Wisconsin Center for Dairy Research

DAIRY PIPELINE

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Modified Atmosphere Packaged Cheddar Cheese Shreds: How Light and Gas Type Influence Color and Volatile Compounds

By Llori M. Colchin, Sandra L. Owens, Galina Lyubachevskaya, Sodexo Marriott Services and Scott A. Rankin, Dept. Food Science, University of Wisconsin—Madison

For convenience, many cheese varieties, including Cheddar, are available pre-shredded in translucent modified atmosphere packaging (MAP). Although flavor development in traditional Cheddar cheese has been well documented (Christensen and Reineccius, 1995; Dunn and Lindsay, 1985; Engels and Visser, 1994; Fox et al., 1995; Manning, 1978; Urbach, 1995), little is known about the flavor chemistry of shredded cheese. Since both processing and storage of shredded cheese differ greatly from traditional cheese, it is likely that flavor and color are affected. For example, look at the major differences in the ripening process of shredded cheese—traditional block cheese ripens in the dark under regular atmospheric conditions, while shredded cheese, with a significantly increased surface area, ripens under altered gas atmospheres and high intensity fluorescent light.

Modified atmosphere packaging is a common method of food preservation that relies on introducing carbon dioxide (CO_2) and/or nitrogen (N_2) into the package to replace air. CO_2 extends the shelf life of cheese by inhibiting mold growth (Alves et al.,1996; Maniar et al.,1994). However, CO_2 may also degrade many flavor compounds (Drost, 1977) and affect the microorganisms essential for flavor development in cheese (Dixon and Kell, 1989). N_2 acts as an inert filler gas and has no documented adverse influence on cheese flavor.

What's Inside:

High intensity light has been reported to have negative effects on the color stability of natural yellow cheeses (Deger and Ashoor, 1987; Barnicoat, 1950; Hong et al.,1995). Shredded Cheddar cheese stored under high intensity fluorescent light may also be susceptible to light-induced oxidation reactions that could affect both flavor and color quality. It's likely that the dramatic increase in surface area of shredded Cheddar cheese multiplies the deleterious effects of high intensity light.

Storage and processing

Understanding how storage and processing conditions influence the flavor chemistry and color of shredded Cheddar cheese is important because it can help us maintain desirable flavor and quality. Our study investigated the effects of packaging gas type and light exposure on the color and volatile compound profile of shredded Cheddar cheese during a six-week storage period. The cheese block was shredded and samples of cheese shreds were packaged in low-oxygen permeable film under 100% CO_2 or 100% N_2. Packages of CO_2 and five packages of N_2 treated samples were randomly assigned to storage under continuous fluorescent light (approximately 120 ft candles) or in the dark at 4∫C for 6 weeks. Volatile compounds were separated and identified using a gas chromatograph coupled with a mass spectrometer.

Aldehydes were the major constituent of the volatile fraction of shredded Cheddar cheese packaged under CO_2. They accounted for approximately 63 and 35% of the total volatiles in the CO_2-treated cheeses exposed to fluorescent light and in CO_2-treated cheeses stored in the dark, respectively. However, no aldehydes were detected in cheeses packaged under N_2 with the exception of very low concentrations of decanal.

The volatiles from cheeses packaged under CO_2 and exposed to fluorescent light contained more than 6

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An Overview of Cheese Flavor

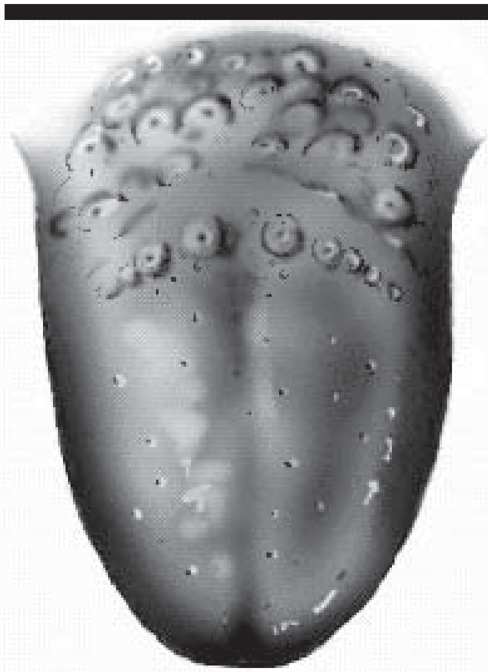
Beginning with the first nibble and ending with the big prize

Part I: The biology behind taste and smell

There are many aspects of humans that distinguish us from the rest of the animal kingdom and some are more obvious than others. Our senses of taste and smell are one example. Unlike field mice, canines, or raccoons, our meals (and our lives) don't depend on our ability to use our sense of smell to find food. We aren't like the social insects either; the ants, termites, and wasps, which use chemical signals to communicate clues about food sources, predators and mates. Instead, we rely heavily on sight and sound, saving the chemical senses of taste and smell to enhance our lives by enlivening our meals and perhaps warning us of bitter poisons or spoiled food.

All it takes is a cold virus to convince anyone that the senses of taste and smell work together. When you can't smell, you simply cannot taste as well either. Although they work together, these senses are very different. The sense of taste, or the gustatory system, processes specific flavors, while, in humans, the olfactory system, or sense of smell, is less specialized. That doesn't mean less complicated, though. Scientists estimate that the average human can detect approximately 10,000 odors. And consider this, while we are skilled at detecting odors, we aren't very good at identifying and describing them. Our expectations influence what we smell and our much-ballyhooed verbal abilities falter when we try to describe odors.

"We may be able to clone sheep, but we still can't grow taste buds in the lab."



According to Eric Haseltine, 25 percent of us have tongues tightly packed with taste buds, which qualifies us as supertasters. Another 25 percent have fewer taste buds and the rest lie somewhere in between. In the February 2000 issue of Discover magazine, he suggests that a simple experiment can satisfy your curiosity about your own tasting ability. You'll need a flashlight, a magnifying glass, cotton swabs, and blue food coloring. Sprinkle a few drops of food coloring on your tongue, swab them around and, using the flashlight and the magnifying glass, you are ready to assess your own fungiform papillae. These structures, the home base of your taste buds, look a bit like pale mushrooms with a blue background.

Advances in genetics

We may be able to clone sheep these days, but we still can't grow taste buds in the lab. This has slowed progress in the world of gustatory science. However, the same advances in genetics that are revealing all kinds of surprises in most scientific fields are also advancing the cause of taste bud research. DNA sequencing has allowed researchers to find genes for receptors that are only active in taste cells. Ironically, the first taste receptor identified was for a taste previously unacknowledged by Western scientists—umami. Named almost a century ago by Kikunae Ikeda, umami, roughly translated, means savory in Japanese. It is a distinct, meaty flavor, triggered by monosodium glutamate, that doesn't taste so great by itself but can enhance many other flavors.

Since the discovery of umami receptors, researchers have been busy puzzling over the pathways of both bitter and sweet tastes. Remember that map of the tongue you learned about in biology class? Well, you might want to update that notion. It turns out that all areas of the tongue respond to all tastes. It's just that some do it better than others. In fact, a single taste bud contains between 50 and 100 taste cells that are a mix of all taste types. When you look further down the sensory road, each taste cell connects to a sensory neuron that can be part of a network linking several cells in several taste buds. However, each single neuron responds best to a single taste.

Along with bitter, sweet, sour, salty, and now umami, some scientists suggest that humans may also have a sense of taste for fat. Richard D. Mattes of Purdue University studied adult volunteers and found that eating fat could trigger a change in the way the body absorbs fats. This change seemed to follow an oral stimulus rather than a smell stimulus.

Does this mean we have taste receptors for fat? It's possible, however most scientists are waiting for more data, as well as clearer link between DNA, receptors, and metabolism before they add fat to our list of tastes.

Olfactory connections to memory

Digging into a hot fudge sundae may trigger some pleasant associations, but not the same way that smelling warm chocolate can. The olfactory system, which is much more sensitive than taste, also has neural connections to both memory and emotion systems in our brains. That is why smells can trigger vivid, often autobiographical, memories from the past—long forgotten scenes that can flood your consciousness with a surge of emotion.

In primitive organisms, and our ancestors, the olfactory system evolved to deliver information about the world that could enhance safety and improve communication. Thus it is no surprise that the sense of smell is connected to areas of the brain that can process information and trigger a fast, reflexive response. Of course, humans went on to complicate their development by learning to think and analyze, which does influence our response to smell and by doing so, influence our perception of flavors.

Julie Mennella, of the Monell Chemical Senses Center in Philadelphia, lists some differences between our senses of taste and smell. In a 1998 issue of Food Technology, she notes that "Unlike gustatory receptors, the olfactory neurons are actual receptor cells, uniquely exposed to the external environment."

> "These olfactory neurons are located in the roof of each nostril of your nose."

Converting external chemistry to internal chemistry

These olfactory neurons are located in the roof of each nostril of your nose, covering an area about 2.5 cm^2 each, or about a square inch. Just to give you a little perspective, the same neurons cover an area of 12.5 cm^2 in each nostril of the cat. Even so, our small area hosts around 5 million neurons. To stimulate the olfactory system, a volatile odor reaches the receptors through the nose or the back of the throat. Right now, we know a lot about the anatomy and neural wiring of the olfactory system. But what we are just beginning to learn is how the wiring converts external

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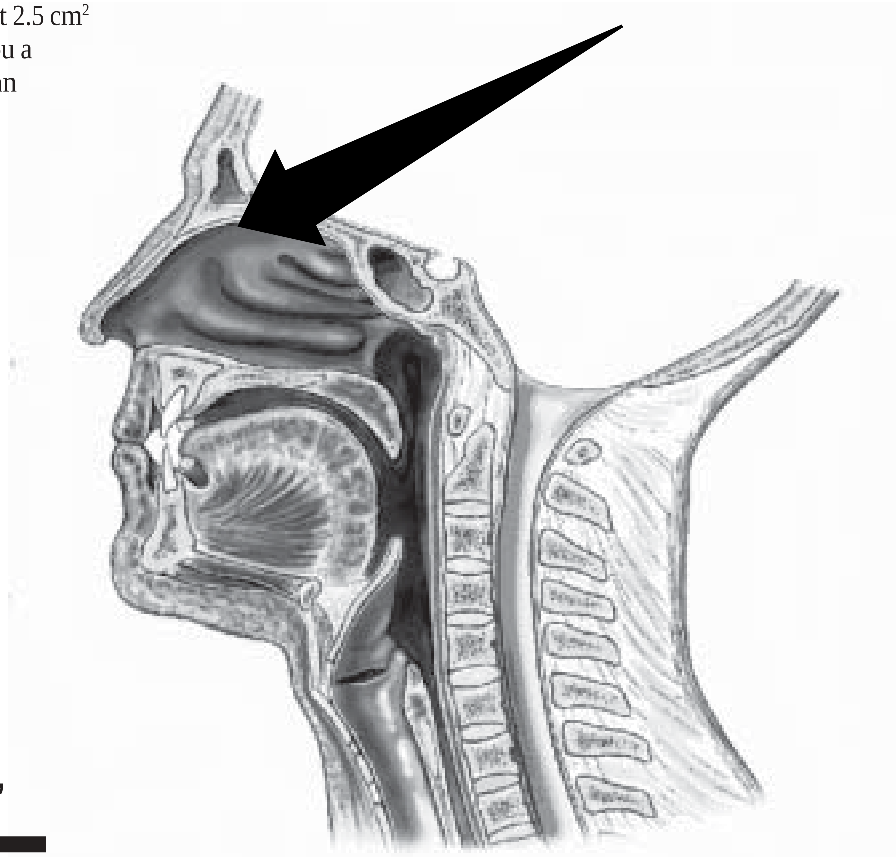
> "...olfactory neurons are actual receptor cells, uniquely exposed to the external environment."



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times the aldehyde concentration than cheeses packaged under CO_2 and stored in the dark. Two different pathways form the aldehydes: the oxidation of unsaturated fatty acids and amino acid degradation. Earlier research suggested that branched-chain aldehydes originate from amino acid degradation (Adda, 1986), and straight-chain aldehydes are formed through the oxidation of unsaturated fatty acids (Engels et al., 1997). The lack of aldehydes in the N_2-treated cheeses may indicate that neither of these pathways is favored in a nitrogen atmosphere.

Branched-chain aldehydes may originate from branched-chain fatty acids. Therefore, it is possible that the majority of aldehydes we detected were the result of lipid oxidation. In addition, our detection of considerably higher concentrations of the aldehydes in cheeses exposed to light relative to cheeses kept in the dark implies that light-induced lipid oxidation was behind the formation of aldehydes.

Ketones, N_2 vs CO_2

Ketones were the major component of shredded Cheddar cheese packaged under N_2. Ketones represented 78% of the total volatiles identified in N_2-packaged cheese exposed to fluorescent light and 77% of the total volatiles identified in N_2-packaged cheese stored in the dark. However, in cheeses stored under CO_2, very low concentrations of ketones were detected.

In traditional Cheddar cheese, which is not a mold-ripened cheese, lipolysis is minimal, and lipolytic products including methyl ketones are present at very low concentrations. In 1989, Horwood suggested that significant concentrations of the ketones 2-heptanone and 2-pentanone in non-mold-ripened cheeses indicate mold contamination. Thus, the high concentrations of methyl ketones present in the cheeses packaged under N_2 were most likely due to mold growth. Additionally, 8-nonen-2-one is a significant component in the flavor of blue and mold-ripened cheese. This compound was identified only in the cheeses packaged under N_2, more evidence suggesting the presence of mold growth in these cheeses.

CO_2 is a powerful antimycotic agent, whereas N_2 acts as an inert filler gas. Thus, it was expected that compounds indicating mold contamination would be present in the N_2-treated samples, and not in the CO_2-treated cheeses. None of the samples tested had any visual indications of mold growth.

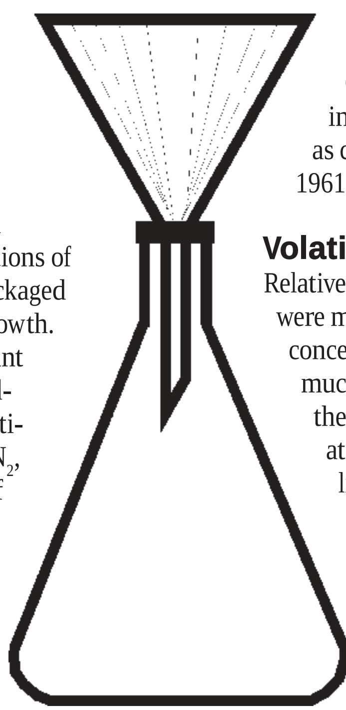
Alcohols and esters

The reducing conditions of Cheddar cheese favor the reduction of aldehydes and methyl ketones to their corresponding alcohols (Engels et al., 1997; Fox et al.,1993). Alcohols represented the second largest class of volatile compounds in samples following both N_2 treatments as well as in those packaged under CO_2 and exposed to fluorescent light. In cheeses packaged under CO_2 and stored in the dark, alcohols were present to a lesser extent, representing only 8% of the total volatiles. Significantly higher concentrations of alcohols were detected in N_2-treated cheeses than in CO_2-treated cheeses.

Alcohols present in the highest concentrations included 3-methyl-1-butanol, 2-pentanol, 2-heptanol, and 1-octen-3-ol. 3-Methyl-1-butanol is formed by the reduction of its corresponding aldehyde, which is produced from leucine. 1-Octen-3-ol is a product of the oxidation of linoleic and linolenic acid (Adda, 1986) and is a significant contributor to the flavor of cheese (Urbach, 1997). The characteristic aroma of 1-octen-3-ol is described as mushroom-like (Adda, 1986).

Verylow concentrations of esters were detected in cheeses analyzed in this study. However, even at very low concentrations, esters are major contributors to the flavor of Cheddar cheese (Arora et al., 1995). Due to their high volatility at ambient temperatures, esters make significant contributions to the total aroma. Cheeses packaged under N_2 contained significantly higher concentrations of esters than did cheeses packaged under CO_2, which may be due to the inhibitory effect of CO_2 on formation of some flavor compounds.

CO_2, in addition to inhibiting the spoilage microflora, also decreases the concentration of many flavor compounds (Drost, 1977). Studies have shown that CO_2 has a negative influence on the fermentation bacteria essential for flavor development in cheeses (Dixon and Kell, 1989). Although the mechanism of CO_2 is not well understood, researchers have suggested that CO_2 exerts its effects when the gaseous CO_2 dissolves into the liquid phase of the food tissue, and is absorbed as carbonic acid (Daniels et al.,1985; Sears and Eisenberg, 1961).



Volatile free fatty acids

Relatively low concentrations of volatile free fatty acids (FFA) were measured in the shredded cheeses in this study. The concentration of FFA in the cheeses packaged under N_2 was much less than that of the CO_2-packaged cheese. However, the concentrations of FFA were similar within each atmosphere, indicating that lipolysis was not affected by light. Low concentrations of FFA in cheese may be an indicator of insufficient maturation. In traditional Cheddar cheese, a gradual increase in FFA (C2 to C12) occurs throughout 60 days of ripening (Fox et al., 1993).

FFA contribute to the background flavor of Cheddar cheese (Urbach, 1997), and also act as precursors to flavor-influencing compounds like esters, methyl ketones, and alcohols. FFA can be derived from both microbial and endogenous lipase activities. The comparatively lower concentration of FFA detected in the N_2 packaged cheeses may be explained by a higher esterification rate as evidenced by the concomitantly higher concentration of ethyl esters.

Acetic acid was the most abundant volatile fatty acid detected. Acetic acid can be derived from the metabolism of carbohydrates and amino acids. The increased concentration of acetic acid in CO_2-treated cheese exposed to light suggests that these conditions may favor the growth of hetero-fermentative bacteria in shredded Cheddar cheese. The concentration of acetic acid was shown to increase during aging in traditional Cheddar cheese (Dimos et al., 1996).

In the present study, the concentration of cyclic compounds was similar following all the cheese treatments with the exception of cheeses packaged under CO_2 and exposed to fluorescent light. These cheeses contained twice the total concentration of cyclic compounds than the other cheeses, due to the presence of two additional compounds, 2-ethylfuran, and D-limonene. The presence of 2-ethylfuran in CO_2-treated cheeses exposed to light may be attributed to degradation of thiamin present in Cheddar cheese. Limonene, which was present in the cheeses exposed to CO_2 and light, probably originated from degradation of bixin, the major pigment used to color most colored Cheddar cheeses. CO_2 in combination with light led to breakdown of bixin as evidenced by loss of color in the cheeses exposed to CO_2 and light. Bixin consists of isoprene units that may degrade to form limonene. Limonene was previously detected in Cheddar cheese and was associated with a characteristic citrus aroma (Engels et al, 1997). Benzaldehyde and 1-methylethylbenzene were the only cyclic compounds detected in all treatment groups. Benzaldehyde is derived from the degradation of phenylalanine (Groot and de Bont, 1998). The presence of the highest concentration of benzaldehyde in the CO_2- and light-treated samples suggests that this reaction is favorable in these conditions.

Color changes

Only the shredded cheeses packaged under CO_2 and exposed to fluorescent light experienced obvious color alterations, shifting from the traditional orange of colored Cheddar cheese to a definite white hue. No significant differences in color were observed among the other treatment groups.

High intensity light is known to be detrimental to the color stability of natural yellow cheeses (Deger and Ashoor, 1987; Hong et al., 1995). Barnicoat (1950) suggested that discoloration observed in yellow cheeses is related to lipid oxidation. Hong et al. (1995) observed a positive correlation between the rate of discoloration of Cheddar cheese and oxygen transmission rates of packaging films.

Another explanation for the color may be related to annatto, the pigment commonly used in Cheddar and other yellow cheeses. Annatto extracts are obtained from the seeds of *Bixa orellana*, which contains the carotenoid bixin. This is the main compound responsible for the coloring properties of annatto and it contains numerous conjugated double bonds. Conjugated double bonds are the target of free radical molecules, leading to oxidation reactions in lipids and probably in the carotenoid, bixin. We propose that the color loss is due to bixin oxidation from CO_2-derived free radical species generated under light exposure.

Summary

The generation and maintenance of Cheddar cheese flavor requires the subtle combination of several key elements. Although a great convenience to consumers, the packaging and storage of cheese using MAP technologies represent a distinct departure from traditional cheese ripening conditions.

Even though visible signs of mold growth were not detected in the samples analyzed in the present study, alterations in volatile profiles, namely high concentrations of methyl ketones, indicated that shredded Cheddar cheese packaged under N_2 was highly susceptible to molding. Packaging of shredded Cheddar cheese in a 100% CO_2 atmosphere had negative effects. The generation of important volatile compounds essential for development of Cheddar cheese flavor was suppressed by CO_2 exposure. In addition, high concentrations of lipid oxidation products and bixin discoloration occurred in shredded Cheddar cheese packaged under 100% CO_2 and stored under fluorescent light.

Actual industry practices may include a variety of CO_2 and N_2 gas blends. Based on the results of this initial study of volatile profiles, further work is under way to characterize the effects of gas types and blends on several indices of Cheddar ripening. In addition, we are looking at lactose utilization, starter and nonstarter microflora, lactate generation, proteolysis and lipolysis. A better understanding of the influence that gas types and concentration have on Cheddar storage will enable us to produce high quality shred products.

ACKNOWLEDGMENTS

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chemistry, the odor, to our own personal internal chemistry, the smell we perceive.

Back in 1991, Linda Buck and Richard Axel discovered seven proteins that looked like they could be the long sought odor receptors that many scientists had been searching for. These receptor proteins detect the external chemistry—the odor molecules. They also identified genes carrying the code for these proteins. Since then, hundreds of receptors have been identified, along with even more genes. Still, these numbers couldn't account for our ability (though paltry compared to other species) to detect over 10,000 odors. By 1999, scientists figured out that a single receptor is stimulated by many odors, a single odor is recognized by many receptors, and that combinations of the receptors interact. This is like any alphabet that combines to form words and language or like musical notes that produce a melody, a song or a symphony. Now we can begin to see how 1,000 receptors operate together, explaining how a blast of a particular odor can smell rotten but a trace whiff of the same odor has a floral scent. It happens because fewer receptors are activated, a different "word" has been spoken. When the concentration is raised, the olfactory code changes again.

Our understanding of both taste and smell has lagged behind knowledge of how we see, hear, and touch. But that is changing rapidly and the pace isn't likely to slow anytime soon.

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Describing Cheddar cheese flavor

If you have read this review of the biology of taste and smell then you know that anything associated with flavor can be rather complex. A recent article in the Journal of Food Science describes an effort to standardize the descriptive language for describing Cheddar cheese to "enable more precise profiling of flavor attributes."

As others have noted, it can be difficult to describe specific flavors. Drake, currently at the Dept. of Food Science at North Carolina State, et al started their cheese lexicon project by collecting 200 Cheddar cheeses from representative geographical areas in the US, and an additional 40 samples from Europe, New Zealand and Australia. They drew on the expertise of cheese flavor experts and organized a roundatable discussion group together to develop descriptive terms with definitions. The terms were then further refined by a descriptive analysis panel. The result is a list of 17 descriptive words for Cheddar cheese flavor, followed by definitions and references. For example, when you detect a sulfur note in Cheddar cheese you are noticing the aromatics associated with sulfurous compounds. Would you like to demonstrate this to someone? Have them smell a boiled, mashed egg or H_2S bubbled through a waterstruck match. Or how about fruity flavor notes in Cheddar cheese? The lexicon defines this note as the aromatics associated with different fruits. As a reference, they suggest fresh pineapple, or for the chemist, ethyl hexanoate at 20 ppm.

Drake and her collaborators propose that this referenced Cheddar lexicon will enhance how we talk about cheese flavor, and cheese flavor research results. In addition, this standardization allows similar training at different sites.

Drake, M. A., McIngvale, S. C., Gerard, P.D., Cadwallader, K. D. and Civille, G. V., Journal of Food Scioence, v66, no 9, 2001. Development of a Descriptive Language for Cheddar Cheese.

Skimming the Shelf—What's New in Print?

Habeas Codfish
Reflections on Food and the Law

By Barry M. Levenson
University of Wisconsin Press 2001

Did you know that the first health inspector was a Greek, and the year was around 500 B.C.? Or that Americans devour 350 slices of pizza per second? Well, neither did I—until I read Levenson's entertaining and information packed "Habeas Codfish." Have you ever wondered if a restaurant is selling food or providing a service? If so, this is the book for you.

Levenson, an avowed lover of butter himself, devotes an entire chapter to "laws and lawsuits that concern the dairy industry." Although he declines to delve into the "intricacies of the milk marketing laws and regulations", Levenson lays out the history of Wisconsin's antimargarine laws and winds up the chapter with a few opinions about the latest target of the dairy industry—soy. By the way, did you know that margarine was first manufactured in 1867, the very same year that the Illinois and Wisconsin Dairymen's Association formed?

Chapter 5, Java Jurisprudence, not only summarizes the famous McDonald's hot coffee lawsuit, but also provides a historical context of the civil law of food injuries. Other chapters cover the development of food standards of identity, adulteration laws, trademark issues, and in Chapter 13—Cruel and Unusual Condiments—the food served in our prison systems.

Levenson's Habeas Codfish turns an often tedious topic into an amusing distraction and I enjoyed reading it. I think I've also added to my store of trivia and my stock of conversation stoppers. For instance, did you know that the first registered US trademark was for Underwood Deviled Ham in 1868?

Barry Levenson describes himself as a recovering lawyer, he now presides over the Mt. Horeb Mustard Museum in Mt. Horeb, Wisconsin.

News from CDR

The Wisconsin Center for Dairy Research was well represented at recent Whey and Dry Milk Ingredients Forum in Phoenix, Arizona. Endorsed by the American Dairy Products Institute and offered by Dairy Management Inc., the forum was part of the Extraordinary DairyÆ Exploration Series. Rusty Bishop, CDR director, extolled the participants with "Lactose Update: The Sweet Side of Whey" and KJ Burrington and Karen Smith, CDR staff running the Whey Applications program, participated in a panel discussion, "Tales from the Front."

Applying to the Wisconsin Master Cheesemaker® Program? The deadline for new candidates and Masters applying for additional cheeses is May 15, 2002. Contact Jim Path at (608) 262-2253 or check the CDR website (www.cdr.wisc.edu) for details.

And now that we've mentioned Jim Path, let me fill you in on his latest travels. He recently journeyed to Ladenburg, Germany, to work on some flavored, processed cheeses. When in Germany, Jim also visited Käsewerk, a producer of specialty process cheese in Zangerhausen. He swung by Poland to buy an array of Polish cheeses and stopped in Weihenstephan at the Technical University Munich before returning to Wisconsin with an array of souvenir cheese (including some cool looking tubes of cheese).

Annual Quality Milk Conference
February 19-20, 2002
Crown Plaza Hotel - Madison East

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Tuesday, Feb. 19
Morning

Biosecurity and Pathogen Control
Moderator – Greg Siegenthaler, Grandee Cheese Company

European Dairy Challenges (foot & mouth)
Chris Olson, DVM, School of Vet Medicine, UW—Madison

Testing for Johnes Disease
Don Sockett, DVM, WI Veterinary Diagnostic Lab, Madison, WI

Animal ID Program
Clarence Siroky, DVM, WDATCP, Madison, WI

Emergency Response to Bioterrorism
Larry Bauman, DVM, UW-River Falls, River Falls, WI

Afternoon

New Environmental Concerns for the Producers
Moderator – Dave Lohr, Foremost Farms USA, Baraboo, WI
Panel Discussion
Producer – Joe Bragger, PDPW, Independence, WI
DNR - Tom Bauman, Dept. of Natural Resources, Madison, WI
Discovery Farms – Dennis Frame, Coop. Ext., UWEX, Whitehall, WI
Farm Bureau – Paul Zimmerman, WI Farm Bureau Fed., Madison, WI

Milk Quality Programs
Moderator – Larry Tuschen, Dairy Farmers of America, Sun Prairie, WI

UW Milk Quality Systems
Pamela Ruegg, DVM, Dept of Dairy Science, UW—Madison

Robotic Milker Update
Doug Reinemann, Ph.D., Dept of Biosystems Engineering, UW—Madison

Wednesday, Feb. 20
Morning

Critical Regulatory Issues for Quality Milk
Moderator – Bill Wendorff, Ph.D., Chr., Dept. of Food Science, UW—Madison

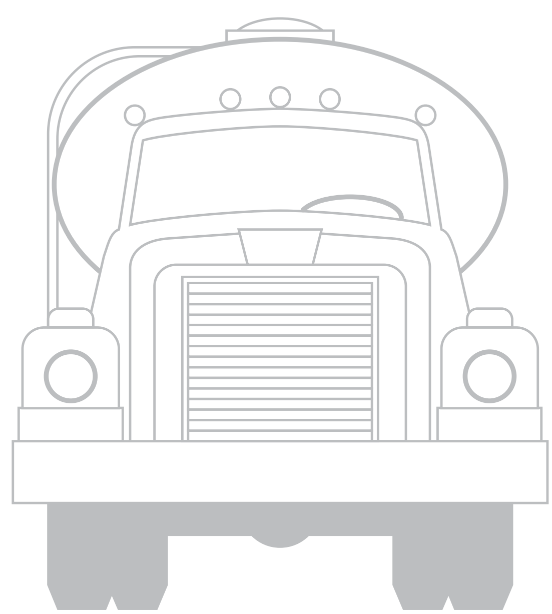
Biotechnology and the Future Impact on the Dairy Industry
Greg Henderson, Monsanto, St. Louis, MO

Water Issues on Milk Surveys
Jim Wickert, Milk Certification Program, DHFS, Madison, WI

Update on Milk Surveys
Randy Daggs, Milk Certification Program, DHFS, Madison, WI

Current Concerns from WDATCP
Tom Leitzke, Division of Food Safety, WDATCP, Madison WI

Value-Added Dairy Products
Scott Rankin, Ph.D., Dept. of Food Science, UW—Madison



Curd Clinic

Curd clinic doctor for this issue is KJ Burrington, coordinator of CDR's Whey Applications program

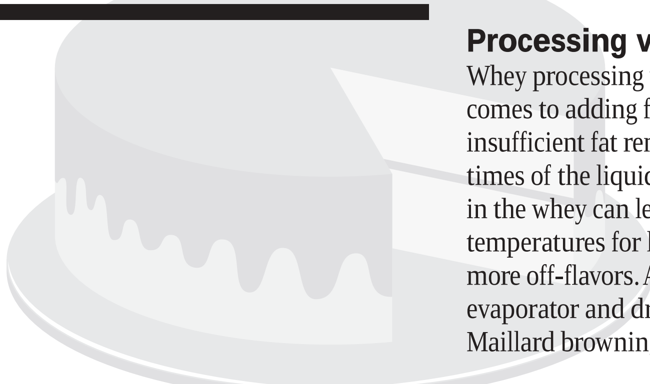
Q. The company I work for processes whey into several different products for various food companies. One of our customers has complained about flavor variability in our whey which affects the quality and consistency of their finished product. What affects whey flavor and how do I deliver a consistent clean flavor to my customer?

A. One of the attributes that is often paid the least attention to in whey is flavor. Most manufacturers are concerned about delivering functional properties like browning, solubility, and water binding. Many manufacturers may see flavor as something they don't have a lot of control over.

Most people expect whey to have a "mild" or "bland" dairy flavor but many times they get a lot more flavors that don't fit into the description "bland". When looking for the origins of whey flavor, it is necessary to go back to the original milk used for cheesemaking. Mark Johnson, senior scientist here at CDR, notes that "Anything that flavors milk can flavor whey". As most of us know, raw milk arrives from the farm with different types and amounts of bacteria. Even though you pasteurize the milk to get rid of bacteria, the flavor has been affected. Milk also comes with it's own set of flavors based on what the cow is eating such as feed versus grass. So your whey flavor may change with the feed type. If you standardize your milk with ingredients such as nonfat dry milk, condensed milk, or other types, the quality of those ingredients will also affect the flavor of your cheese milk. So far you haven't even produced any whey and you have several variables affecting whey flavor.

"It is important for all of the operators in the plant to be aware that controlling each step of the process is the key to a consistent whey flavor."

One of the more well-known factors that affect whey flavor is the cheese variety that it comes from. Each cheese variety has different starter cultures, production methods, and possibly different types of rennet or other enzymes used. Starter cultures use the lactose in milk to produce lactic acid. Depending on the starter, a lot of lactic acid can be produced which all ends up in the whey, giving it an undesirably low pH and acid flavor. Up to this point in the process, the fate of the whey flavor has been in the hands of the dairy farmer and the cheese plant. Now you're ready to get the whey to the whey plant.



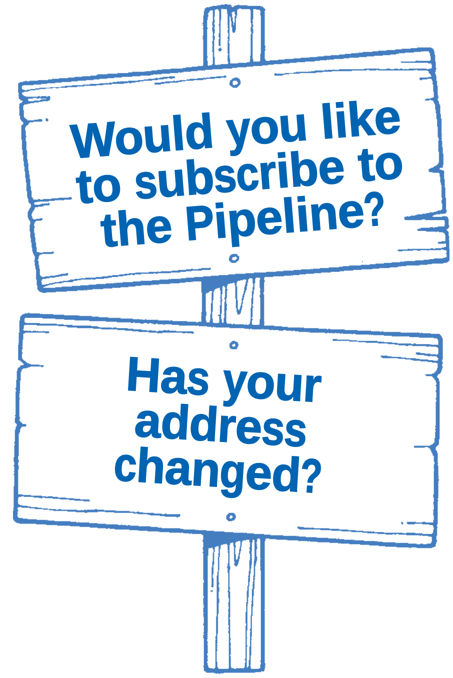
Processing variables

Whey processing variables can put the frosting on the cake when it comes to adding flavor variability. All of the processes such as insufficient fat removal, improper storage temperatures and storage times of the liquid whey can really contribute to undesirable flavors. Fat in the whey can lead to fat oxidation and rancid flavors. Warm storage temperatures for long periods will allow bacteria to grow and produce more off-flavors. Any excessive heat treatments from pasteurization, evaporator and drying conditions can lead to cooked flavors caused by Maillard browning reactions between the lactose and proteins. Ph adjustment of the whey to a specific level may be necessary because the pH is lower due to lactic acid from the starter. Varying amount of chemicals added to raise the pH may cause variability in whey flavor. All this and you still have to put the whey in a bag and expose it to varying storage conditions.

After it's all said and done, how can a processor ever expect to control all those variables? Many processors are aware of these variables and try to control them. It is important for all of the operators in the plant to be aware that controlling each step of the process is the key to a consistent whey flavor. The tricky part is identifying the flavors and linking them to specific variables from the milk all the way through the process to the dry whey. That is a job for the researchers.

Future research

Very few research projects have investigated whey flavor. However, that is about to change. Here at the UW-Madison, Food Science Department, Dr. Scott Rankin will be evaluating whey samples to determine the effect of manufacturing variables on whey flavor. Researchers at the University of Minnesota, North Carolina State University, Oregon State University, and Ohio State University are also examining whey flavor. Stay tuned.



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The Dairy Pipeline
Center for Dairy Research
1605 Linden Dr.
Madison, WI 53706-1565
phone: 608/262-5970
fax: 608/262-1578

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Calendar

Feb. 19-20 Quality Milk Conference (WI Dairy Field Reps). Madison, WI. Call Bill Wendorff at (608) 263-2015.

Feb. 26-27 Wisconsin Process Cheese Short Course. Madison, WI. Call Jim Path at (608) 262-2253 or Bill Wendorff at (608) 263-2015 for more details.

Mar. 18-22 Wisconsin Cheese Technology Short Course, Madison, WI Call Bill Wendorff at (608) 263-2015.

Mar. 25-28 Premium Ice Cream Project, Madison, WI. Call Scott Rankin at (608) 263-2008.

Apr. 4 WDPA Butter & Cheese Evaluation Clinic, Wis. Dells, WI. For information, call Brad Legreid at (608) 836-3334.

Apr. 23-25 International Cheese Technology Exposition, Madison, WI. For information, call Judy Keller at (608) 255-2027.

May 7-8 Whey and Whey Utilization Short Course, Madison, WI. Call Bill Wendorff at (608) 263-2015 or K.J. Burrington (608) 265-9297.

May 14-15 Applied Dairy Chemistry Short Course, Madison, WI. Call Bill Wendorff at (608) 263-2015.

May 21 Wisconsin CIP Workshop, Madison, WI. Call Bill Wendorff at (608) 263-2015.

May 22 Dairy HACCP Workshop, Madison, WI. Call Marianne Smukowski at (608) 265-6346.

June 4-5 Wisconsin Cheese Grading Short Course, Madison, WI. Call Scott Rankin at (608) 263-2015 or Marianne Smukowski at (608) 265-6346.

Wisconsin **Center for Dairy Research**
University of Wisconsin-Madison
1605 Linden Drive
Madison, Wisconsin 53706-1565

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