Medical device manufacturers are also concerned about biofilms, which are the leading cause of life threatening infections in people with new parts after knee or hip replacements. Biofilms can protect organisms from sanitzers in pipelines and antiobiotics in circulatory systems. Because of this, researchers are looking to the nanoworld for a solution. Scientists have long known that silver, positively charged in an aquaeous solution, is an effective antimicrobial with low toxicity. Antimicrobial silver nanoparticles are the latest innovation, used as a surface treatment on an artificial joint to prevent biofilm formation and infection or in dressings used on burns and wounds. The greater surface to volume ratio in silver nanoparticles is the key to its success as an antimicrobial.

Although many of the applications of nanotechnology will be in the medical and electronics industries, the food industry will use nanotechnology, too. For instance, it is being used to create packaging embedded with nano materials that could alert consumers to contaminated food products that are no longer safe to eat. Nanomaterials can be designed to cross the blood-brain barrier to deliver drugs and avoid side effects, thus food scientists are looking at the possibility of using nanomaterials to deliver nutrients in new and novel ways.

Table 1. Comparing nano to meter.

meter	m	1	1×10^{1}
millimeter	mm	1/1000	1×10^{-3}
micrometer	μm	1/1000000	1×10^{-6}
nanometer	nm	1/1000000000	1×10^{-9}

However, it is this ability to cross the blood brain barrier that has raised safety concerns about nanoparticles. Although no policy changes are expected this year, the U.S. Food and Drug Administration, (FDA), held a public meeting on Nanotechnology Materials in FDA Regulated Products on October 10, 2006. Previously, FDA officials have suggested that they lack the resources to oversee nanotechnology, and in the areas of cosmetics, dietary supplements and food, the legal authority to regulate nanotech applications.



If you want to look at few nanotech applications heading for the marketplace you can download a recent report on anticipated applications in agriculture and food production by Jennifer Kuzma and PeterVerHage. The authors, supported by the Woodrow Wilson Center and the Pew Charitable Trust, developed a database of food and agriculture nanotechnology related research projects funded by the US government. This downloadable database currently lists 160 projects and identifies technologies that may be in the marketplace soon.

It is too early to predict where nanotechnology will lead us in the future, but now is the time to start following this story.

Using nanomaterials to deliver nutrients in new and novel ways

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U. S. Food and Drug Administration http://www.fda.gov/nanotechnology/agenda1010.html

News from CDR

Dana Wolle, research specialist

Introducing three new employees at CDR

We always hate to say good-bye to coworkers who have become friends after years of working together. However, we do get to meet new friends when we find replacements for them. Here's the latest.

Dana Wolle, research specialist, will be working with the Cheese Applications group and the Dairy Ingredients group. Dana is learning a lot about whey, proteins and, of course, cheese. He brings 10 years of experience in the brewing industry.

Debra Wendorf Boyke, communications coordinator

Due to her varied background, Debra Wendorf Boyke may be familiar to many in the dairy industry. She gained her communications experience working for the Wisconsin Milk Marketing Board, ABS Global, Inc., and the International Dairy Federation. Ms. Wendorf is the new communications coordinator at CDR.

Mike Molitor, pilot plant project manager

Mike Molitor, pilot plant project manager, takes charge of operating and maintaining the pilot plant equipment in Room 36. If you do a project with us that involves the whey dryer or the filtration equipment you will work with Mike now that Gene Barmore has retired. Molitor began his dairy career as a quality assurance specialist with Wisconsin Dairies. He moved to R and D and product development and took his experience to Organic Valley before joining CDR in September.

Coming Soon

Updated University of Wisconsin Dairy Marketing Website

Since 1997, the Dairy Marketing and Economics component of CDR has maintained a website providing producers, processors and policy analysts information about U.S. and international dairy markets. This website, the University of Wisconsin Dairy Marketing Website, is located at www.aae.wisc.edu/future. It contains the most comprehensive collection of dairy-related data, policy analyses, decision-making software, and material related to the use of alternative price risk management systems within a single location.

The developers of this website have improved and updated the website and are now making a "beta" pre-release version available. This revised website, located at http://future.aae.wisc.edu, contains approximately 25% more data series than the older version. It also has an updated user interface and a user-friendly system for customizing graphical analysis of U.S. dairy markets.

Note that for this beta version, the data may not be current. You should rely on the "old" website until the beta version replaces the old version. Also note that the new website is still under construction so some features may not be fully operational.

Comments and questions are welcome

Over the next 2 months, the developers are seeking input from users. Which features do you want in this new website? Feel free to contact, Dr. Brian W. Gould, the coordinator of CDR's dairy marketing and economics program with any suggestions or questions. Contact him by e-mail at : gould@aae.wisc.edu .

Seeking input from website users!

Curd Clinic

The Curd Clinic doctor for this issue is Kathy Glass, researcher at the Food Research Institute, University of Wisconsin-Madison. You can reach her at kglass@wisc.edu

Q. I know that the US Food and Drug administration requires pasteurization or a 60 day aging period for cheddar made from raw milk, but what is it about aging that helps to ensure cheese safety?

A. Well, you are right that aging cheese affects safety, although there is nothing magic about 60 days! Let's take a closer look at the inner microbial life of cheese as it ages. Many factors influence the safety of cheese, including moisture, salt level, pH, temperature and competition from other microflora. Taken from the bacterial point of view, a battle is raging as they try to survive and multiply under siege.

Like any battle, elements interact to influence the outcome. In cheese, the combined effect of influential factors, as well as the factors themselves, set numerous hurdles in front of pathogens. Thus, safety is optimized when cheese is aged at the appropriate temperature, the salt level is adequately high, the moisture and pH are low, and starter bacteria are healthy and thriving.

When one safety factor is absent or less potent the cheese environment is different; perhaps even more friendly to pathogens. For example, higher temperatures can stress microflora just like they do marathon runners or overdressed cavalry. But with a source of fresh water to mitigate the effects, some bacteria can take advantage of higher temperatures and their growth will accelerate. Think about fresh cheeses, like queso fresco, which are high moisture, low acid cheeses. This cheese may be produced with starter culture, but typically it is not. When your cheese has fewer hurdles, pathogens can indeed grow.

Moisture in cheese is a big factor in safety because bacteria need it to thrive, but high salt levels in the moisture phase can influence growth. As a result, a truer measure of available water, known as water activity, is used to describe the food environment. Water activity can range from 0 to 1, although most dairy products are usually over 0.9. Parmesan or romano are at a low of 0.92 and brie or camembert at the other end of the range measuring around 0.98. To put things into perspective, most disease-causing bacteria can grow at water activity greater than 0.93.

If you want to make a raw milk cheese, these parameters are rough guidelines to help you eliminate particular pathogens.

To inhibit this pathogen	Water activity	pH
Staphlococcus	.85	less than 5
Listeria	.92	less than 4.8
E. coli or salmonella	.94 to .95	less than 4.2

The acid level, or pH, of cheese is another major factor that influences the survival and growth of bacteria. The pH of cheddar ranges from 4.9 to 5.4, which is somewhat stressful for bacteria. Compare it to brie, a cheese with a rising pH during ripening which can hit 6 to 6.9 at its peak, and which can encourage the growth of bacteria, including pathogens if they are present. Another consideration is rate of acid development and type of acid. When starter cultures are active, acid is produced rapidly, preventing growth of pathogens in the ripening milk. Slow acid development will allow time for pathogens to grow to higher populations, making them more difficult to eliminate during aging. Acid type also has an effect. While lactic acid produced by starter cultures used for cheeses, such as cheddar, is very effective in inhibiting pathogens, the same concentration of propionic or acetic acid produced by swiss cheese type starter cultures has even more anti-microbial activity. In contrast, the weak organic citric acid (e.g. lemon juice) that can be added to coagulate milk does not provide the same level of preservative activity.

Water activity and acid work together

These two factors, water activity and acid, work together to determine if pathogens will grow or die during ripening of the cheese. Cheddar, which typically has a water activity of 0.95 and a pH less than 5.4, will stress pathogens, and eventually cause them to die. On the other hand, a soft, surface-ripened cheese with a water activity of 0.98 and pH greater than 6.0 may actually encourage growth of pathogens during storage.

We can add a third factor—temperature. Going back to the army analogy, if the enemy soldier is trying to battle under 98ºF heat and has no fresh water, he won't be as formidable as if the temperature were 50ºF. Similarly, under stressful conditions of low pH and water activity, higher temperatures will cause the pathogens to die more quickly. In contrast, when bacteria enjoy ideal water activity and a pleasing pH, high temperatures promote rapid growth. Certain bacteria, such as Listeria, can tolerate and even grow at refrigeration temperatures!

The acid level, or pH, of cheese is another major factor that influences the survival and growth of bacteria

Starter cultures compound the stress

Competitive microflora, such as cheese starter cultures, compound the stress to the pathogens. In addition to producing acid to drop the pH, cheese starter cultures can compete with pathogens for nutrients thereby starving the pathogens, and can produce other by-products which interfere with the metabolic machinery of the disease-causing bacteria.

Put all these factors together properly, and the pathogens lose the battle over time, and the cheese is safe. In the case of certain soft and surface-ripened cheeses with high moisture and high pH, such as queso fresco or brie, pathogens may actually thrive and grow over time. But, cheese types with low moisture and low pH, such as hard grating cheese, offer an environment that is very stressful to pathogens, and therefore, the pathogens die gradually during the aging process.

continued on page 10

continued from page 9

Recent research suggests that a 60 day aging is not sufficient to eliminate these pathogens from cheese.

As mentioned earlier, 60 days of aging doesn't guarantee that all bad bugs, or pathogens, die in the siege. This rule was set during the World War II era, to tame *Brucella abortus*, which did seem to die off in 60 days. Since then, other pathogens like *E. coli* O157:H7 and *Listeria monocytogenes* which can be found in raw milk, have emerged. Recent research suggests that a 60 day aging is not sufficient to eliminate these pathogens from cheese. For example, one study reported that populations of *E. coli* O157:H7 decrease somewhat, but are not eliminated from raw milk cheddar during 60-day aging. Anything short of complete demise for this particular pathogen is not good enough since it doesn't take many of these bugs to make people sick. In another study, experiments showed that populations of *L. monocytogenes* initially decline on bloomy rind cheese manufactured from raw milk, but then grow as the surface pH increased during a 60-day ripening process.

I think you can see that many factors affect the growth and survival of bacteria in cheese. It is essential to monitor the factors and understand how they interact with each other in each particular variety of cheese. That is why many experts recommend pasteurizing milk and using good manufacturing and strict sanitation practices for cheesemaking; it is simpler to get rid of pathogens at the outset.

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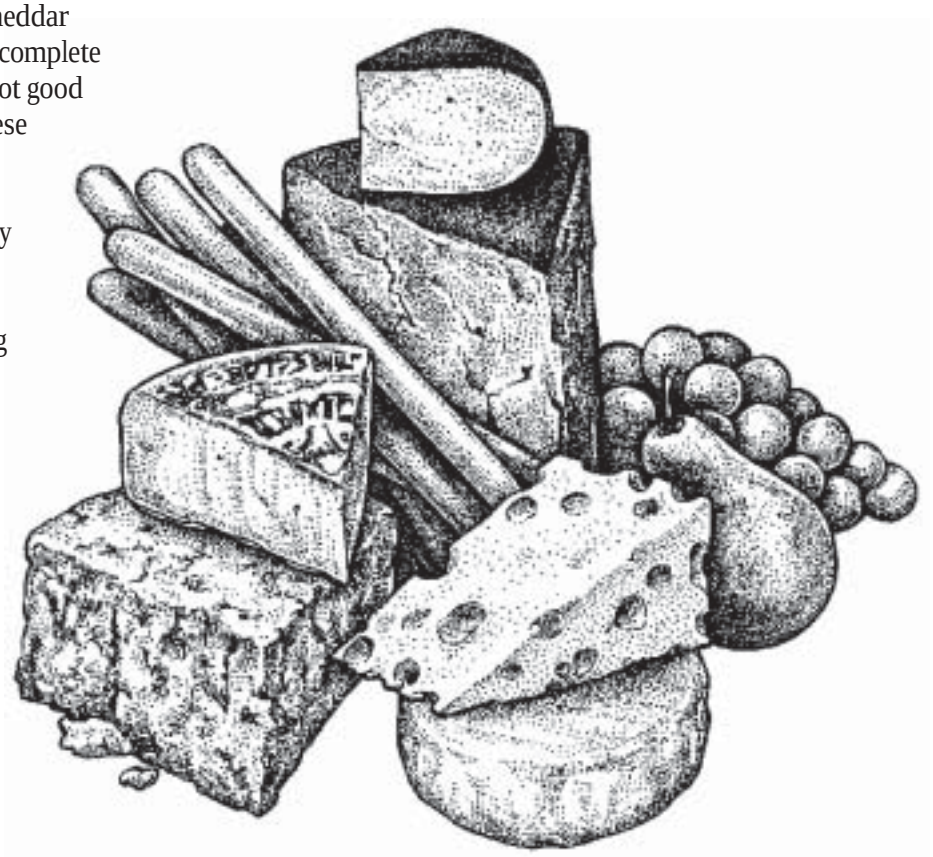


Dairy Processing Energy Best Practice Guidebook

A new tool to help dairy plants conserve energy

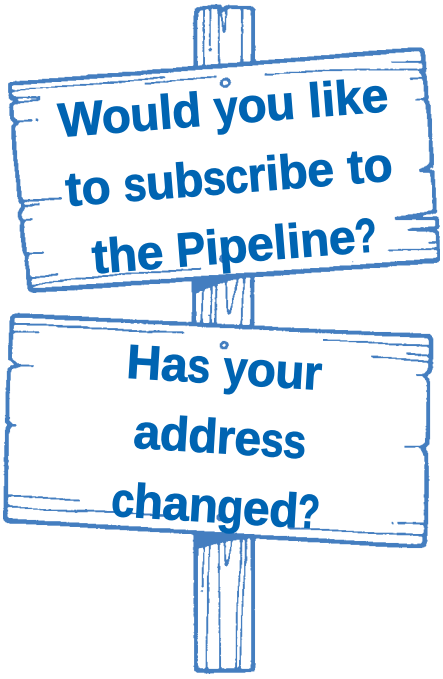
The increasing cost of energy has affected all of us, but when energy costs are up there in the top three costs of doing business —as in the dairy industry—then the effect is major. Anew tool is available to help you take stock of your energy use and then use a proactive approach to set up an energy management program.

Focus on Energy is a partnership of groups from both the public and private sector that offers energy information and services to Wisconsin utility customers. They have recently published a guidebook to help you set up a program in your plant. Rather than focusing on a single point in time, the Guidebook suggests that energy improvement is an ongoing process. Like your HACCP program, an energy management program may take time to set up in the beginning, but it will save you time and money over the long term.

Establish a baseline

Using the Focus on Energy Guidebook can help you establish a baseline of your plant's energy use, then estimate the energy your major systems use before focusing on projects that will make your plant more energy efficient. For example, the summary checklist in the guidebook lists eleven technical energy tips in the refrigeration area alone. From resetting pressure controls to improving defrost control, the guide will help you assess the limitations and benefits of applying suggested best energy practices.

To get your copy, contact Craig Schepp of the Focus on Energy Industrial Program. The best way to do that is to send him an e-mail at scheppc@saic.com, include your contact information; name, company, address, and telephone number. You can call Schepp, at 608-277-2948, but he prefers e-mail. The guidebook is only available in hard copy and it is free to Wisconsin businesses. Out of state requests will be charged $85 per copy.



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Karen Paulus, Editor
e-mail: Paulus@cdr.wisc.edu
phone: 608/262-8015

You can also find the Dairy Pipeline on our website: www.cdr.wisc.edu

Calendar

Nov. 7-8 Cheese Grading and Evaluation Short Course. Madison, WI. Call Scott Rankin at (608) 263-2008.

Nov. 9-11 Great Lakes Dairy Sheep Symposium. La Crosse, WI. For information, contact Lorraine Toman at the Spooner Ag Research Station at (715) 635-3735 or register at: CALS Conference at: http://www.cals.wisc.edu/ccs.

Dec. 6-8 Ice Cream Makers Short Course. Madison, WI. Call Scott Rankin at (608) 263-2008 for information, or the CALS Outreach Services (608) 263-1672 to register.

Jan. 9-10 Milk Pasteurization and Process Control School. Madison, WI. Call Scott Rankin at (608) 263-2008 for information, or the CALS Outreach Services (608) 263-1672 to register.

Jan. 18-19 Producing Safe Dairy Products. River Falls, WI. Call Ranee May at (715) 425-3704 for information.

Feb. 6-7 Quality Milk Conference (WI Dairy Field Reps). Madison, WI. Call Scott Rankin at (608) 263-2008.

Feb. 27-28 Wisconsin Process Cheese Short Course. Madison, WI. Call Bill Wendorff at (608) 263-2015 or John Jaeggi at (608) 262-2264 for more details.

Mar. 26-30 Wisconsin Cheese Technology Short Course, Madison, WI Call Bill Wendorff at (608) 263-2015.

Apr. 25-27 Wisconsin Cheese Industry Conference, La Crosse, WI. For information, call Judy Keller at (608) 828-4550.

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