Wisconsin Center for Dairy Research

DAIRY PIPELINE

A Technical Resource for Dairy Manufacturers Volume 19 Number 2 2007

Preventing color fade in grass-based natural cheeses

By W.L. Wendorff, Dept. of Food Science
University of Wisconsin-Madison

Bleaching and pinking might sound like laundry problems but they are indeed issues for cheesemakers, too. We have known for some time that cheese colored with the plant extract annatto can fade and discolor. However, recent reports indicate a loss of color in natural cheeses that did not have added colorants. In particular, farms using rotational grazing management practices seem to be linked to the milk that produces this problem in cheese. This milk has a more intense background color, which in turn produces golden yellow natural cheese. So, what is the impact of grass-based feeding systems on the color of cheese and how can those colors be stabilized in natural cheeses?

The problem of pink discoloration and loss of color in annatto-colored natural and process cheeses is not a new one. Previous studies (1, 2, 3) have been reported on the light-catalyzed oxidation of annatto components that leads to color changes in cheddar and colby cheeses. This discoloration can be prevented by total exclusion of light and storage in an oxygen-free atmosphere.

Natural colors in milk

The color of natural cheese, without added colorants, largely depends on the color of the milk fat. The primary color components normally present in milk fat are a group of hydrocarbons called carotenoids. The concentration of carotenoids in milk fat depends on a number of factors, including species and breed of animal, stage of lactation, milk yield, and feeding system.

Carotenoids in cow's milk mainly consist of β-carotene, and to a lesser extent, lutein, zeaxanthin, retinol, α-carotene and β-cryptoxanthin (4). β-Carotene comprises 90% of the total carotenoids present in cow's milk (5). The β-carotene concentration in milk fat ranges from 1 to 17 mg/g while retinol, the only other significant carotenoid measured and reported, ranges from 1 to 12 mg/g (4). β-Carotene concentrations vary widely among dairy breeds, with Guernsey having three-fold higher levels than Holstein while Jersey and Brown Swiss have intermediate levels. On the other hand, Holstein has 1.6-fold higher levels of retinol than Guernsey while Jersey has intermediate levels. β-Carotene and retinol concentrations are initially high in colostrum and then decrease as milk yield increases. In mid-lactation, the concentration increases again when the milk yield decreases over time.

The concentration of β-carotene in cow's milk depends on the concentration of β-carotene in the diet of the animal. Grass-based diets contain significantly more β-carotene than hay or silage-based diets (6). Since β-carotene is very light sensitive, much of it is lost due to sunlight during the drying process of harvesting hay or silage (4).

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CDR Offers Regional Workshops in October

Are you wondering how to take advantage of consumers' focus on health and wellness? Still have questions on how to effectively standardize your milk for the highest cheese yields? Then plan to attend the CDR regional workshops in October. These one-day, nuts and bolts type of workshops are being offered in three (3) locations around the state.

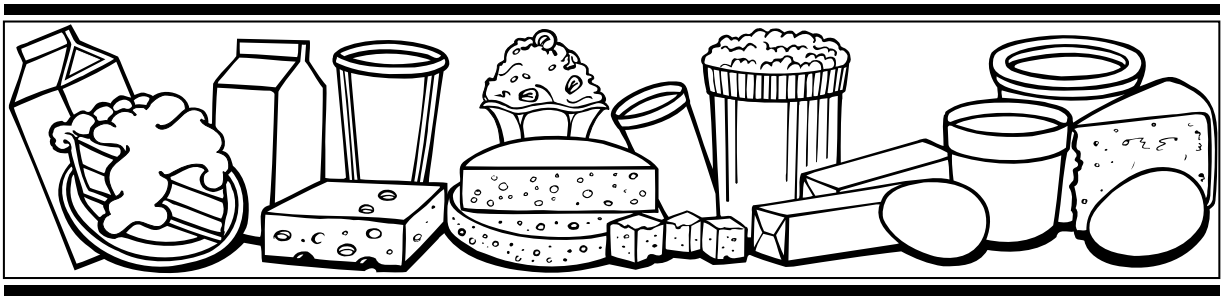
Dates/Locations:

Tuesday, October 16, 2007 – Ludlow Mansion, Monroe
Wednesday, October 17, 2007 – Darboy Club, Appleton
Thursday, October 18, 2007 – Belvedere Supper Club, Marshfield

The Program:

8:30 – 9:00	Registration
9:00 – 10:00	What and why of standardization, Mark Johnson
10:15 – 11:00	How to/Mechanics from the plant perspective, Dean Sommer
11:00 – 11:30	CDR learnings, John Jaeggi
11:45 – 12:30	Case scenarios – Formulas to consider when standardizing, Brian Gould
1:00 – 1:45	Lunch
1:45 – 2:30	What are the health & wellness opportunities in cheese?, Dean Sommer
2:40 – 3:40	An in-depth look at each ingredient opportunity; things to think about, products that work best with each ingredient, labeling and regulatory considerations - Omega 3, John Jaeggi - Pro/pre biotics, Dean Sommer and John Jaeggi - Low sodium/lowfat, Mark Johnson - Antioxidants/CLA, Dean
3:40 – 4:30	Wrap Up

Workshops are open to all Wisconsin manufacturers. Registration must be received by October 5, 2007. Attendance will be limited, so please register early. Cost of this workshop is $40 per person to cover registration, materials and lunch/breaks. For more information, contact Deb Wendorf Boyke at (608) 262-2217.



Research Update

Pumping up cheese

If you tried the omega-3 fortified cheddar during the 2007 Cheese Expo in La Crosse last April you probably thought of it as simply eating a piece of cheese. But food scientists might describe popping a chunk of omega-3 fortified cheddar into your mouth as sampling the leading delivery system for functional ingredients. Whether you are talking about milk, ice cream, cheese, or yogurt, dairy products are the most popular vehicle for punching up your diet with healthy bacteria like probiotics, fiber to nurture them (or prebiotics) and healthy fats like omega-3 fatty acids.

For decades, Europeans and Asians have bought into the notion of probiotics for better health. Here in the United States, people are just getting used to the idea that bacteria can be good for you. Although yogurt with live cultures was always sought out by health conscious consumers, Danone's low fat yogurt, Activia, loudly extolling the probiotics within, is winning new converts. According to Lynda Searby in Functional Foods and Nutraceuticals, Danone Activia has built sales of $100 million since its launch and probiotic dairy drinks along with probiotic yogurt for kids will hit the market soon.

We have all heard from nutritionists that we should eat more fish. Omega-3 fatty acids are one reason behind the advice. Omega-6 fatty acids and omega-3 fatty acids are two distinct classes of essential fatty acids (EFA's), essential because our bodies require them and we can't produce them ourselves. Thus, we need to get them from food. EFA's are important in every system of the body, from brain to heart, because they are an integral component of cell membranes—serving as a gatekeeper for enzymes, hormones and neurotransmitters.

The crucial detail about these EFA's is the need to keep them in the proper balance since they compete with each other and they have opposite metabolic functions. Too much omega-6 promotes a pathway of inflammation, leading to arthritis, heart disease and strokes while omega-3 fatty acids have an anti-inflammatory effect that can help to prevent coronary artery disease. Researchers note that our historical diets, prior to the industrial revolution, provided equal amounts of omega-3 and omega-6 fatty acids. After a switch to vegetable oils, like corn oil, safflower oil and soybeans, high in omega-6 and low in omega-3 fatty acids, the common ratio now is roughly 20 to 25:1, with an excess of omega-6.

Cheese Expo 2007
CDR staff get ready to serve cheese samples fortified with probiotics and omega-3 fatty acids. From left, Bilal Dosti, Gina Mode, and Dana Wolle.

Enter omega-3 fortified cheese. Here is a chance to help people get back to a healthier balance of essential fatty acids. Scientists at the Center for Dairy Research have been fortifying cheese with omega-3 fatty acids and they can deliver a nutritionally signifcant quantity without changing the taste of the cheese. They have also worked with probiotics in cheese. If you want to learn more about the latest health and wellness options available for developers of dairy products, consider attending one of CDR's regional workshops. More information is available on page 2.

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Natural colors in cheese

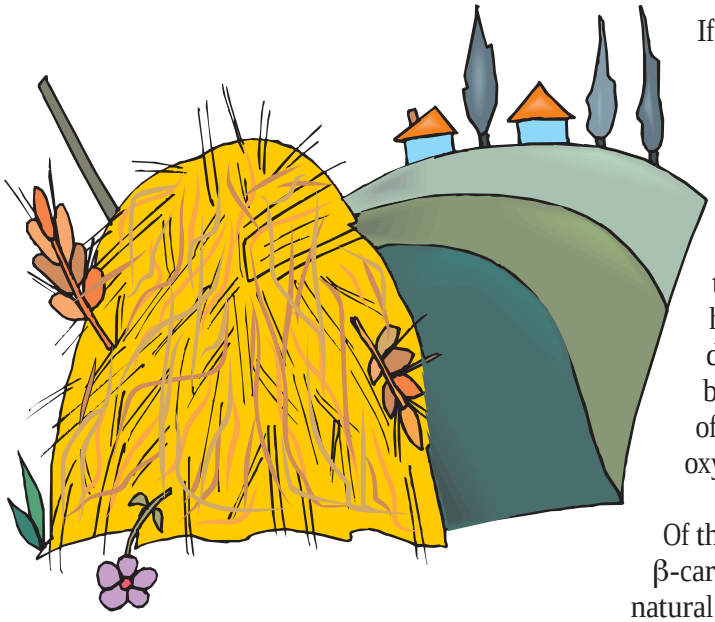
Since carotenoids and retinol are fat-soluble, they are primarily recovered with the milk fat in cheese. The yellow color of natural cheeses is a function of both fat color and concentration, and fat color is a function of the carotenoids concentration in the fat (10). The color of natural cheeses produced from milk of cows consuming native pasture plants is much more yellow than from a total mixed ration (TMR) (11). Cheese fat is richer in β-carotene, xanthophylls, retinol, and a-tocopherol with pasture-based rations versus stored forage-based rations (7).

Thermal processing of milk for cheesemaking does not significantly influence the retention of β-carotene or retinol (4). French researchers (9) reported on average, 950 g/kg of β-carotene, but only 660 g/kg of retinol and 640 g/kg, of xanthophylls originally present in milk fat were recovered in cheese fat. These results suggest that β-carotene is very stable, whereas retinol and xanthophylls are partially destroyed or lost in the whey during cheesemaking. On the other hand, Dutch researchers (5) reported less than 50% of the retinol and β-carotene in raw milk was retained in gouda cheese. Since the color of natural cheese depends on the concentration of carotenoids, measuring color may be a quick tool for tracing feeding conditions (4, 7).

Stability of color in natural cheeses

Like annatto colorants (1,2), carotenoids and retinol are sensitive to different physico-chemical factors including air, oxidizing agents and light. In field trials, researchers reported an average 83% loss in carotenoids between direct-cut silage and sun-dried hay (12). Lutein and epilutein losses occurred less rapidly than for zeaxanthin and carotene. Moderate losses of carotenoids also occurred in stored hay and silage when they were stored under aerobic conditions (4).

"In field trials, researchers reported an average 83% loss in carotenoids between direct-cut silage and sun-dried hay."



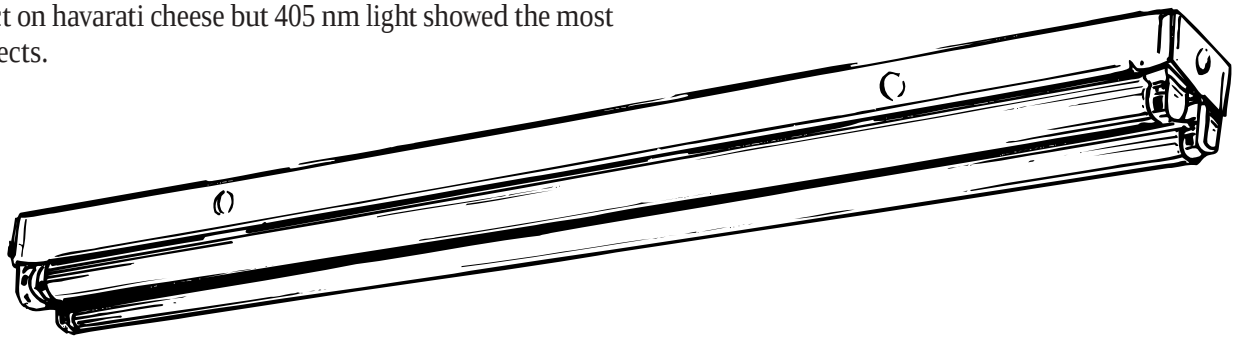
If oxygen is present in food products, extensive losses of carotenoids can occur, stimulated by light, enzymes, and co-oxidation with lipid hydroperoxides (13). In general, the stability of carotenoids is expected to parallel that of unsaturated fatty acids in a given food. Cheeses from grass-based milk were reported to have higher concentrations of polyunsaturated fatty acids that were susceptible to oxidation (14). In addition, high fat cheeses are more susceptible to oxidative discoloration than cheeses with low fat content (1). The body of the cheese is also important since the openness of the cheese will determine how deep both light and oxygen can penetrate to cause light-catalyzed oxidation.

Of the major carotenoids present in grass-based cheese, β-carotene is probably the major contributor to color of natural cheese. β-Carotene is sensitive to both light and

oxygen leading to degradation and a decrease of color intensity (15). In comparison, annatto is reported to be at least 5 times more sensitive than β-carotene. Also, β-Carotene was more susceptible to light-catalyzed oxidation with UV light (366 nm). However, the light sensitivity of both colorants depended significantly on the combination of pH and irradiation wavelength. Studies with retinol showed it to be very sensitive to light (16) while lutein was reported to be fairly stable under normal conditions in an aging cooler (17).

Controlling color fade in natural cheeses

Cheese manufacturers can reduce photooxidation and color fade by minimizing light exposure, optimizing packaging barrier, and improving headspace conditions. Since lower wavelength light with high quantum energy causes the most problems, you can reduce photooxidation by using soft fluorescent lights versus cool white lights (1, 18). Exposure to 366 nm wavelength light had little effect on havarati cheese but 405 nm light showed the most severe effects.



Packaging materials offer varying degrees of protection against light-induced changes due to differences in reflectance, transmittance, and oxygen permeability. Incorporating titanium dioxide into plastic packaging materials reduces light transmittance and red surface ink will reduce light transmission at wavelengths below 550 nm (20). Black laminates reportedly offer the best protection against photooxidation of havarti cheese, followed by a white laminate (18). Unfortunately, incorporating UV-absorbing material into plastic packaging is expected to have little impact since the plastic material itself screens out most of the UV-light (18). By attaching labels to the packaging, you can reduce light transmission but placement is critical since it must be directly in the pathway of transmitted light.

> "Cheese manufacturers can reduce photooxidation and color fade by minimizing light exposure, optimizing packaging barrier, and improving headspace conditions."

Light-induced oxidation occurs when oxygen is available. Hence, reducing the oxygen content of the headspace by vacuum packaging or displacement with carbon dioxide/nitrogen in modified atmospheric packaging (MAP) will limit the photooxidation of natural colorants. Researchers (18) have reported oxidative off-flavors in havarti and samsoe cheeses with a residual oxygen level as little as 5 ml/L of headspace. Packaging with a very low oxygen transmission rate (OTR) is necessary to maintain low levels of oxygen in the packaged cheese (2).

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This photo of an oxidized piece of cheese displays better on a computer screen, go to our website for a better view, www.cdr.wisc.edu and look for Pipeline Vol. 19 No. 2

Conclusions

The increased yellow color of grass-based cheese is a positive attribute; consumers may see it as a "value-added" product. They view this product as one produced when pastures are lush and the quality of milk is ideal. However, the increased color from the carotenoids in the cheese fat makes the cheese more susceptible to photooxidation. The result is color loss and oxidative off-flavors. To minimize the potential for color fade in these naturally colored cheeses, package cheeses in low oxygen atmospheres using materials that limit light exposure and oxygen transmission. Proper handling of packaged cheeses throughout the distribution network is another critical factor necessary to limit light exposure and temperature abuse. Good controls on handling these value-added products will help to assure a quality product that consumers will seek out and pay the premium price.

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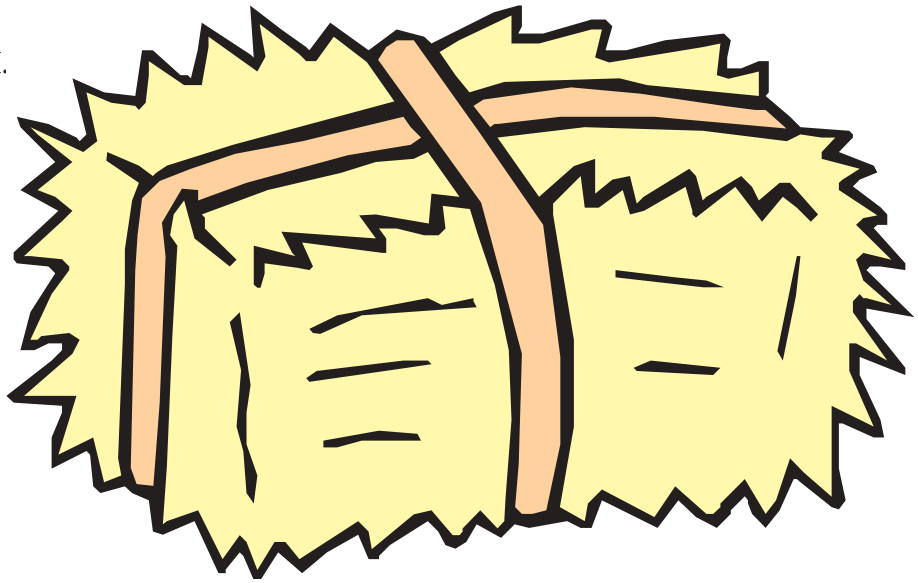


Curd Clinic

Curd Clinic doctors for this issue are Mark Johnson and Dean Sommer, CDR

Q. I was reading a recent newsletter published by the American Cheese Society (4th Quarter 2006) and I found a quote about Mark Johnson, one of CDR's scientists. After sampling David Jisa's cheese, Mark suggested he drop the pasteurizer temperature by two degrees. The cheesemaker was surprised that Mark knew he had raised the temperature to be "extra safe." How did Mark know that?

> "If a little bit is good then more must be better."

A. Drawing on a combination of years of experience and simple intuition allows people like Mark to diagnose cheese making problems. Here is his explanation.

I can not remember exactly what it was about David's cheese that indicated excessive heat-treatment of the milk, but it must have really stood out. Over the years, the Center has made a lot of cheese with excessively heat-treated milk and I think I saw a particular characteristic of some of those cheeses in David's cheese. What was it that I detected? It was more than just a matter of taste since the heat-treatment of milk also affects the texture or body of the cheese. Indeed, it could have been a combination of things.

Cheeses made from excessively heated milk may be slightly too curdy or non-cohesive for the age and pH of the cheese. Generally, the flavor is clean but subdued although that doesn't always indicate excessive heat-treatment. Sometimes you can detect a cooked or sweet heated whey flavor. Very low non-starter bacteria counts (< 1000 CFU/g cheese) in an aged cheese (>6 months) also indicates excessive heat-treatment, but this could be exacerbated by cooling the cheese fast and keeping the cheese cold during storage (<38ºF). Cheese makers should not be afraid of compromising cheese quality by heat-treating milk, just be aware that excessive use of high temperatures (>167ºF) and times (>20 s) may have unintended effects while doing nothing to increase the safety of the cheese.

The intuition factor

The explanation above exemplifies the experience part of problem solving. The intuition factor drew on common mistakes that we humans often make when we start with the assumption that if a little bit is good then more must be better. Think of it as amateur extrapolation.

We have all learned this lesson. Dean Sommer, another CDR scientist, remembers making a bowl of mashed potatoes while he was a college student. If a potato masher is good, then an electric mixer must be better. When the starch broke down after all that overmixing and his potatoes turned into a gooey, sticky mass, Sommer learned to use the implement made for the task.

Dairy products are complex foods, which can set you up for many miscues. Here are a few common mistakes that we have seen more than once.

To mix bulk starter appropriately you have to agitate it to provide the best environment for your bacteria. Agitation prevents settling and keeps the bacteria and nutrients interacting. If agitation is good, then faster agitation is better, right? In this case, not at all. If the agitation is too fast you introduce oxygen into the mix, which inhibits the growth of desired bacteria.

Cooking curd

When cooking cheese curds, sometimes cheesemakers decide to heat the curd a little faster to shorten the cook process. So, you increase the temperature a bit faster and cook for a shorter time. Now you are producing curds with a soft center and a hard exterior, particularly apparent in large curd pieces. The moisture of the curds increases but the finished cheese may have pockets with higher acid that appear mottled.

Everyone wants to make a safe, high quality dairy product. So, of course, it is tempting to "adjust" cleaning and sanitation procedures. Do you have a clean in place (CIP) system? Maybe you have been tempted to apply the principle of amateur extrapolation here, if ten minutes of circulating water is good then twenty must be better. Right? Wrong. If you don't have a reheating module in your system you are now letting the circulating water cool. The cooler water allows the milk soil to redeposit and your equipment is dirtier than when you started cleaning.

Many people are tempted to tweak the process when they make up a batch of cleaner or sanitizer. But this isn't a good idea. These chemicals are designed to be effective at a particular concentration. For example, adding "extra" chlorine to your sanitizer is not only a waste of money, but it also changes the chemistry and makes the sanitizer less effective. And, to remind you of your error, you just might find a soapy off-flavor in your cheese from the residue of this botched mixture. Follow the directions.

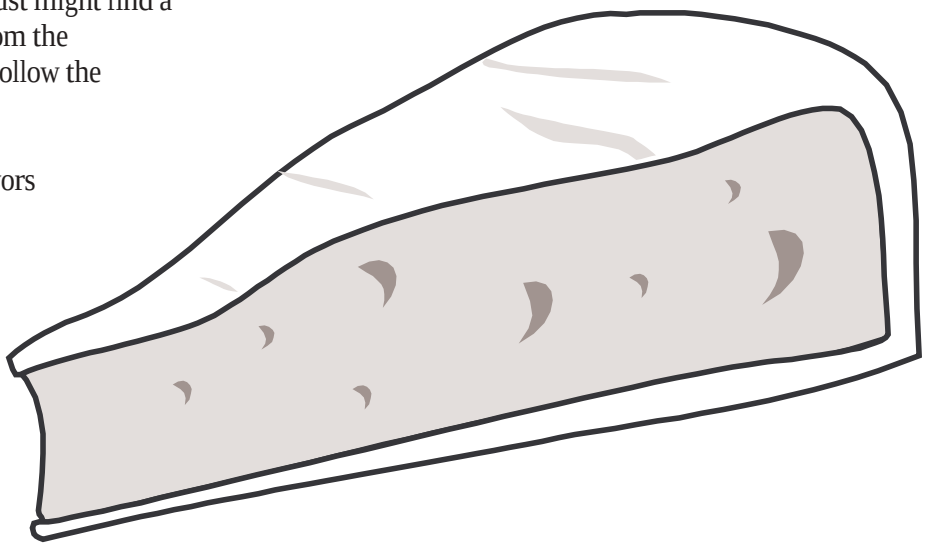
You can also develop oxidized flavors in your cheese when you use too much chlorine to clean your workspace, including counters, implements, and forms. The cheese that you set on this clean counter will suffer from the residual chlorine and you will be sorry.

We tell people that cheese should be cooled rapidly. Now, maybe this is more of a semantic issue than amateur extrapolation, but cooling cheese too fast causes problems. The moisture migration in your block of cheese will not be uniform, which means varying degrees of proteolysis and consequently varied flavor and texture. Rapid cooling for a 40 lb block of cheese means 2 to 3 days. For a 640, you are talking 7 to 10 days.

Aging cheese

The correct temperature for aging cheese depends on the type of cheese you are making, in particular the composition. Temperatures can be higher for salty cheeses and those with a low water activity. However, as a general rule, packaged cheese should not be stored above 50º F. Of course, aging cheese at 60ºF will produce a better flavor faster, but other things are happening too and you may end up with some strange tasting cheese. Or your cheese might exude serum. Serum on the cheese surface can lead to "rind rot," produced by the growth of undesirable microorganisms, including yeasts and molds. Development of crystals, calcium lactate or tyrosine, is another potential side effect of serum on the surface.

One of our Wisconsin Master Cheesemakers, who will remain anonymous, relayed this experience with amateur extrapolation. Knowing the importance of high humidity for mold growth in camembert and brie this young cheesemaker casually cranked it up as he left for the weekend. If a little bit is good, more is better! When he returned, mold covered the walls and ceiling, draping the room in webs of white mold. Oops.



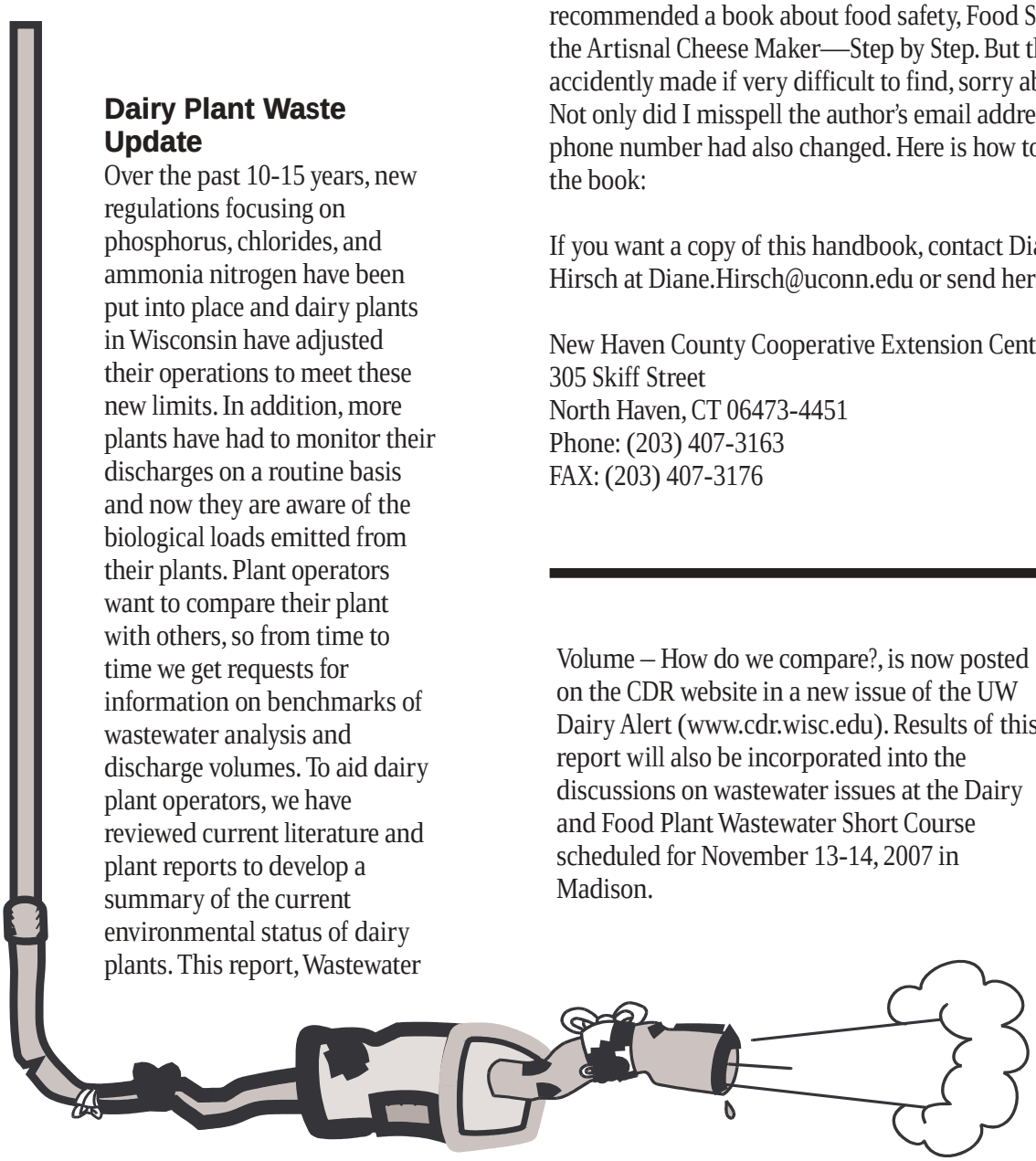
News from CDR

Short Courses

Summer is here and it is time to sit back and just enjoy it, but don't forget about the short courses offered at the end of the season. Cheese Affinage in August, Cultured Dairy Products and Dairy Ingredients in Fine Foods in September. Or, let us come to you. Go to page 2 for a description of CDR on the road with regional workshops.

Dairy Plant Waste Update

Over the past 10-15 years, new regulations focusing on phosphorus, chlorides, and ammonia nitrogen have been put into place and dairy plants in Wisconsin have adjusted their operations to meet these new limits. In addition, more plants have had to monitor their discharges on a routine basis and now they are aware of the biological loads emitted from their plants. Plant operators want to compare their plant with others, so from time to time we get requests for information on benchmarks of wastewater analysis and discharge volumes. To aid dairy plant operators, we have reviewed current literature and plant reports to develop a summary of the current environmental status of dairy plants. This report, Wastewater Volume – How do we compare?, is now posted on the CDR website in a new issue of the UW Dairy Alert (www.cdr.wisc.edu). Results of this report will also be incorporated into the discussions on wastewater issues at the Dairy and Food Plant Wastewater Short Course scheduled for November 13-14, 2007 in Madison.



Correction

In the last issue of the Pipeline (Vol 19#1), I recommended a book about food safety, Food Safety for the Artisnal Cheese Maker—Step by Step. But then I accidently made if very difficult to find, sorry about that. Not only did I misspell the author's email address, but the phone number had also changed. Here is how to request the book:

If you want a copy of this handbook, contact Diane Hirsch at Diane.Hirsch@uconn.edu or send her a note at:

New Haven County Cooperative Extension Center
305 Skiff Street
North Haven, CT 06473-4451
Phone: (203) 407-3163
FAX: (203) 407-3176

Mercedes Brighenti was awarded the 2007 Olson Scholarship at the Cheese Expo in LaCrosse, Wisconsin. Brighenti, under the guidance of John Lucey, explores the texture and spreadability of cream cheese. You can read more about her and her work in a profile published in Wired Magazine:

http://www.wired.com/wired/archive/14.06/cheese_pr.html

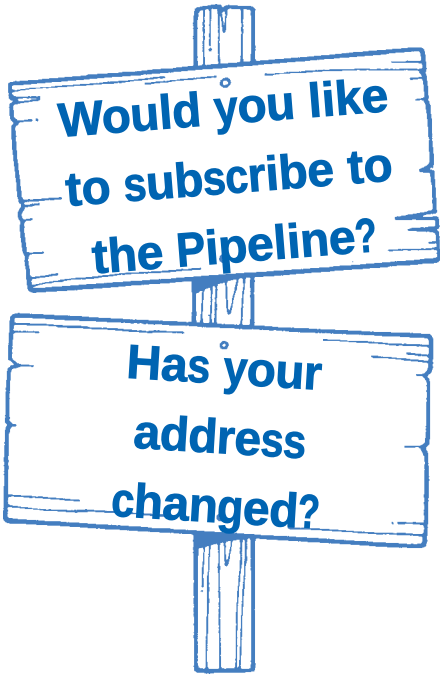
Calendar, continued

Oct. 2-7 World Dairy Expo, Madison, WI. For information see www.world-dairy-expo.com.

Oct. 8-12 Cheese Technology Short Course, Madison, WI. Call Bill Wendorff at (608) 263-2015.

Oct. 30-31 Dairy Ingredients Utilization Workshop, Madison, WI. Call Bill Wendorff at (608) 263-2015 or K.J. Burrington at (608) 265-9297.

Nov. 13-14 Dairy & Food Plant Wastewater Short Course, Madison, WI. Call Bill Wendorff at (608) 263-2015,



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Calendar

July 8-12 American Dairy Science Association Annual Meeting, San Antonio, TX. For more information see www.adsa.org.

July 8-11 International Assn. for Food Protection Annual Meeting, Lake Buena Vista, FL. For information see www.foodprotection.org.

July 26-28 IFT Annual Meeting, Chicago, IL. For information see www.ift.org.

Aug. 1-5 American Cheese Society Annual Meeting. Burlington, VT. For info, see www.cheesesociety.org.

Aug. 7-8 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.

Aug. 21-22 Cheese Affinage Short Course, Madison, WI. Call John Jaeggi at (608) 262-2264 or Bill Wendorff at (608) 263-2015 for information.

Sept. 11-12 Cultured Dairy Products Short Course, Madison, WI. Call Bill Wendorff at (608) 263-2015 or John Jaeggi at (608) 262-2264 for information.

Sept. 18-19 Dairy Ingredients in Fine Foods, Madison, WI. Call K.J. Burrington at (608) 265-9297.

Sept. 26-27 Dairy, Food and Environmental Health Symposium. cosponsored by Wisconsin Association of Food Protection, WI Association of Dairy Plant Field Reps, and WI Environmental Health Assn., La Crosse, WI. For more information, contact Matt Mathison at (608) 836-8820 or e-mail at: mmathison@wmmb.org.

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