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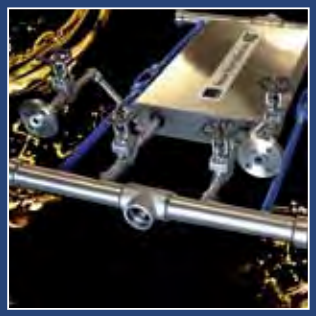

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Prescribing dietary fat: therapeutic uses of ketogenic diets

Catherine Watkins

One of the victims of the war against dietary fat has been the ketogenic (ketone-producing) diet. This high-fat, adequate-protein, and very-low-carbohydrate way of eating has been known for more than 100 years as an effective treatment for a number of disorders. William Banting published a monograph in 1863 titled *Letter on Corpulence* (page 11), which detailed the successful treatment of his own obesity with a low-carbohydrate diet. Severe childhood epilepsy has been treated since the 1920s with the ketogenic diet (KD), and some type 2 diabetics have achieved normal blood glucose levels without medication by following a high-fat, low-carbohydrate diet.

- **The high-fat, adequate-protein, and very-low-carbohydrate way of eating known as the ketogenic diet (KD) has been used to treat epilepsy for almost 100 years.**
- **The therapeutic effects of KDs have been investigated in a number of diseases and disorders, including diabetes, obesity, cancer, cardiovascular disease, and neurological conditions such as Alzheimer's and Parkinson's disease.**
- **This article provides an overview of where the research stands.**

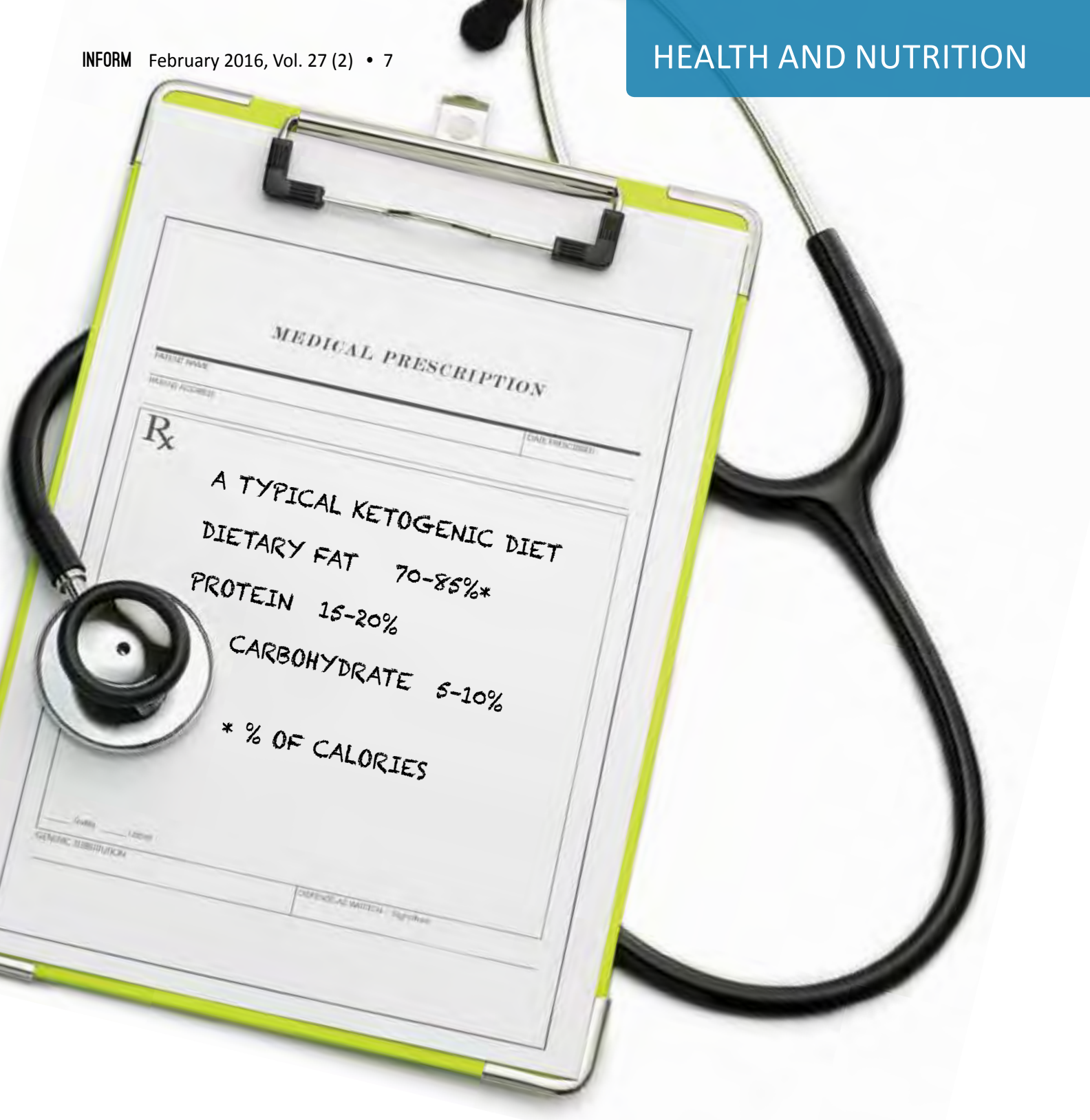
Despite an abundant anecdotal and scientific history, many modern-day physicians—often underschooled in nutrition and over-reliant on pharmacotherapy—have written off KDs as being unsustainable and unsafe, thanks in large part to the demonization of dietary fat. Now, however, after a significant increase in research on KDs and a shift in opinion regarding dietary fat, ketogenic diets are experiencing a comeback.

A recent review article co-written by Jeffrey S. Volek neatly summarizes a number of the conditions in which KDs appear to play a therapeutic role. These include a wide variety of neurological conditions such as epilepsy and Alzheimer's disease, diabetes, and certain cancers. In addition, KDs may improve cardiovascular risk parameters. The review, which appeared in the *European Journal of Clinical Nutrition* (Paoli, A., *et al.*, http://dx.doi.org/10.1038/ejcn.2013.116, 2013), serves as the backbone of this feature article.

"There are so many exciting developments in nearly every chronic noncommunicable disease, especially type 2 diabetes and other diseases associated with insulin resistance such as heart disease and polycystic ovary syndrome," Volek wrote in an email. "The science supporting ketogenic diets for healthy weight loss is impressive, but equally exciting is the application in a number of other conditions." Volek is a registered dietitian and a professor in the Department of Human Sciences at The Ohio State University (Columbus, USA) and an associate professor in the Department of Kinesiology at the University of Connecticut (Storrs, USA).

WHAT CONSTITUTES A KETOGENIC DIET?

Researchers are still working to establish precisely why and how KDs lead to therapeutic outcomes, but the "what" of the matter is well understood. At its simplest, there are two possible sources of fuel for most cellular functions—glucose or fat. However, cellular respiration (energy production in the



presence of oxygen) using glucose has a weakness: The body can only bank about 1,000–1,600 calories of excess carbohydrate as glycogen—the storage form of glucose. Any excess glucose beyond that is converted via lipogenesis into fat and is stored. On the other hand, either dietary or stored fat can fuel cellular respiration using ketone bodies (a byproduct of the breakdown of fatty acids in the liver). Since many of us have too much of the latter and ready access to the former, fat-as-fuel is in plentiful supply. The advantage of metabolizing stored fat for the overweight and obese is obvious.

Once the body's glucose and glycogen stores are depleted, ketosis begins, and the body uses stored and/or dietary fat as energy. Generally, carbohydrate consumption must be below 50–60 g/day for ketosis to begin, although each person's metabolic requirement is unique. The popular and well-studied Atkins diet, which is a type of KD, calls for no more than 20 g of carbohydrate/day during its initial phase. To put that in perspective, there are about 7 g of carbohydrate in 100 g of raw broccoli and 31 g of carbohydrate in 100 g of cooked pasta. (See Table 1 on page 8 for the macronutrient ranges of ketogenic diets.)

TABLE 1. Macronutrient ranges and total grams for ketogenic diets

Macronutrient	% of calories	Total grams*
Dietary fat	70–85%	178 g
Protein	15–20%	75 g
Carbohydrate	5–10%	25 g

*Based on 2,000 calories/day with 80% fat, 15% protein, 5% carbohydrate

Likewise, protein must be held at moderate levels—generally between 15–20% of total daily calories—because the liver will convert as much as 60% of excess protein into glucose via gluconeogenesis, thus stopping ketosis. Fats from sources such as butter, coconut oil, and extra virgin olive oil make up the remainder of the KD macronutrient equation (usually at between 70–85% of daily calories).

Although the body needs small amounts of glucose to function, dietary carbohydrate in and of itself is not an essential nutrient. When ketosis begins, fat—whether stored or consumed—becomes the primary metabolic fuel in the form of ketone bodies (KBs). The three KBs produced by the liver from fatty acids are acetone, acetoacetic acid, and β-hydroxybutyric acid (BHB). Acetoacetate and BHB can be converted into acetyl-CoA and burned for energy through the citric acid cycle. Acetone can be converted into pyruvate, although it generally is excreted as waste; in some circumstances, it can be metabolized into glucose. The heart favors the use of fatty acids for energy in normal conditions, and it has no problem using KBs under ketotic conditions. The brain requires some glucose under both normal and ketotic conditions; this is readily produced by the liver in ketosis through gluconeogenesis using substrates such as pyruvate, lactate, glycerol, and glucogenic amino acids.

Clearly, the biochemistry of KDs is much more complicated than this bare-bones description suggests. The focus of this article, however, is on research regarding therapeutic uses of KDs and not on the cellular mechanisms at play.

KETOSIS VS. KETOACIDOSIS: ARE KDs SAFE?

Nutritional ketosis is a normal, strictly benign, and tightly regulated physiological process. Yet, medical practitioners often confuse it with ketoacidosis, a pathological condition seen in some insulin-dependent diabetics (type 1, or T1D) when they are under stress and/or have failed to administer enough insulin. This confusion has led to the mistaken idea that KDs and nutritional ketosis are inherently dangerous.

"Ketogenic diets are metabolically regulated and are far outside the danger range of ketoacidosis," said Richard D. Feinman, a professor of cell biology and medical researcher at the State University of New York Downstate Medical Center in Brooklyn (USA). Feinman is the author of *The World Turned Upside Down: The Second Low-Carbohydrate Revolution* (2014) and a pioneer in incorporating nutrition into the biochemistry curriculum.

"The low-carbohydrate way of eating in general is probably the safest thing you can do to improve your diet," he continued. "It is not really a joke to say that we know that low-carbohydrate diets are safe because the medical establishment has spent 40 years trying to find something wrong with them, and they never come up with anything. Of course, most of the 'concerns' are just mindless fear of doing something different, but there have been serious tests of potential risks, particularly in cardiovascular disease. In fact, [KDs] usually prove to be beneficial—they lower triglycerides dramatically and increase high-density lipoprotein (HDL), the so-called good cholesterol. The low-fat message never had a scientific foundation and is finally being recognized as a mistake."

KDs are not without side effects in some individuals, particularly as their metabolisms transition from burning glucose to running primarily on fat and KBs. These side effects can include kidney stones, diarrhea, dizziness, fatigue, tachycardia, and thirst. No one way of eating is ideal for everyone, and some conditions such as hypothyroidism and adrenal fatigue may preclude the use of therapeutic KDs. However, Volek suggests that the majority of side effects can be eliminated by properly formulating the ketogenic diet.

Research led by Amisha Patel of Johns Hopkins University in Baltimore, Maryland, USA, found that KDs are safe over the long term (*Epilepsia,* http://dx.doi.org/10.1111/j.1528-1167.2009.02488.x, 2010). "Despite its temporary side effects, we have always suspected that the ketogenic diet is relatively safe long term, and we now have proof," said Eric Kossoff, a co-author on the study and director of the ketogenic diet program at Johns Hopkins Children's Center, in a news release. "Our study should help put to rest some of the nagging doubts about the long-term safety of the ketogenic diet," he added.

"It turns out that when a person's metabolism runs on these small molecules [ketone bodies], there is a host of positive effects, including decreased oxidative stress and inflammatory markers and improved tolerance to stress," said Volek.

"Basic and applied scientists are studying the mechanisms of how this fat-burning state improves a variety of different cancers, wound healing, post-traumatic stress disorder, the aging process, and much more," he added. "Research is not just focused on weight loss and clinical applications. Recreational and elite athletes and soldiers are also using ketogenic diets to enhance their physical and mental performance and speed recovery from exercise."

Below are summaries of some of the conditions and disorders in which the well-formulated KD shows promise, as identified by Paoli *et al*. The list undoubtedly will grow over time. Wouldn't it be ironic if, after decades of demonizing fat, it turns out to be among the best of all dietary prescriptions for a number of diseases and disorders?

LEVEL OF EVIDENCE—STRONG

Cardiovascular risk parameters

Contrary to popular opinion about the dangers of dietary fat in general and saturated fat in particular, the high-fat ketogenic diet has been shown to have favorable effects on cardiovascular risk factors.

"The [KD] effect seems to be particularly marked on the level of blood triglycerides," Paoli *et al.* write, adding that "there are also significant positive effects on total cholesterol reduction and increases in high-density lipoprotein. Furthermore, [KDs] have been reported to increase the size and volume of low-density lipoprotein-cholesterol particles, which is considered to reduce cardiovascular disease risk. …"

Diabetes

Research that has evaluated well-formulated very-low-carbohydrate diets and documented high rates of compliance in individuals with type 2 diabetes (T2D) indicates that KDs have the potential to reverse symptoms of the disease. Given that diabetes—whether T2D or T1D—is a disease characterized by carbohydrate intolerance—the results are not surprising.

Type 2 diabetics exhibit insulin resistance, in which high levels of insulin released after ingestion of carbohydrates cause a greater diversion of carbohydrate to the liver, where much of it is converted into fat. This increases the level of serum triglycerides, largely as saturated fat (mainly palmitoleic acid [C16:1*n*7]), which in turn increases the risk of cardiovascular disease. By greatly lowering dietary carbohydrate through ketogenic eating, diabetics often lose weight and can lower or stop the use of insulin and other medications.

One study reported by Paoli *et al.* found "significant improvements in both weight loss and metabolic parameters . . . seen at 12 weeks and continued throughout the 56 weeks" of the research. Subjects exhibited improvements in fasting circulating glucose (–51%), total cholesterol (–29%), HDL-cholesterol (63%), low-density lipoprotein-cholesterol (–33%), and triglycerides (–41%).

Epilepsy

Fasting and other dietary modifications have been used to treat epilepsy for several thousand years. In the 1920s, the KD was introduced for the treatment of intractable childhood epilepsy. With the advent of antiseizure drugs in 1938, however, KDs fell out of favor until the 1990s. Since then, research has proliferated and the KD (in several different formulations) remains an effective therapeutic tool, particularly for children who do not respond to drug therapy. In fact, a recent Cochrane review led by R.G. Levy (see http://tinyurl.com/Cochrane-KD) found that all studies reviewed "showed a 30–40% reduction in seizures compared with comparative controls."

Recent work in rats by a group led by Katja Kobow at University Hospital Erlangen in Germany points to a possible mechanism (Kobow *et al., Acta Neuropathol.,* http://dx.doi.org/10.1007/s00401-013-1168-8, 2013). Animals fed a normal diet exhibited an increased level of methylation (the addition of a CH_3 group) in their DNA compared with rats on the KD. The alteration in methylation could be linked to deactivation of the genes responsible for epilepsy. Other research suggests alternative mechanisms such as the anti-convulsant effects of KBs as well as a KB-induced reduction of neuronal excitability.

Obesity/weight reduction

Ketogenic diets, beginning with William Banting's in the 1860s, have a long history of efficacy in weight loss. As Paoli *et al.* indicate, "the majority of *ad-libitum* studies demonstrate that subjects who follow a low-carbohydrate diet lose more weight during the first 3–6 months compared with those who follow balanced diets."

But what about the suggestion, made by the Mayo Clinic and others (see http://tinyurl.com/KD-Mayo), that ". . . most studies have found that at 12 or 24 months, the benefits of a low-carb diet are not very large?"

"In most longer-term studies of low-carbohydrate diets, rather than encouraging subjects to consume more fat in the later phases of the diet, [researchers] often reintroduce high-carbohydrate foods," Jeff Volek writes. "Thus, it is not surprising in randomized clinical trials that weight loss at six months is higher in groups assigned to a low-carbohydrate diet than to a low-fat diet, but the effect is diminished at 12 months. Nevertheless, weight loss is at least as good and some cardiovascular risk markers improve to a greater extent, especially in subjects with insulin resistance."

Volek also points to a clinical practice in Kuwait that adopted a low-carbohydrate, moderate-protein, high-fat diet to deal with the dramatically increased incidence of obesity and T2D in that region (Dashti, *et al., Mol. Cell Biochem.,* http://dx.doi.org/10.1007/s11010-005-9001-x, 2006). This research concerns a cohort of 66 subjects (35 with T2D) who were instructed to maintain a total daily carbohydrate intake under 50 g/day; 49 achieved a mean weight loss of 27 kg in a year, Volek said, with dramatic improvements in dyslipidemia and normalization of blood glucose among the diabetics. "Given that intensive pharmaceutical management of T2D to achieve normoglycemia consistently leads to weight gain (as opposed to the marked weight loss in this study)," Volek added, "it is hard to believe that any potential (but as yet undemonstrated) risks of long-term carbohydrate restriction outweigh the benefits of this dietary approach in this group of patients."

LEVEL OF EVIDENCE—EMERGING

Cancer

"The Warburg effect is the single most common malady expressed in all cancers," noted Thomas N. Seyfried, a professor of biology at Boston College and author of *Cancer as a Metabolic Disease: On the Origin, Management, and Prevention of Cancer.*

"The Warburg effect" refers to Otto Warburg, the German Nobel laureate and physician who hypothesized that cancer arises largely from impaired energy metabolism (mitochondrial dysfunction), which then produces genetic instability.

"The mitochondrial defects force cancer cells to use fermentation as a major source of energy production for growth and survival," Seyfried wrote in an email. "Consequently, the restriction of fermentable fuels (primarily glucose and glutamine) will target cancer cell growth and survival."

Indeed, tumor cells often have "glycolytic rates up to 200 times higher than those of their normal tissues of origin," Paoli *et al.* write. Further, "there is evidence that hyperinsulinemia [excess levels of serum insulin], hyperglycemia [excess levels of serum
glucose], and chronic inflammation may affect the neoplastic process through various pathways, including the insulin/IGF-1 pathway, and most cancer cells express insulin and IGF-1 receptors."

A search in December 2015 for phase 1 clinical trials on KDs and cancer returned 14 results (see http://tinyurl.com/KD-clinical). Eight of the studies are in the recruitment phase; one of the 14 has been completed, with results reported in 2014 (Rieger, J., *et al., Int. J. Oncol.,* http://dx.doi.org/10.3892/ijo.2014.2382). The researchers, led by Johannes Rieger of the University Hospital Frankfurt, concluded that the KD is both feasible and safe "but probably has no significant clinical activity when used as a single agent in recurrent glioma."

Until the clinical trials are reported, Seyfried noted, "Lipid biochemists are ideally positioned to help unravel the mechanisms underlying the therapeutic action of the KD."

Neurological disorders

Research on KDs and Alzheimer's disease is in the beginning stages. Because Alzheimer's patients exhibit an increased incidence of seizures compared with those not affected by the disease—along with impaired glucose metabolism and poor mitochondrial function—investigation of KDs and Alzheimer's makes sense.

Preliminary data in humans suggest that dietary ketosis "can provide neurocognitive benefit for older adults with early memory decline and increased risk for neurodegeneration," according to researchers led by Robert Krikorian at the University of Cincinnati (Ohio, USA). Their study appeared in *Neurobiology of Aging* (http://dx.doi.org/10.1016/j.neurobiolaging.2010.10.006, 2012). Additional work in humans found significant clinical improvement in subjects with mild to moderate Alzheimer's disease (Henderson *et al., Nutr. Metab.,* http://dx.doi.org/10.1186/1743-7075-6-31, 2009). "It was suggested that this was, at least in part, related to improved mitochondrial function secondary to the reported protective effects of KBs against the toxic consequences of the exposure of cultured neurons to β-amyloid," Paoli et al. note (Kashiwaya, *Proc. Natl. Acad. Sci.,* http://dx.doi.org/10.1073/pnas.97.10.5440, 2000).

Research has also been conducted into KDs and headache, neurotrauma, amyotrophic lateral sclerosis, multiple sclerosis, Parkinson's disease, sleep disorders, brain cancer, and autism. "Although these various diseases are clearly different from each other," Paoli et al. write, "a common basis potentially explaining KD efficacy could be a neuroprotective effect in any disease in which the pathogenesis includes abnormalities in cellular energy utilization, which is a common characteristic in many neurological disorders."

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The beginning of the *Letter on Corpulence*
Of all the parasites that affect humanity I do not know of, nor can I imagine, any more distressing than that of Obesity, and, having emerged from a very long probation in this affliction, I am desirous of circulating my humble knowledge and experience for the benefit of other sufferers, with an earnest hope that it may lead to the same comfort and happiness I now feel under the extraordinary change, which might almost be termed miraculous had it not been accomplished by the most simple common-sense means.
—William Banting, 1863, who lost 50 pounds on a low-carbohydrate diet.

DEFINING A "WELL-FORMULATED KETOGENIC DIET"

"A well-formulated ketogenic diet is one personalized to the individual, and it addresses more than just carbohydrate restriction," says Jeff Volek, who is the co-author—along with Stephen D. Phinney—of *The Art and Science of Low Carbohydrate Living.* "The level of carb restriction required to become keto-adapted varies from person to person, but most people will find they get the best results at levels below 50 g/day . . . but it may vary from 30 to 100 g/day.

Volek notes that it is important not to overdo protein on a low-carbohydrate diet because an excess of protein can interfere with ketosis. "The best approach is to experiment with finding the right amount of carbs and protein, coupled with regular monitoring of blood (not urine) ketones," using a simple finger-stick instrument.

"Given that this diet is low in carbs and moderate in protein, the majority of calories need to come from fat," he says, with a limited amount of those rich in polyunsaturated fat (e.g., corn, soybean, safflower, cottonseed, and peanut oils). "You don't need to worry about increasing saturated fat intake. We have repeatedly shown that on a ketogenic diet, blood levels of saturated fat actually decrease as the fat-adapted body prefers to burn them as fuel," Volek says.

In the fat-adapted body, the kidneys tend to discard more water and salt, which can result in reduced plasma volume, fainting, and a general "washed-out" feeling (sometimes called the "Atkins flu"). "An easy solution," Volek says, "is to take an extra 1–2 g of sodium/day as broth, bouillon, or soup. And in particular, on days you exercise, be sure to take 1 gram of sodium to prime your circulation 30 minutes before your workout."

Catherine Watkins is a freelance writer based in Champaign, Illinois, USA. She can be reached at c.e.watkins@sbcglobal.net.

Creating corporate memory

Fiona Case

Medieval alchemists wrote in code to keep their findings secret. Corporate archiving of paper laboratory notebooks can be almost as effective at preventing dissemination of hard-won knowledge to future researchers and information sharing between groups. But informal sharing of experimental results in an online document-sharing system or lab-wiki, as used in many academic groups, may not be appropriate for commercial organizations. Over the last two decades a host of electronic laboratory notebook (ELN) systems have been developed to provide secure record keeping, sharing, and more.

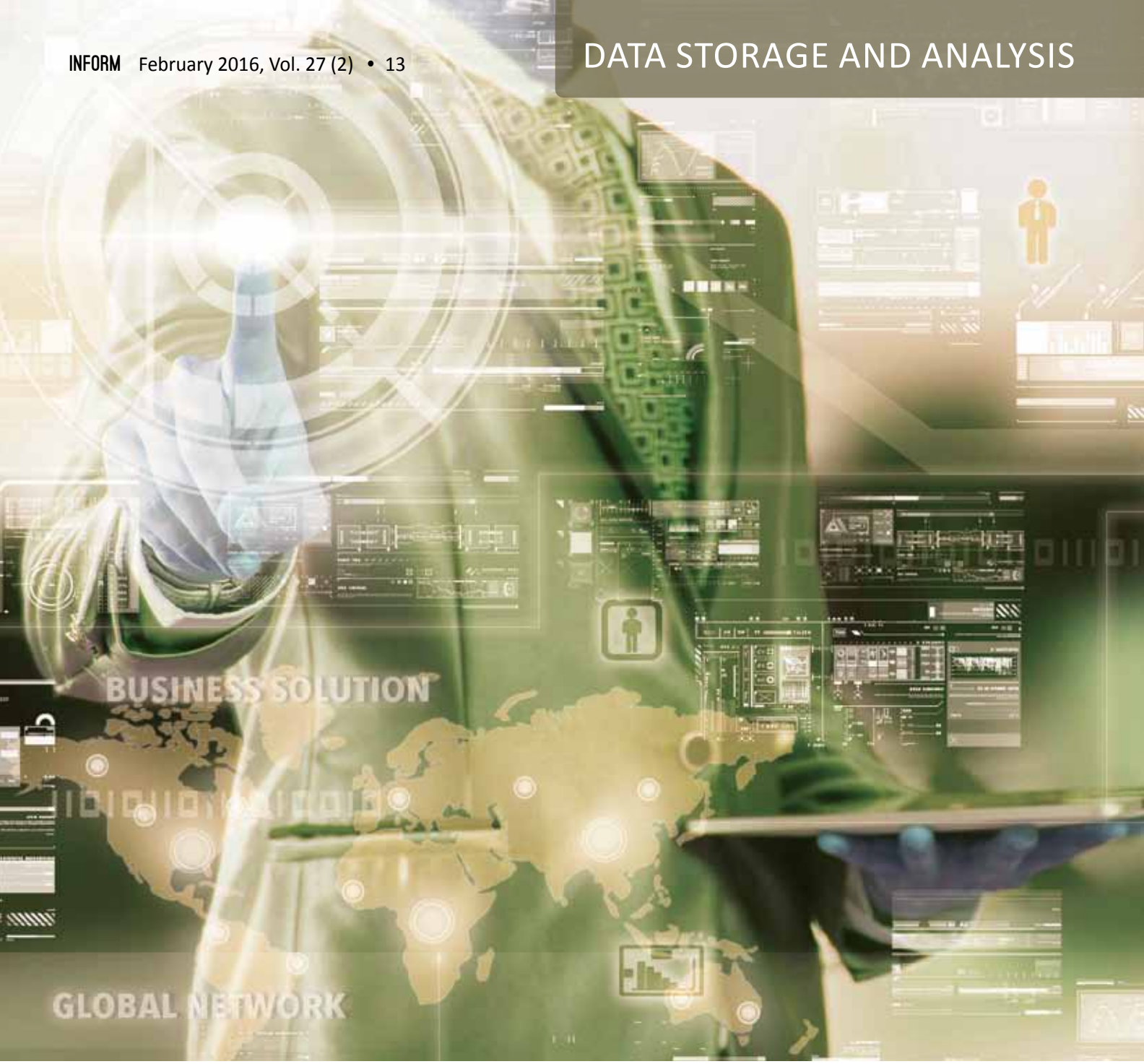
- **Moving laboratory notebooks onto computers, or into the cloud, can enable researchers to collaborate across different research and development sites, while maintaining necessary control on data and ensuring documentation compliance.**
- **Data archived in an Electronic Laboratory Notebook (ELN) system creates a corporate memory which can later be mined, potentially revealing new relationships between materials, formulation, and consumer perceptions of performance.**
- **ELNs may be particularly valuable in consumer goods companies where concepts need to be transferred between regional development laboratories to be optimized for regional customer preferences, and where technical challenges frequently re-emerge in new products.**
- **In recent years two types of ELN product have emerged: More structured ELNs are designed to facilitate data querying and searching. Less-structured products allow groups, and even individual researchers, to customize their own notebooks. These less-structured ELNs are more readily accepted, and cheaper to purchase and maintain. Sophisticated data mining tools may aid researchers in searching and querying these unstructured systems.**

"ELNs started to be deployed at commercial companies, predominantly within the pharmaceutical industry," says Philip Skinner, technical presales consultant at PerkinElmer, Waltham, Massachusetts, USA, which produces of one of the leading ELN products. "Over time, the most sophisticated products have developed from simple lab-book replacements to support compliance with FDA [US Food and Drug Administration] regulations, providing audit trails and electronic signatures, but also capabilities to check the calibration of instruments, the shelf life of reagents, to manage inter-user workflows (samples, requests) and to automatically collect characterization, assay and test data."

WHAT SHOULD AN ELN DO?

At its simplest, an ELN is just an electronic version of the traditional paper notebook. Data is typed in, ideas and insights are noted, graphs are scanned, and a manager signs off on the work with an electronic signature. The information is stored in a corporate mainframe or increasingly in the cloud.

Rich Products Corporation, Buffalo, New York, USA, implemented an ELN system in 2011. "We were moving towards a more global organization and we wanted to rein in knowledge management," says Mark Baker, a Group Leader at Rich's. "We wanted to standardize lab notebook procedures at all our locations to develop a global collaborative environment and ensure documentation compliance. We wanted to allow information sharing, but with proper information protection, not an unfettered flow," he says.



Research and development in consumer product companies is often distributed. An ELN can enable collaboration, and allow research at regional development laboratories to gain more visibility throughout the organization.

"In the food industry, we must address regional tastes. We have development centers in South America and in China. A product is developed in one part of the world and needs to be transferred securely to another. ELN allows collaboration on the new product prior to its entry into our enterprise resource planning system," Baker explains.

Data validation and the ability to share information with control and security are common motivations for ELN adoption. In the recent past, documentation compliance placed a significant burden on researchers.

"A possibly apocryphal workflow with paper notebooks in a commercial setting is the pizza party, where scientists get together every quarter over pizza to witness each other's notebooks," Skinner says. "Certainly, the time between when scientists complete work, to them signing it, to them having it witnessed can be extensive with paper," he says.

With the passage of the Americas Invents Act, and a shift from first to invent (FTI) to first to file (FTF), the focus has shifted away from formal witnessing compliance, and some organizations have adopted informal, unsigned, data log books for day-to-day laboratory work. But the ability to monitor research progress and data collection still has value within an organization. Managers find value in being able to monitor a project without calling researchers away from their work.

Researchers working on characterization and analysis find value in being able to identify the history of a sample—details of exactly how it was made. Globally dispersed teams find value in being able to share experimental data.

Formal, verified experiments become even more important as the product matures.

"As a product moves out of the laboratory and into production the ELN can enable electronic batch records and support QA /QC, recording not only the formulation or composition of the product, but also processing and equipment information—how the product is actually made," explains Michael Elliott, Atrium Research & Consulting LLC., Connecticut, USA, who has been has been working with companies implementing informatics systems since 1983. "Using the ELN you can refer back to the original research, enabling end-to-end data integration. The ELN can be especially useful for knowledge transfer if you are using a contract manufacturer," he notes.

ELN requirements vary between companies, and within companies (large corporations often use more than one ELN system). Industry experts recognize two distinct markets: more complex systems including laboratory workflow, and systems offering simple "paper on glass" systems for experimental documentation, intellectual property protection, and information sharing at the lowest price point.

"Higher-end companies already have a high level of automation for formulation design and testing which they can integrate with more complex ELN systems. Smaller companies, who do not want the overhead, will opt for the simpler systems," Elliott says. "But, if your needs for regulatory or IP are light you don't necessary need an ELN."

There are a number of document sharing applications that can enable collaborative research, but for some companies going paperless provides no tangible benefit.

"For a company with only a small number of people working on research and development, paper can work fine provided the notebooks are indexed and archived correctly," Elliott adds.

EASE OF USE

A big issue in choosing an ELN system is ease of use. At its most sophisticated, the ELN is at the center of a complex Laboratory Information Management System (LIMS), tracking samples, managing workflows, controlling chemical inventory, providing sophisticated data analysis, and ensuring regulatory compliance. But this level of complexity comes at a price. Researchers want the flexibility to format their lab book as they wish.

"If an ELN replaces a paper notebook, a researcher is going to be using it eight hours a day. It has to be robust and easy to use, not complex or clunky," says Mats Kihlen, product manager at BIOVIA, San Diego, California, USA, which produces one of the leading ELN products. "This is a surprising immature industry given that is has been around for a couple of decades. The first products were just not good enough."

Rich's started looked at ELN's 10 years ago but concluded that they were too complex. They eventually chose a system from BIOVIA that could be customized with different templates for different research groups or activities. "There was anxiety among many of the developers and scientists that they were going to be forced into doing things in a certain way," Baker says.

But the anxiety fell away once they started using the system.

"It's used by everyone from recent college graduates to our most senior researchers," says Baker. "People heavily customize their systems, they have different documentation styles, it depends on where they went to school, or where they worked before."

"Typing is generally slower than handwriting," Skinner says, "and the early ELN's weren't portable. But the efficiency gains can offset this. You can quickly clone an existing experiment description and use your ELN to archive supporting data (replacing a filing cabinet). You can easily output your results to a report or presentation, or share directly from the ELN saving the time spent on creating Word documents or PowerPoint slides."

SEARCHING AND QUERYING

The greatest promise, and challenge, of ELN technology is in data searching and querying. Data in an ELN is intrinsically easier to retrieve than in a paper notebook

"A typical cycle of retrieving a paper notebook from offsite storage takes days and you need to know the content exists and approximately where," notes Skinner. "You can search through ELN's automatically and if the raw data—NMR traces, analytical results, and instrument data—has been kept electronically with the narrative you get much better information."

The broader promise of widespread ELN adoption, in conjunction with sophisticated informatics tools, is data mining: By pulling together results from different projects, new relationships may emerge between chemical structure, formulation, processing, and final consumer-perceivable product performance.

This can be particularly valuable in areas where empirical data dominates, such as food, personal and home care, and cosmetics companies. There are perennial challenges such as enhanced delivery of actives or fragrances, improved absorption onto surfaces, microbial safety and stability, rheology control, foam boosting or suppression. These tend to re-emerge in different projects. Access to a corporate memory can avoid duplication of efforts. The use of informatics tools may help to define a completely new solution space.

Pharmaceutical companies, the first adopters of ELN technology, set out to gain this advantage by requiring researchers to record data in specific (easily searched) formats and to use systematic naming for their compounds. They invented new tools to capture and search for chemical structures, and to import data from diverse analytical equipment in common formats to facilitate subsequent queries.

"Systems that support structured input with controlled vocabularies are useful for capturing key information but you can't anticipate everything that a researcher will want to include during the documentation stage or find in the future," says Wendy Cornell, who recently started Wachung Text Mining and Information, Warren, New Jersey, USA, after a career in scientific information management at Merck.

Mats Kihlen goes further: "There is a trade-off between the additional effort required by researchers recording experiments in their notebooks and what is meaningful to require. It's difficult to define and enforce the naming conventions, the ontology. Small biotech companies with less than 1,000 users have achieved well-publicized successes using ELN data and informatics, but larger pharmaceutical companies have not found it as easy."

There is, however, a new approach based on the emerging field of text mining. Cornell explains: "Most ELN systems have an option for free text entry, an area where researchers can record data and notes. Text mining is a very useful tool for going back and extracting the desired information from these areas, normalizing it, and integrating it with related content. Text mining can help to extract experimental details as well as the results of the experiment itself."

Modern tools are far beyond traditional word-matching searchers. Algorithms search for synonym and contextual similarity can emulate an expert searching a roomful of paper notebooks.

The scientific literature also provides fertile ground for text mining. Most publishers provide search engines, and there are rumors of future tools which will automatically integrate information harvested from literature sources with data stored in a corporate ELN system.

"Technology has caught up, data analysis can be applied on top of an ELN," says Mats. "I didn't think this could exist 10 years ago. Impressive search capabilities have been developed by companies like Google and can be applied to text mining in research and development. The food and beverage industry coming in with this second wave of ELN's, are not hit by the first wave when corporations tried to develop complex ontologies and capture everything during data entry."

IS THERE AN ELN IN YOUR FUTURE?

A survey carried out by Atrium Research & Consulting in 2013, found that 60% of medicinal chemists used ELNs, but adoption in the food, personal and home care, and cosmetics industries was far lower.

"The food and beverage industry as a whole has only about a 15–20% adoption for ELN systems. This is not terribly surprising; there was a similar trend for other informatics-based tools. Pharmaceutical companies were early adopters, willing to spend a lot of money. Other industries waited until the price dropped" Elliott says.

"The price of ELN's is being pushed down. High-end systems have dropped below $2,000 per seat and you can get good basic cloud systems for less than $50 per month per user. There are more than 40 ELN vendors—and most offer generic capabilities—competition, and the drop in the price of deployment with cloud based systems, is driving down the price," he says.

"Savannah River National Labs justified their ELN investment purely on the basis of eliminating the processing costs of their old paper notebooks," Skinner notes.

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Fundamentals of energy savings and recovery

Farah Sköld

To make informed decisions about the improvements, expansions, and upgrades that will lead to maximum energy savings at plants where equipment has been added and upgraded over a long period of time, it is important to consider the energy efficiency of existing operations in addition to optimizing energy recovery.

- **Energy savings and recovery of waste heat in an oilseed crushing plant can potentially reduce overall energy consumption and save operating costs.**
- **This not only benefits the operating company but also consumers and society at large, as many oilseed plants are located close to inhabited regions and reduction in odor emissions is of great interest to these communities.**
- **The basic fundamentals governing energy recovery and heat transfer in bulk solids are a good starting point for achieving an optimal balance of performance (maximized energy recovery), operational flexibility (design and sizing of energy recovery loop), and commercial objectives (capex and payback on energy saving).**

New equipment or technologies that provide greater efficiency with respect to steam usage and minimize losses are obvious choices, as is equipment that allows for better recovery of waste heat. In the case of dryers, operating equipment that provides exhaust vapor at high temperature and high relative humidity at exit is more desirable than equipment that operates at higher air flows, low temperature, and low relative humidity (Fig 1).

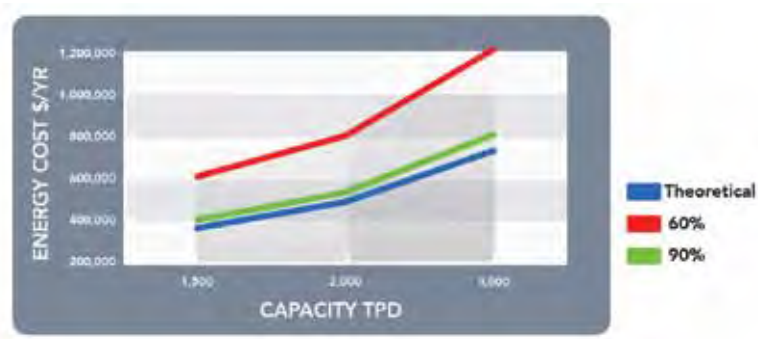

FIG 1. Comparison of annual energy cost when equipment is operating at 60% and 90% efficiency with base case of cost at no losses

The efficiency of heat transfer equipment is affected by several factors:

- equipment design, age, and utilization;
- maintenance and cleaning;
- insulation; and
- plant layout.

SOURCES OF WASTE ENERGY

To ensure that all energy savings potential is realized, it is essential to approach this from both ends by reducing losses and recovery from waste streams. Fig. 2 illustrates the combined impact of upgrading to energy efficient equipment and capturing waste energy for re-use.

The most common sources of waste energy broadly listed are:

- vapors from dryers and other equipment;
- cooling of hot product, such as meal, oil, or pellets; and
- sub-cooling of condensate.

Sub-cooling of condensate can be considered waste heat recovery in cases where the condensate is returned to the steam supplier at any temperature without monetary impact, or is otherwise not used.

In a typical soybean plant, 47% of the total steam consumption is used for toasting, and another 14% for meal drying. These are obvious stages to consider recovery of heat. The heat that is recovered can be then be used during seed preheating and drying, which consume another 16% and 14% of the steam energy, respectively.

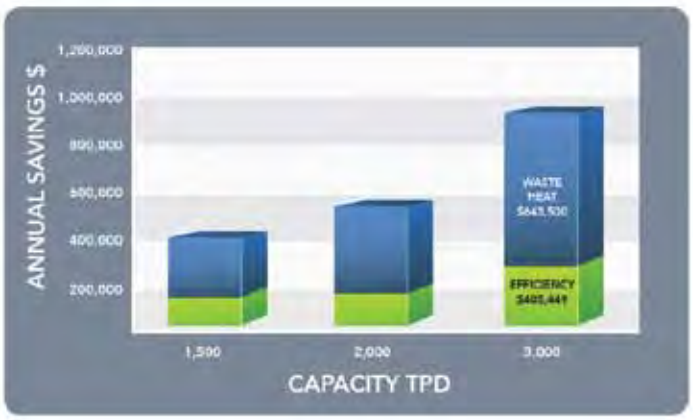

FIG. 2. Potential of annual savings by waste heat recovery as well as improved efficiency of seed conditioner in a typical rapeseed/ canola plant

In a rapeseed/canola plant, cookers use 37% of the total steam consumption, and seed preheating another 17%. Recapturing the vapors from the cooker where the flakes are heated and dried is an obvious way to recover waste energy that would otherwise be lost. As in soybean plants, preheating/ conditioning is the ideal stage for use of this recovered energy.

HEAT TRANSFER IN BULK SOLIDS

The recovered energy from various steps is converted into a hot-water loop that is in turn used in heat exchangers for preheating/conditioning of incoming seed before flakers (Fig. 3).

This recovered energy is what we might refer to as low-grade energy. The hot water temperature in a recovery loop from cooker vapors, and hot oil can be in the range of 65˚C–85˚C. Oil temperature is, of course, influenced by the properties of the cooker vapors, temperature/relative humidity, and the design and efficiency of the scrubber or condenser used to transfer this energy to the clean hot-water loop. The mechanism by which this recovered energy is transferred to the seeds is as follows.

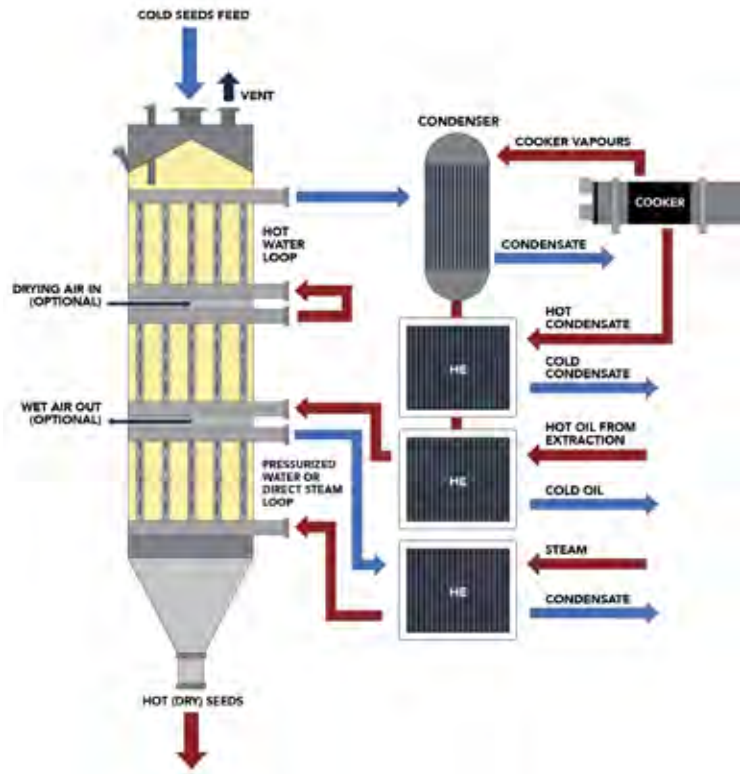

FIG. 3. Typical energy recovery loop in a rapeseed/canola plant

The recovered energy is transferred indirectly in a heat exchanger. Within the heat exchanger, hot water flows through welded plates or tubes, and the surface of those plates or tubes is in contact with a moving bed of gravity-fed seed (Fig. 4).

FIG. 4. Bed of gravity-fed seed between heat transfer plates

Conduction heat transfer through solids is due to molecular vibration. This is governed by Fourier's equation:

$$Q/A = -k\,\frac{dT}{dx}$$

The heat transfer per unit area (w/m²) is proportional to the temperature gradient dT/dx. The constant of proportionality is called the material thermal conductivity k.

According to Newton's Law of Cooling, the heat-transfer rate is related to the instantaneous temperature difference

between hot and cold media. In a heat-transfer process, the temperature difference varies with position and time. For this reason, the Log Mean Temperature Difference (LMTD) is used for thermal calculations.

This LMTD is the driving force for the heat transfer.

When using steam to heat seeds, the LMTD and hence the driving force is considerably higher due to a higher operating temperature of steam (above 100°C). Whereas achieving the same heat transfer with water at a lower temperature (below 90°C) requires an additional heat-transfer area (Fig 5).

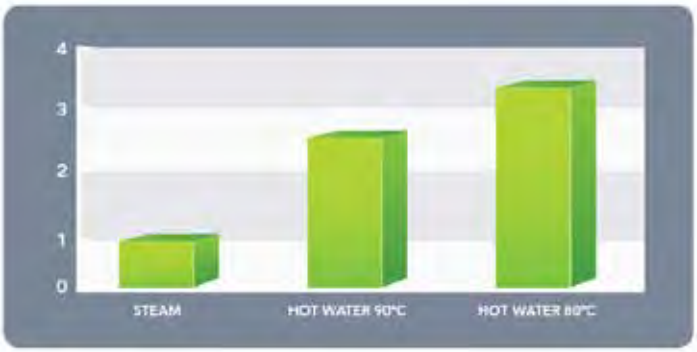

FIG. 5. Impact on heat transfer area required when heating seeds with steam compared to hot water from energy recovery loops at 90˚C or 80˚C

OPTIMIZATION

To maximize the heat-transfer efficiency from the recovery loop, it is important to increase heat-transfer and use equipment that provides a greater density of heat-transfer area, along with operational flexibility and lower maintenance costs. The additional heat-transfer area comes at additional cost; therefore, an optimization exercise is required to find the most economical solution with the highest calculated return on investment.

Increased heat-transfer area is a requirement for benefiting from waste heat, but there is rate of diminishing returns that

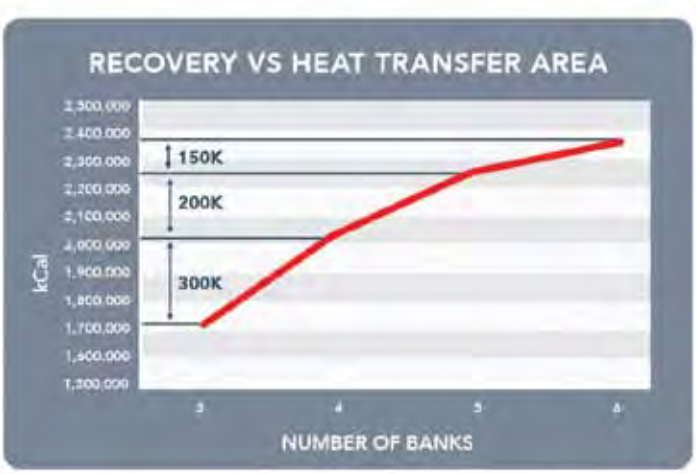

FIG. 6. Diminishing returns from additional heat-transfer area on heat-transfer efficiency

Fig. 6 illustrates an example in which additional adding banks after the initial three used for heat recovery results in reduced returns on amount of energy transferred to incoming seed.

A financial analysis over a period of 15 years for this case

FIG. 7. Calculating the rate of return made on investment for additional heat-transfer area for heat recovery

It is prudent to carry out a detailed audit or study to identify the possible sources of energy recovery and find the optimal solution. Even though the overall process may be similar, every plant has to approach this topic for a customized solution. The various factors to be taken in to account are governed by:

1. Variable plant conditions. The type of seed, whether the plant processes more than one type of seed, and the ambient conditions and variability in incoming seed properties need to be considered when performing the energy balances.
2. Plant layout. Distances and available space will have an impact on the project, installation costs, and the design of the heat transfer equipment.

FLOW OPTIMIZATION

In energy-recovery loops, it is often the case that to maximize the LMTD and hence the water temperature in recovery loop, it is desirable to operate at lower flow rates.

Reynolds number is a dimensionless quantity that helps predict flow patterns in different flow situations.

$$\text{Reynolds Number} = DV\rho / \mu$$

Laminar flow occurs at low Reynolds numbers, where viscous forces are dominant and characterized by smooth, constant, fluid motions.

Turbulent flow occurs at high Reynolds numbers and is dominated by inertial forces, which tend to produce flow instabilities.

Turbulent flow in heat transfer equipment is desirable, because:

1. Heat transfer in the radial and azimuthal directions, or "eddy transport," takes place, providing much better transfer of energy across the flow at a given axial position than in laminar flow.
2. The extent of the "thermal entrance region" in which the transverse temperature distribution becomes "fully developed" is relatively short.

Heat exchanger designs rely on mechanical aspects to maximize Reynolds numbers, such as adding baffles (Fig. 8). For a given flow, plate heat exchangers provide higher Reynolds numbers and are thus the universally preferred solution for such applications.

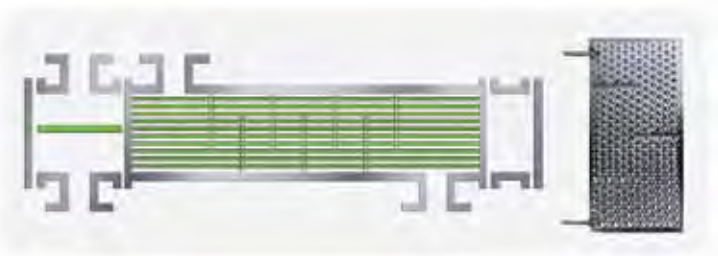

FIG. 8. Baffles in shell & tube and plate heat exchangers.

Again, optimizing heat transfer is a balancing act where higher flow rates result in a higher Reynolds number and better heat transfer. This does, however, mean operating at lower temperatures and hence lower LMTD. High velocity can also require larger piping and nozzle sizes in the heat exchanger, adding cost and pressure drop, hence increasing pumping costs.

Lower flow rates result in a smaller Reynolds number and the associated lower heat transfer, but the lower heat transfer is compensated by a higher driving force that results from a higher LMTD. Low flow rates also run the risk of poor distribution in the heat exchanger, hence loss of effective heat-transfer area.

In summary, the impact of each parameter when taken into account results in a solution that not only is thermally efficient but also cost-effective for the lifetime of the equipment.

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Increasing the reach and impact of your publications

"Adequate communication is a prerequisite for strong science and technology," says a government report on my desk. The report addresses the challenges of communicating research effectively during an era of "information explosion," and the need to "explore and exploit new methods" for sharing knowledge [1].

Charlie Rapple and Antony Williams

- Kudos is a new digital platform that helps researchers track efforts to communicate about their work.
- Charlie Rapple, one of the co-founders of Kudos, explains how the service aims to benefit researchers.
- Antony Williams, a scientist at the US Environmental Protection Agency's National Center of Computational Toxicology, provides a user perspective.

Sound familiar? And yet the report is dated January 10, 1963. (Neither of the authors of this article was even alive at that time!)

The "information explosion" has achieved levels that US President John F. Kennedy's Science Advisory Committee (the authors of the report) could barely have imagined. There are currently over 50 million research articles, and this number is estimated to be doubling every 20 years. If we consider alternative publishing approaches such as blogs, wiki, and exposure of work via other social networks, that growth in the overall "literature" is even more dramatic. It is already acknowledged that a substantial proportion of online articles and books are never downloaded [2]. What can you do to ensure that your own work does not meet this fate, but is found, read, applied, and cited?

WHAT OPTIONS DO RESEARCHERS HAVE?

Discoverability is now more important than ever, but researchers' time is no more abundant. Many are experimenting with social media, but the challenge is in knowing which of these approaches is actually helping to increase readership of your work. A related challenge is explaining work to wider audiences; many advocate for Open Access to research, but providing access to your work does not guarantee that those who access it will be able to understand it.

Options for spreading the word about research include social media, such as Twitter, Facebook, and LinkedIn; academic networks, such as ResearchGate, Academia.edu, or Loop; other digital platforms, such as blogs or repositories; and, of course, email, which remains a common way for researchers to inform colleagues about new work. Meanwhile, several services can help you to measure various aspects of your publications' performance, from citations (Scopus, Google Scholar, or Web of Science, for example) to newer "altmetrics" (Plum Analytics, ImpactStory, Altmetric, and so on). But again, the challenge is being able to connect these results back to any efforts you undertook to spread the word.

Many researchers publish supplementary info alongside their work. In the past, this has often been limited to PDFs on publisher sites, but more recently there has been a movement toward formats that allow for reprocessing and repurposing. An increasing number of services provide support—Github or Sourceforge for code, Slideshare for presentations, YouTube or Vimeo for videos, Figshare for figures or data. If you are quick to get content on these sites prior to publication of related articles, you can link to these sites from the finished paper. However, problems arise, when you try to add the next iteration of data or code, or the latest images from an ongoing project to the original publication. It is similarly difficult to connect the original work with post-publication communications, such as blog postings, press releases, media coverage, and even erratum. The ability to keep connecting your paper to relevant materials as your work evolves can offer significant benefits to both the reader(s) of the work and to the author(s) who can ensure that a publication remains alive and that the full story around the research is presented.

WHAT IS THE ROLE OF KUDOS?

Kudos helps to augment and connect these other services. However you typically communicate about your work, you can use trackable links generated by Kudos to map the effect of your efforts using whichever metrics you are interested in. This allows you to learn which tools and networks are most effective. You can add plain language explanations to your work that help people within your field skim and filter the literature more quickly, and help those outside your field understand what your work is about and why it is important. These explanations are useful to speakers of other languages, as they lend themselves more readily to auto-translation than the formal abstract does, and they can increase "discoverability" in search engines. Finally, you can link all your related materials so the Kudos publication page becomes an up-to-date hub for your research. About 70,000 researchers are signed up to use Kudos, and this number is growing rapidly as the word spreads among research communities.

WHAT LEVEL OF EFFORT IS INVOLVED?

"Having spent hundreds of hours gathering data, analyzing data, writing it up, and going through peer review and revisions, I'd be doing myself a disservice if I don't then spend some time letting people know that my work has now been published," according to Antony Williams, a computational chemist at the National Center of Computational Toxicology at the US Environmental Protection Agency.

Williams adds that "Kudos is a great service for this because it gives me feedback on my efforts: I can see a range of metrics, and that is mapped directly against my actions. It took me ten minutes to set up a profile. The process of finding my articles was straightforward—the site is well explained and easy to follow."

Explore the world of online resources for researchers

Digital and online resources for researchers are proliferating. Here are five that have been featured by nature.com. Read more about how scientists are using social networking to collaborate at http://tinyurl.com/SN-science.

- **Overleaf.com:** Formerly known as writeLaTeX, this online tool for collaborative writing and publishing is "popular among physical scientists and mathematicians for rendering mathematical formulas, tables, and figures," according to nature.com.
- **Authorea.com:** This service bills itself as a "collaborative typewriter for academia." Authors are able to share data through interactive visualizations and use a variety of formats such as LaTeX, Markdown, HTML, and Javascript.
- **Sciencescape.org:** Get real-time updates about research "you care about" through this free service.
- **LabArchives.com:** Teachers can review students' work, grade it, and make comments. This cloud-based application software, LabArchives says, is used by "professional research labs and higher education institution lab courses throughout the world."
- **ORCID.org:** ORCID provides a "persistent digital identifier . . . in key research workflows such as manuscript and grant submissions" aimed at allowing researchers to build a professional profile across platforms.

WHAT RESULTS CAN YOU EXPECT?

Williams has used Kudos to enrich about half of his 180+ articles and book chapters, and has seen the benefits in a number of ways.

- Catalyzing new views of old publications. Williams picked two of his four articles published in 2007 explained and shared them via Kudos, and monitored the views over the new few months. The articles were of similar "importance" based on the citations listed on Web of Science. On average, for this limited set, simple efforts to expose work to new researchers resulted in about three times the number of views of the Kudos page.
- Ability to link follow-up presentations, blog posts, and additional analyses to the publication.

One of William's articles (http://bit.ly/aocs-k1) received high media coverage and was the topic of various blog posts—one by an influential pharmaceutical blogger (http://tinyurl.com/ht9nrby), and another by a scientist who independently modeled the data and published (http://tinyurl.com/hljh3dr) the resulting code—unknown to the original authors until compiling their Kudos page, where they were then able to connect all of these important post-publication resources together. This not only enhanced the original article but also ensured the extended research was easily accessible to readers.

Similarly, the work on Olympicene, a chemical compound modelled on the Olympic Rings (http://bit.ly/aocs-k2) received a lot of press coverage and catalyzed research into the compound; Kudos enabled a number of follow-up articles by independent scientists to be linked to the initiating work. Kudos also provided the opportunity to frame the work in a more general manner for broader readership, by adding the alternative title, "Single Molecule Microscopy of Olympic Rings at the molecular level: The Structure of Olympicene," versus the more scientifically accurate article title of "The Synthesis and STM/AFM Imaging of 'Olympicene' Benzo[cd]pyrenes."

GIVE IT A GO!

Kudos is free for researchers, as it is supported by publishers and institutions. Pick a recent publication—or an older one that you would like to "bring back to life"—and try explaining and sharing it via Kudos (www.growkudos.com) to see if you can generate additional readership.

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Antony Williams is a computational chemist at the National Center of Computational Toxicology at the US Environmental Protection Agency. He is passionate about connecting people to chemistry and is known online as the ChemConnector. Williams has almost a decade of experience in analytical laboratory leadership and management, and is a prolific author with over 150 scientific publications, book chapters and books, and hundreds of public presentations. He is one of the original founders of the ChemSpider database that was sold to the Royal Society of Chemistry.

Further reading

1. US President's Scientific Advisory Committee. 1963. *Science, Government and Information: The Responsibilities of the Technical Community and the Government in the Transfer of Information.* Washington, DC: U.S. Gov. Print. Off.

2. Rose Eveleth. 2014. Academics Write Papers Arguing Over How Many People Read (And Cite) Their Papers. *The Smithsonian.* http://www.smithsonianmag.com/smart-news/half-academic-studies-are-never-read-more-three-people-180950222/#gFDkvxL1mvQidVu8.99.

Chinese edible oils market and consumption trends

The consumption of edible oils in China has increased considerably during the past decade. In 2014, 29.7 million metric tons (MMT) of edible oils were consumed. Soybean oil continues to be the primary vegetable oil, accounting for 42% of the total oil consumption, followed by rapeseed oil (21%) and palm oil (15%). These three major oils account for 78% of the total consumption, and cottonseed oil, peanut oil, and other minor oils account for the remaining 22% (Table 1).

Tian Kui Yang and Yan Zheng

- **Continued migration from rural areas to cities and rising per-capita incomes are driving increased consumption of edible oils in China. In 2014, consumption of vegetable oils in China reached 29.7 million metric tons (MMT), accounting for 15% of the world's total consumption.**
- **The increased demand for oil and meal in China, along with a reduction of arable land available for domestic oilseeds, have boosted imports of oilseeds and vegetable oils.**
- **Soybean, rapeseed, palm, and peanut oil make up 88% of the Chinese edible oil market, and the quantity of edible oils consumed within the food service sector is growing. As China moves toward industrialization and urbanization, its consumption of edible oils has the potential to keep growing at a reasonable speed over the next 10 years.**

TABLE 1. Main edible oils for food consumption (MMT) in China

	Soybean oil	Rapeseed oil	Palm oil	Peanut oil	Cottonseed seed oil	others	total
2008	9.0	4.2	4.7	1.8	1.3	1.4	22.4
2009	9.7	4.5	4.6	2.0	1.2	1.6	23.6
2010	10.0	5.5	4.4	2.3	1.2	1.8	25.3
2011	10.8	5.5	4.4	2.4	1.3	1.9	26.3
2012	11.4	5.5	4.7	2.5	1.3	2.1	27.6
2013	12.0	5.8	4.7	2.6	1.3	2.2	28.6
2014	12.5	6.3	4.6	2.7	1.3	2.3	29.7

Source: China National Grain and Oils Information Center

Soybean oil, which accounts for more than 40% of the total edible oils consumed in China, is primarily used as cooking oil in the home and in the catering industry. The total consumption of soybean oil alone increased from 9.0 MMT in 2008 to 12.5 MMT in 2014—an increase of 38.8% in just five years.

Palm oil is primarily used in the food processing industry. Its lower price and broader application place it among the top three oils consumed. Because palm is almost exclusively planted in tropical areas, all of the palm oil consumed in China is imported. The consumption of palm oil increased dramatically following the 2006 termination of the tariff rate quota for edible oil in China, and it has increased steadily since then.

Rapeseed oil is predominantly produced and consumed in southern China. The majority of oil produced comes from domestic rapeseed, and most imported rapeseed comes from Canada. The consumption of rapeseed oil has remained steady for many years.

Peanut oil is tremendously popular in China due to its pleasant roasted flavor. Consequently, it is a premium edible oil in the Chinese market. Both production and consumption of peanut oil have risen gradually in recent years. In 2014, peanut oil production was 2.54 MMT, almost half of the total global production. Its consumption is expected to keep steadily increasing in the future.

LARGE RELIANCE ON IMPORTS

Though consumption keeps steadily increasing, the total area of land devoted to growing oilseed crops in China has dropped due to limited arable land and water shortages. Price pressure from low-priced imported oilseeds (mainly soybean), outdated farming practices, and subsidy reductions,

encourage Chinese farmers to switch from planting soy to corn and rice or other cash crops (Table 2). This further reduces the amount of arable land that is available for domestic oilseeds, and drives imports (Tables 3 and 4). Table 5 shows how China dominates the global soybean market as the single largest importer of soybeans in the world. During the last three years, China absorbed, on average, 61% of the world's total soybean exports. China's imports are expected to continue on an upward trend driven by declining domestic production and growing demand for soybean meal in the animal feed industry.

TABLE 2. Planting area of major oilseeds (million hectares) in China

	2010	2011	2012	2013	2014
Soybean	852	789	717	685	680
Rapeseed	737	735	743	753	750
Cottonseed	525	550	530	480	440
Peanut	453	458	464	463	470
Sunflower seed	98	94	89	92	92
total	2,665	2,626	2,543	2,473	2,432

TABLE 3. Main imports (MMT) of oilseeds in 2008–2014

	2008	2009	2010	2011	2012	2013	2014
Soybean	37.4	42.6	54.8	52.6	58.4	63.4	71.4
Rapeseed	1.3	3.3	1.6	1.3	2.9	3.7	5.1
Other seeds	0.3	0.5	0.6	0.9	1.0	0.8	1.0
Total Volume	39.0	46.3	57.0	54.8	62.3	67.8	77.5

Source: China National Grain and Oils Information Center

TABLE 4. Main imports (MMT) of oils in 2008–2014

	2008	2009	2010	2011	2012	2013	2014
Soybean Oil	2.586	2.391	1.341	1.143	1.826	1.158	1.136
Palm Oil	5.282	6.441	5.696	5.912	6.341	5.979	5.324
Canola Oil	0.270	0.468	0.985	0.551	1.176	1.527	0.810
Other Oils	0.025	0.202	0.24	0.192	0.257	0.557	0.603
Total Volume	8.163	9.502	8.262	7.798	9.6	9.221	7.873

Source: China National Grain and Oils Information Center

TABLE 5. Imports (MMT) of soybean in 2008-2013

	World soybean export	Chinese soybean import	Domestic soybean production	Soybean import share
2008	78.1	37.4	15.5	47.9%
2009	81.9	42.6	15.0	52.0%
2010	91.6	54.8	15.1	59.8%
2011	90.9	52.6	14.5	57.9%
2012	93.3	58.4	13.1	62.6%
2013	99.9	63.4	12.0	63.5%

Source: USDA

China is also one of the top palm oil consuming countries. Palm oil is primarily used to produce specialty fats (margarine, shortening, and cocoa butter substitutes), and it is also used as base oil for frying instant noodles, chicken, potato snack food, and traditional snacks. Palm oil imports in 2014 were 5.9 million tons—not much higher than they were in the previous year (Table 6). In response to lower prices, China's palm oil imports peaked in 2012 (6.44MT). This created a large surplus, which resulted in a significant import decline the following year. Palm oil's inexpensive price relative to soybean oil and rapeseed oil is a major factor affecting its consumption in China. The current low prices for soybean oil and rapeseed oil are expected to put pressure on palm oil imports and consumption growth. Malaysia and Indonesia are the two major palm-oil-exporting countries.

TABLE 6. Imports (MMT) of palm oil in 2008-2014

Year	Total imports	Imports from Malaysia	Imports from Indonesia	World palm oil exports
2008	5.28	3.56	1.68	35.22
2009	6.44	3.92	2.51	36.37
2010	5.94	3.43	2.25	37.29
2011	5.91	3.61	2.30	39.84
2012	6.34	4.12	2.09	43.22
2013	5.98	4.01	1.85	43.33
2014	5.32	4.04	1.78	43.88

Source: China National Grain and Oils Information Center

CONTINUED ON NEXT PAGE 46

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Heated debate over GC-MS

Laura Cassiday

Olio is an Inform *column that highlights research, issues, trends, and technologies of interest to the oils and fats community.*

Countless laboratories have analyzed molecules using gas chromatography-mass spectrometry (GC-MS) since the technique's inception more than 50 years ago. Recently, a study in *Analytical Chemistry* claimed that the heat applied during GC-MS degrades samples to a greater extent than previously appreciated (Fang, M., *et al.,* http://dx.doi.org/10.1021/acs.analchem.5b03003, 2015). Not surprisingly, this report has sparked a heated debate over the reliability of GC-MS data.

GC-MS unites two powerful techniques to first separate, and then identify and quantify, molecules within a test sample. Researchers inject a sample into a GC-MS system, and the instrument heats and vaporizes the sample. A carrier gas propels the vapor through a heated GC column, and molecules within the sample separate based on their affinities for the column packing material. As molecules elute from the GC column at different rates, a mass spectrometer detects them and reports their mass-to-charge ratio, which can be used to identify the molecules. GC-MS is widely used in many fields including medicine, environmental monitoring, criminal forensics, and food and beverage analysis.

In the new study, researchers led by Gary Siuzdak at The Scripps Research Institute in La Jolla, California, USA, heated samples at three different temperatures (60, 100, or 250 °C) for three different times (30 s, 60 s, or 300 s) to mimic GC conditions. According to Siuzdak, the typical GC separation has a 37.5-minute run time at temperatures that gradually increase from 60 to 325 °C. Then, the researchers separated and analyzed the molecules in the samples by liquid chromatography (LC)-MS, a technique that does not heat samples for long periods, as in GC. Siuzdak and his colleagues examined the effects of heating human plasma metabolite extracts. The LC-MS spectra showed that heating at 60 °C did not significantly alter plasma metabolites compared with unheated samples. In contrast, heating at 100 °C and 250 °C caused considerable changes in the metabolomic profile. For example, heating at 250 °C for 300 s altered 40% of the molecular peaks in the LC-MS spectra, with significant formation of degradation and transformation products. The researchers also examined the degradation of specific molecules, including the fatty acid linoleic acid. After 60 s at 250 °C, about 50% of linoleic acid had disappeared.

The team examined the effects of derivatization—a process that adds chemical groups, such as a trimethylsilyl (TMS) group, to small molecules—on thermal stability. Derivatization is designed to protect molecules from degradation at GC-MS temperatures. After TMS-derivatizing plasma extracts, the researchers heated the samples at 250 °C for different times and analyzed them by LC-MS. The results showed that derivatization did not effectively protect the metabolites from degradation, but the process did appear to decrease the formation of new compounds from the breakdown or chemical reaction of metabolites.

Next, the researchers examined the thermal stability of a standard mixture of 64 small molecules, including amino acids, purines, sugars, sugar phosphates, and free fatty acids. Most of the small molecules (derivatized or not) degraded rapidly at 250 °C. Small molecules such as citric acid, glutamate, NADH, and acetyl coA were particularly unstable, whereas fatty acids tended to be more stable. Triphosphates such as ATP were rapidly converted to monophosphates (AMP) or even nucleosides during heating. New products, such as oleoyl ethyl amide, were formed during heating. The researchers hypothesize that

oleoyl ethyl amide resulted from the reaction of oleic acid with ethylamine, a breakdown product of other metabolites.

"From our perspective, it's really not that surprising or controversial that molecules degrade when they're exposed to heat," Siuzdak told *Inform.* However, critics have attacked everything from the derivatization technique to the controls to the study design. In a particularly withering commentary, Oliver Fiehn of the University of California, Davis, USA, told *C&EN,* "I am unclear why a scientific journal would publish work that is such clear nonsense" (Borman, S., http://tinyurl.com/heated-dispute, 2015).

One of Fiehn's criticisms focused on derivatization conditions and the fact that Siuzdak and his colleagues analyzed derivatized samples in a water-containing LC-MS solvent, which could cleave TMS groups. "First of all, if [Fiehn] had read the paper, he would notice that we were using his approach for derivatization," says Siuzdak. He also notes that at neutral pH, as used in the paper, hydrolysis of TMS groups requires several days. "We were conscious of this issue, and we made very effort to ensure that we weren't observing processes that were a result of the preparation, but things that had directly to do with the heat," Siuzdak says.

"It shouldn't be a surprise to anyone running GC that there are some analytes that are more stable than others," says Mark Collison, director of analytical chemistry at Archer Daniels Midland in Decatur, Illinois, USA. "We occasionally see this problem with fats and oils. We use a much shorter method to run marine oils that have a high level of unsaturation because they're not stable for a very long time on a GC column." Collison emphasizes that no single method, whether LC-MS, GC-MS, or something else, can be used for all analytes because each method has its own strengths and limitations. "There isn't a global metabolomics method, and there never will be," he says. He adds that most people already know not to use GC-MS to study molecules that degraded rapidly in Siuzdak's study, such as nucleotide triphosphates.

Siuzdak hopes that his study will spark conversations between students who use GC-MS and their mentors. "It's a good thing for students to be thinking about when they're doing experiments, so they don't spend four years chasing down molecules that may not be relevant to the experiments they've performed, but are more relevant to the thermal degradation process," Siuzdak says.

Olio is produced by Inform's associate editor, Laura Cassiday. She can be contacted at laura.cassiday@aocs.org.

Glycosyldiacylglycerols of bacteria

Lipid Snippets is a regular Inform *column that features select content from The AOCS Lipid Library (http://lipidlibrary.aocs.org/).*

This is from http://lipidlibrary.aocs.org/content.cfm?ItemNumber=39345.

Cyanobacteria are oxygenic photosynthetic bacteria (Gram negative) that are distinct from most other bacteria in their lipid compositions, as they contain appreciable amounts of mono- and digalactosyldiacylglycerols together with sulfoquinovosyldiacylglycerol in which the configuration of the anomeric head groups is identical to that of the corresponding plant lipids. Indeed, the membrane architecture of cyanobacteria and chloroplasts in higher plants is very similar. This may be explained by the theory that an ancestral cyanobacterial cell, which was photosynthetically active, was engulfed by a eukaryotic organism to become the precursor of the first plant cell, the composition of which has been largely conserved throughout evolution. The role of digalactosyldiacylglycerols in the photosynthetic apparatus in these organisms is discussed above.

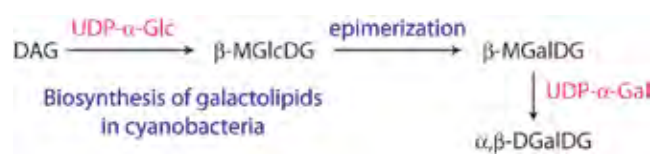
As can be seen from the data in Table 1, the overall fatty acid compositions of the lipids of the cyanobacterium *Synechocystis* PCC6803 resemble that of photosynthetic tissues in higher plants although the polyunsaturated fatty acids (C_{18}) are concentrated in position *sn*-1 in this instance with saturated fatty acids (C_{16}) in position *sn*-2. Phosphatidylglycerol is often the only phospholipid present in appreciable amounts.

Table 1. Composition (mol %) of fatty acids in positions *sn*-1 and *sn*-2 of mono- and digalactosyl- and sulphoquinovosyldiacylglycerols from *Synechocystis* PCC6803*.
Position Fatty acids

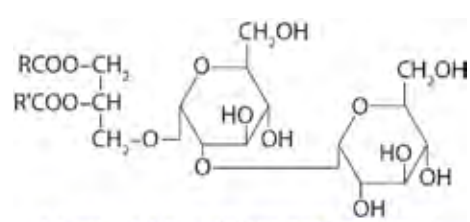
	16:0	16:1	18:0	18:1	18:2	18:3**	18:4
MGDG							
sn-1	14	4	tr	-	8	54	20
sn-2	94	2	tr	2	tr	tr	tr
DGDG							
sn-1	16	4	2	2	8	50	18
sn-2	94	2	2	tr	-	-	-
SQDG							
sn-1	34	8	2	10	16	28	tr
sn-2	92	tr	4	tr	tr	tr	-

* Grown at 22°C; ** mainly α-18:3; tr = trace.
Data from Wada, H. and Murata, N. *Plant Physiology,* **92,** 1062-1069 (1990).
On average, cyanobacteria contain ~52% MGDG, ~15% DGDG and ~9% SQDG, together with ~22% phosphatidylglycerol and ~1% minor components (Petroutsos, D. et al. (2014).

Although the nature of the lipids is highly conserved in plants and photosynthetic bacteria, the biosynthetic mechanisms are somewhat different. Cyanobacteria contain trace amounts of a monoglucosyldiacylglycerol in which the glucosyl group is in the β conformation, i.e. 1,2-diacyl-3-*O*-(β-D-glucopyranosyl)-*sn*-glycerol. This is also found in *Bacillus subtillis* where it amounts to 10% of the total lipids. It is now known that the production of monoglucosyldiacylglycerol in cyanobacteria is the first step in biosynthesis of galactosyldiacylglycerols by means of conversion by an epimerization reaction to the galactosyl form. The second galactose unit is added to the mongalactosyl product by a digalactosyldiacylglycerol synthase with UDP-galactose as the carbohydrate donor.



Many species of anoxic photosynthetic bacteria contain monogalactosyldiacylglycerols, but digalactosyldiacylglycerols are rarely found in other bacteria. However, the latter are major membrane components of free-living and bacteroid forms of *Bradyrhizobium japonicum*, which normally live symbiotically with plants in root nodules. The green photosynthetic bacterium *Chlorobium tepidum* contains rhamnosylgalactosyldiacylglycerols.



1,2-diacyl-3-O-α-Dkojibiosyl-*sn*-glycerol

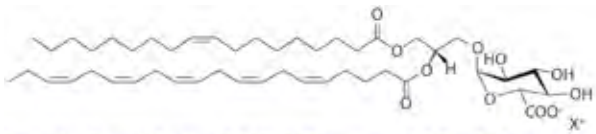
A wide variety of glycosyldiacylglycerols are found in non-photosynthetic bacteria; those with one to three glycosyl units linked to *sn*-1,2-diacylglycerol are most common, although others with up to five glycosyl units are found. These are very different from the plant glycosyl diacylglycerols, in that glucose is much more common than galactose, while the fatty acid

components are mainly saturated, monoenoic and branched-chain or cyclopropanoid. The nature of the glucose linkages is also variable. For example, some *Streptococcus* species contain mono- and diglucosyldiacylglycerols, with the diglucoside unit having an α-(1→2) linkage as in kojibiose, and so can be termed 'kojibiosyldiacylglycerols'. Related lipids together with diglucosyl-1-monoacyl-sn-glycerol and glycerophosphoryldiglucosyldiacylglycerol are present in *S. mutans. S. pneumoniae* contains glucopyranosyl- and galactoglucopyranosyldiacylglycerol, while this and other species contain similar lipids with a fatty acyl group attached to a carbohydrate moiety (usually in position 3 or 6).

Some microorganisms accumulate galactofuranosyl-diacylglycerols rather than the galactopyranosyl form, and a variety of unusual glycosyldiacylglycerols with differing carbohydrate moieties, or with differences in the glycosidic bonds from those in higher plants, have been found. For example, *Micrococcus luteus* synthesises mono- and dimannosyldiacylglycerols. Other bacteria have glycosyldiacylglycerols with a glycerophosphate group linked to a carbohydrate moiety (phosphoglycolipids). Bacillus megaterium contains *N*-acetylgalactosamine linked to a diacylglycerol. As might be expected, even greater complexity exists in the triglycosyldiacylglycerols. In mechanistic terms, the biosynthesis of these lipids is analogous to that in higher plants described above.

In gram positive bacteria such as *Staphylococcus aureus*, lipoteichoic acid is anchored in the membrane by a diglucosyldiacylglycerol moiety. The membranes of this organism also contain 8 mol% of the free glycolipid, and the ratio of mono- to diglucosyldiacylglycerol may play an important role in determining bilayer stability; only the latter will form a bilayer. Similarly, the human pathogen *Enterococcus faecalis* produces diglucosyldiacylglycerol as a membrane component and as a lipoteichoic acid precursor in a secreted biofilm, which is involved in adherence to host cells and virulence in vivo. There is increasing interest in such lipids as it has been demonstrated that galactosyldiacylglycerols from *Borrelia burgdorferi,* the causative agent of Lyme disease, are involved in the antigen response via specific receptors.

Certain bacteria, fungi and algae contain the ionic 1,2-diacyl-3-*O*-α-D-glucuronyl-*sn*-glycerol among their membrane lipids, and a conjugate of this with taurine is known (see our webpage on sulfonolipids). Of course, the algal lipid illustrated has a very different fatty acid composition from those of bacteria. In addition, glucosylglucuronyl- and galacturonyldiacylglycerols have been detected in bacteria.



1-octadec-9-enoyl-2-eicosa-5,8,11,14,17-penta enoyl-3-O-α-*D*-glycuronyl-*sn*-glycerol

The complex diether isoprenoid glycerolipids from the extreme halophilic bacteria of the Archaea family exist in the form of glycosyldiacylglycerols, both as neutral lipids and in sulfated form, with two to four glycosyl units attached to glycerol.

PATENTS

Method and device for carboxylic acid production

Bhavaraju, S., *et al.,* Ceramatec, Inc., US9057137, June 16, 2015

A method for producing and recovering a carboxylic acid in an electrolysis cell. The electrolysis cell is a multi-compartment electrolysis cell. The multi-compartment electrolysis cell includes an anodic compartment, a cathodic compartment, and a solid alkali ion transporting membrane (such as a NaSICON membrane). An anolyte is added to the anodic compartment. The anolyte comprises an alkali salt of a carboxylic acid, a first solvent, and a second solvent. The alkali salt of the carboxylic acid is partitioned into the first solvent. The anolyte is then electrolyzed to produce a carboxylic acid, wherein the produced carboxylic acid is partitioned into the second solvent. The second solvent may then be separated from the first solvent and the produced carboxylic acid may be recovered from the second solvent. The first solvent may be water and the second solvent may be an organic solvent.

Oil-in-water emulsion sunscreen cosmetic composition

Harada, T., *et al.,* Shiseido Company, Ltd., US9060942, June 23, 2015

Provided is an oil-in-water emulsion sunscreen cosmetic composition that can provide high protection ability against UVA and excellent emulsion stability. The oil-in-water emulsion sunscreen cosmetic composition is characterized in that it contains (A) a hydrophobized zinc oxide having an absorbance of 0.3 or more at a wavelength of 370 nm, (B) a UVA absorber being solid at room temperature, (C) a UVB absorber, (D) a liquid-state higher fatty acid, (E) a nonionic surfactant, (F) a volatile oil, (G) a quaternary ammonium compound having a long-chain aliphatic group and (H) water. Particularly, it is preferable that the hydrophobized zinc oxide has an average particle size within a range of 35 to 100 nm; the hydrophobized zinc oxide is hydrophobidized by use of hydrogen dimethicone; the quaternary ammonium compound having a long-chain aliphatic group is distearyldimethylammonium chloride; and the UVB absorber is octylmethoxy cinnamate.

Oil composition and method for producing the same

Bootsma, J., Poet Research, Inc., US9061987, June 23, 2015

This invention relates to a corn oil composition comprising unrefined corn oil having a free fatty acid content of less than about 5 wt%, and methods for producing the same.

Conjugated linoleic-acid-rich vegetable oil production from linoleic rich oils by heterogeneous catalysis

Proctor, A., *et al.,* Board of Trustees of the University of Arkansas, US9062276, June 23, 2015

The invention is generally directed to conjugated linoleic acid (CLA)-rich vegetable oil production from linoleic rich oils by heterogeneous catalysis. A heterogeneous catalytic vacuum distillation process is used under high temperature conditions to isomerize linoleic acid in triacylglyceride vegetable oils to CLA to produce CLA-rich oils. After processing, the catalyst may be removed by filtration or centrifugation to obtain high quality, CLA-rich oils. The CLA-rich oils may then serve as a potent and bioactive nutraceutical and can be incorporated into various food products, such as a CLA-rich dressing, margarine or chips.

Compositions and methods for increasing the suppression of hunger and reducing the digestibility of non-fat energy satiety

Kristensen, M., *et al.,* University of Copenhagen, US9066536, June 30, 2015

The present invention relates to methods for increasing the suppression of hunger and/or increasing the reduction of prospective consumption and/or increasing the reduction of appetite and/or increasing the feeling of satiety and/or reducing non-fat energy uptake in the gastrointestinal tract of a mammal in order to prevent a positive non-fat energy balance, weight gain, overweight and obesity, and to induce a negative non-fat energy balance and weight loss in subjects who wish to reduce their body weight. In particular, feed, food and/or beverages and dietary supplements of the present invention comprises mucilage such as flax seed mucilage and/or one or more active compounds of mucilage useful for increasing the suppression of hunger and/or increasing the reduction of prospective consumption and/or increasing the reduction of appetite and/or increasing the feeling of satiety and/or reducing the digestibility of non-fat energy in the gastrointestinal tract of a mammal.

Synergistic antioxidant composition

Jourdain, L. and L. Sagalowicz, Nestec SA, US9068138, June 30, 2015

The present invention relates to an antioxidant composition comprising a galactolipid, ascorbic acid and/or a derivative thereof, and at least one further lipid. Further aspects of the invention are the method of manufacturing such an antioxidant composition as well as the use of galactolipids in combination with ascorbic acid and/or a derivative thereof for protecting a composition against oxidation. Particularly, the invention relates to a composition to be used in food products.

Modified-immobilized enzymes of high tolerance to hydrophilic substrates in organic media

Basheer, S., Trans Biodiesel. Ltd., US9068175, June 30, 2015

Disclosed are preparations of modified interfacial enzymes, particularly lipases and phospholipases, immobilized on a solid support, wherein the enzyme is surrounded by hydrophobic microenvironment, thereby protected from deactivation and/or aggregation in the presence of hydrophilic agents, substrates and/or reaction products. The enzyme may be protected by being covalently bonded with lipid groups which coat the enzyme, or by being immobilized or embedded in a hydrophobic solid support. Also disclosed are processes for the preparation of the hydrophobically protected enzymes. The enzymes may be efficiently used in the preparation of biodiesel.

High-melting-point sunflower fat for confectionary

Garces, R., *et al.,* Consejo Superior De Investigaciones Cientificas, US9072309, July 7, 2015

The present invention is based on the finding that stearin fats, obtainable by dry or solvent fractionation of sunflower high-stearic and high-oleic oils, optionally with seeding with tempered stearin crystals, have a high solid fat content at temperatures higher than 30 degrees centigrade, even higher than cocoa butter or other high saturated tropical fats with a similar disaturated triacylglycerol content due to the presence of disaturated triacylgiycerols rich in stearic acid, and improved melting point due to the presence of arachidic and behenic acids in these disaturated triacylgiycerols, being at the same time healthier that actual fats made from palm, palm kernel and coconut oils, or hydrogenated and trasesterified vegetable oils.

Nutritional products including monoglycerides and fatty acids

Lai, C.S., *et al.,* Abbott Laboratories, US9078846, July 14, 2015

Disclosed are nutritional formulations including predigested fats that can be administered to preterm infants, infants, toddlers, and children for improving tolerance, digestion, and absorption of nutrients and for reducing the incidence of necrotizing enterocolitis, colic, and short bowel syndrome. The predigested fats include fatty acid-containing monoglycerides and/or a fatty acid component.

Nutritional products including a novel fat system including monoglycerides

LAI, C.S., Abbott Laboratories, US9078847, July 14, 2015

Disclosed are nutritional formulations including predigested fats that can be administered to preterm infants, infants, toddlers, and children for improving tolerance, digestion, and absorption of nutrients and for reducing the incidence of necrotizing enterocolitis, colic, and short bowel syndrome. The predigested fats include fatty acid-containing monoglycerides and/or a fatty acid component.

System and method for extracting vitamin E from fatty acid distillates

Soinak, K. and P Raviyan, Chumporn Palm Oil Industry Public Co., Ltd., US9078850, July 14, 2015

Various systems and processes for extracting Vitamin E from a fatty acid distillate (FAD) having a Vitamin E component are disclosed. The process includes preparing a mixture of a FAD and a non-polar solvent (e.g., hexane). The mixture can be sequentially cooled to a series of pre-determined temperatures. As the mixture is sequentially cooled to each of the pre-determined temperatures within the series of pre-determined temperatures, non-Vitamin E components present in the FAD can form solid fractions within the mixture at the various pre-determined temperature stages. The process further includes removing the solid fractions from the mixture at each of the pre-determined temperature stages. After completion of a number of cooling and separation stages or cycles, the non-polar solvent can be removed from the remaining mixture to recover a Vitamin E extract.

Surfactants derived from epoxidized oils and compositions thereof

Lele, B.S., US9085709, July 21, 2015

Present invention relates to surfactants derived from epoxidized oils and compositions thereof. Particularly this invention describes surfactants derived from epoxidized oils covalently attached to water soluble polymers via thioether bond forming linker and formulations thereof.

Process for obtaining oleochemicals with reduced content of by-products

Sobierska, E., *et al.,* Cognis IP Management GMBH, US9085746, July 21, 2015

Processes for obtaining fatty acids with reduced content of by-products, wherein unrefined fats or oils are subjected to steam stripping in a counter-current column to produce a bottom fraction of de-acidified fats or oils, a first distillate consisting mainly of fatty acids and glycerides, and a second distillate comprising fatty acids and essentially all unwanted ketones, aldehydes and phenols, and the bottom fraction containing the de-acidified fats or oils is combined with the first distillate containing fatty acids and glycerides.

Patent information is compiled by Scott Bloomer, a registered US patent agent with Archer Daniels Midland Co., Decatur, Illinois, USA. Contact him at scott.bloomer@adm.com.

EXTRACTS & DISTILLATES

Techno-economics of microalgae production and conversion to refinery-ready oil with co-product credits

Manganaro, J.L., *et al., Biofuel, Bioprod. Bior. 9:* 760–777, 2015, http://dx.doi.org/10.1002/bbb.1610.

The economics of the production of hydrotreated algal oil (HTAO) along with co-production of animal feed and nutraceuticals (omega-3 oils) was explored. Base case calculations were for commercial scale production of 10 000 barrels per day of HTAO with nutraceuticals claiming only 0.05% of the raw algae oil (AO). The sensitivity of economics to critical parameters was studied. The greatest sensitivity of sales price was to the algae doubling time. Doubling time might be reduced by increasing pond velocity or other mixing-inducing means. Other important parameters were oil content, CAPEX, and moisture content of post-extracted algal residue. Algal area weight productivity ($g/m^2/day$) was calculated from four parameters: initial algal concentration, pond depth, residence time in pond, and algae doubling time. Using presently accepted operating parameter values and with co-product credits, the estimated plant gate price was ~ $10/gal. However, it was shown that there is significant potential for enhanced economics through moderate improvements in many areas. Credits for co-production of animal feed and nutraceuticals were $3.24/gal and $0.14/gal, respectively. At constant oil area productivity (gal/acre/yr), the trade-off between oil content and area weight productivity favors oil content. In the limit of 100% oil content (no solid co-product) a sale price of $7.90/gal was estimated. Hydrotreatment of AO was discussed. Municipal waste-water tertiary treatment was briefly discussed but not deemed viable on a large scale. An easy-to-use Excel spreadsheet for material and energy balances and economics was developed as a flexible scouting tool. The symbol '$' denotes US dollars.

Using MALDI MS for rapid analysis of food lipids

Shinn, S.E., *et al., Lipid Technol. 27*: 255–257, 2015, http://dx.doi.org/10.1002/lite.201500055.

Matrix-assisted laser desorption/ionization (MALDI) is an ionization method that produces intact lipid molecule species that can be separated and characterized by mass spectrometry. Recent research has concentrated on using rapid MALDI MS lipid analysis that employs little sample cleanup, simple sample preparation, no chemical derivatization, and minimal chromatography. This article takes a look at selected MALDI MS applications for edible oils and lipid rich foods, such as meat and eggs, and explores potential uses in food and lipid science.

Sin and pleasure: the history of chocolate in medicine

Lippi, D. , *J. Agric. Food Chem. 63:* 9936–9941, 2015, http://dx.doi.org/10.1021/acs.jafc.5b00829.

In ancient Mayan texts cocoa is considered a gift of the gods: Pre-Columbian populations used chocolate as medicine, too. After the discovery of America, chocolate was introduced in Europe, but Christian Europe looked to this new exhilarating drink with extreme suspiciousness and criticism. From this reaction, the necessity derived to appeal to the reasons of health, with which doctors and scientists committed themselves to explain that chocolate was good for the body. However, during the Enlightenment, the road of therapy separated from that of taste, and chocolate mainly maintained its leading role of excipient, bearing the burden, over time, of a negative valence, being associated with obesity, dental problems, unhealthy lifestyle, and so forth. The rehabilitation of chocolate has arisen only in recent times, re-establishing that value that Linnaeus himself credited to chocolate, calling the generous plant *Theobroma cacao,* food of the gods.

Formation of oil-in-water emulsions from natural emulsifiers using spontaneous emulsification: sunflower phospholipids

Komaiko, J., *et al., J. Agric. Food Chem. 63:* 10078–10088, 2015, http://dx.doi.org/10.1021/acs.jafc.5b03824.

This study examined the possibility of producing oil-in-water emulsions using a natural surfactant (sunflower phospholipids) and a low-energy method (spontaneous emulsification). Spontaneous emulsification was carried out by titrating an organic phase (oil and phospholipid) into an aqueous phase with continuous stirring. The influence of phospholipid composition, surfactant-to-oil ratio (SOR), initial phospholipids location, storage time, phospholipid type, and preparation method was tested. The initial droplet size depended on the nature of the phospholipid used, which was attributed to differences in phospholipid composition. Droplet size decreased with increasing SOR and was smallest when the phospholipid was fully dissolved in the organic phase rather than the aqueous phase. The droplets formed using spontaneous emulsification were relatively large ($d > 10$ µm), and so the emulsions were unstable to gravitational separation. At low SORs (0.1 and 0.5), emulsions produced with phospholipids had a smaller particle diameter than those produced with a synthetic surfactant (Tween 80), but at a higher SOR (1.0), this trend was reversed. High-energy methods (microfluidization and sonication) formed significantly smaller droplets ($d < 10$ µm) than spontaneous emulsification. The results from this study show that low-energy methods could be utilized with natural surfactants for applications for which fine droplets are not essential.

Exploitation of amaranth oil fractions enriched in squalene for dual delivery of hydrophilic and lipophilic actives

Ott, C., *et al., Ind. Crops Prod .77:* 342–352, 2015, http://dx.doi.org/10.1016/j.indcrop.2015.08.057

The study describes an ideal approach to increase the co-encapsulation of two water and lipid-soluble drugs in the same delivery system. The main purpose is represented by the exploitation of oil fractions isolated from amaranth seeds for the development of squalene-based nanocarriers able for a dual release of one antitumor drug, pemetrexed and one bio-flavonoid, hesperidin. The co-encapsulated nanocarriers presented unique nanoassembly morphology and showed excellent stability against aggregation. A delimited repartition of both actives, mainly in oily nanoconfinements of lipid nanocariers has been indicated by scanning calorimetry. The entrapment efficiency study revealed a great encapsulation effect with values reaching 94% for hesperidin and 89% for pemetrexed. These values are associated with a high ability of squalene-nanocarriers to capture free radicals. The greatest antioxidant activity was determined for nanocarriers that co-encapsulate 1.4% drugs, e.g., 97.3 and 98.2%. In vitro co-release tests demonstrated that pemetrexed and hesperidin were gradually released despite of their different lipophilicity. The most concentrated squalene fraction assures a slower release of both actives. The cumulative results showed that the applied strategy is a promising approach to improve the performance of medical treatments used to prevent and treat diseases associated with tumor and oxidative stress.

Synergistic effect of surfactants and silica nanoparticles on oil recovery from condensed corn distillers solubles (CCDS)

Fang, L., *et al., Ind. Crops Prod. 77:* 553–559, 2015, http://dx.doi.org/10.1016/j.indcrop.2015.09.031.

Most of the oil in condensed corn distillers solubles (CCDS) is in an emulsified form and centrifugation alone is not sufficient to recover the oil in high yield. The synergistic effect between nonionic surfactants (Tween® 80 and Span® 80) and silica nanoparticles (hydrophilic and hydrophobic) on oil recovery was investigated using 3 batches of commercial CCDS. The use of surfactant mixture with Hydrophilic-Lipophilic-Balance (HLB) value of 9.7 led to the highest oil recovery. Tween® 80/silica and surfactant mixture (HLB 9.7)/silica recovered 5–10% more oil compared with the control groups. However, Span® 80/silica was not effective. Surfactant mixture/silica made the oil recovery by centrifugation more efficient by destabilizing oil-in-water emulsion and washing out free oil droplets. The use of surfactant and silica significantly affected the distribution of different types of oil, as well as centrifugation conditions, heating and shaking. About 20% of total oil remained in the unbroken cells or germ pieces in CCDS, which is unrecoverable without additional treatment.

Addition of cellulolytic enzymes and phytase for improving ethanol fermentation performance and oil recovery in corn dry grind process

Luangthongkam, P., *et al., Ind. Crops Prod. 77:* 803–808, 2015, http://dx.doi.org/10.1016/j.indcrop.2015.09.060.

Application of hydrolytic and other enzymes for improving fermentation performance and oil recovery in corn dry-grind process was optimized. Non-starch polysaccharide enzymes (BluZy-P XL; predominantly xylanase activity) were added at stages prior to fermentation at optimum conditions of 50 °C and pH 5.2 and compared with conventional fermentation (30 °C, pH 4.0). Enzyme applications resulted in faster ethanol production rates with a slight increase in yield compared to control. The thin stillage yield increased by 0.7–5% w/w wet basis with corresponding increase in solids content with enzyme treatment after liquefaction. The oil partitioned in thin stillage was at 67.7% dry basis after treatment with hydrolytic enzymes during fermentation. Further addition of protease and phytase during simultaneous saccharification and fermentation increased thin stillage oil partitioning to 77.8%. It also influenced other fermentation parameters, e.g., ethanol production rate increased to 1.16 g/g dry corn per hour, and thin stillage wet solids increased by 2% w/w. This study indicated that treatments with non-starch hydrolytic enzymes have potential to improve the performance of corn dry-grind process including oil partitioning into thin stillage. The novelty of this research is the addition of protease and phytase enzymes during simultaneous saccharification and fermentation of corn dry-grind process, which further improved ethanol yields and oil partitioning into thin stillage.

Lipophilic phytochemicals from sugarcane bagasse and straw

del Ríoa, J.C., *et al., Ind. Crops Prod. 77:* 992–1000, 2015, http://dx.doi.org/10.1016/j.indcrop.2015.09.064.

The composition of lipophilic phytochemicals in sugarcane bagasse and straw, the two major residues of sugarcane processing, was investigated in detail by gas chromatography and mass spectrometry. The composition of the lipids from sugarcane bagasse and straw was completely different from each other. While the extracts of sugarcane bagasse were dominated by n-aldehydes (ca. 48% of all identified lipids) and n-fatty alcohols (ca. 23%) with lower amounts of n-fatty acids (10%) and steroid ketones (14%), the extracts from sugarcane straw were strongly dominated by n-fatty acids (accounting for ca. 60% of all identified compounds) with significant amounts of steroid compounds, particularly sterols (10%) and steroid ketones (14%). Tocopherols and triterpenols were also found, being particularly abundant among the extractives of sugarcane straw. Sugarcane bagasse and straw can thus be considered as promising feedstocks for obtaining highly valuable phytochemicals of nutraceutical or pharmaceutical interest.

Recent advances in vegetable-oils-based environment-friendly coatings: a review

Sharmin, F., *et al., Ind. Crops Prod.76:* 215–229, 2015, http://dx.doi.org/10.1016/j.indcrop.2015.06.022

The overarching goal worldwide for the scientific community is "sustainable development" today, for an everlasting sustainable and green tomorrow. The strategy includes (i) harvesting renewable resources instead of fossil fuels, (ii) using environment friendly routes, and (iii) engineering material degradation pathways operating under reasonable time frames. The concept revolves around the focal point of "Green" or "Sustainable" Chemistry. In the world of coatings, the idea has already made its debut in the form of environment friendly technologies-low or no solvent, high solids, hyperbranched, water borne and UV curable coatings, utilizing monomers/polymers derived from renewable resources. Vegetable oils [VEGO] constitute Mother Nature's most abundant, cost-effective, non toxic, and biodegradable resource. They have been traditionally used for several non-food applications mainly coatings since primitive times. Today, the implementation of the modern technologies coupled with the full fledged use of VEGO based monomers or polymers in the field as raw materials, is an excellent effort toward sustainable future in the world of coatings globally. The review highlights some state-of-the art-modifications of VEGO as environment friendly-low or no solvent, high solids, hyperbranched, water borne and UV curable coatings. The article provides a handy overall vision of VEGO based environment friendly coatings on a single platform. These approaches can be well employed on those oils that are non-edible, non-medicinal and are left unexplored, unutilized or underutilized to date, thus adding value to an unutilized or underutilized sustainable resource.

Impact of association colloids on lipid oxidation in triacylglycerols and fatty acid ethyl esters

Homma, R., *et al., J. Agric. Food Chem. 63:* 10161–10169, 2015, http://dx.doi.org/10.1021/acs.jafc.5b03807.

The impact of association colloids on lipid oxidation in triacylglycerols and fatty acid ethyl esters was investigated. Association colloids did not affect lipid oxidation of high oleic safflower and high linoleic safflower triacylglycerols, but were prooxidative in fish triacylglycerols. Association colloids retarded aldehyde formation in stripped ethyl oleate, linoleate, and fish oil ethyl esters. Interfacial tension revealed that lipid hydroperoxides were surface active in the presence of the surfactants found in association colloids. The lipid hydroperoxides from ethyl esters were less surface active than triacylglycerol hydroperoxides. Stripping decreased iron and copper concentrations in all oils, but more so in fatty acid ethyl esters. The combination of lower hydroperoxide surface activity and low metal concentrations could explain why association colloids inhibited lipid oxidation in fatty acid ethyl esters. This research suggests that association colloids could be used as an antioxidant technology in fatty acid ethyl esters.

Lipid Oxidation

Role of water and selected minor components on association colloid formation and lipid oxidation in bulk oil

Kittipongpittaya , K., *et al., JAOCS,* published online Nov. 24, 2015, http://dx.doi.org/10.1007/s11746-015-2752-y.

This study investigated the influence of water content in combination with selected minor components including oleic acid, stigmasterol, α-tocopherol, and Trolox on their association colloid formation as well as their impact on lipid oxidation in bulk corn oil. First, surface activity of each minor component was evaluated by determining the ability of these components to lower the interfacial tension between bulk oil and water. All components but α-tocopherol were able to decrease interfacial tension of stripped oil. Second, the critical micelle concentration (CMC) of each minor component was determined in bulk oil with no water added and in the presence of 1000 ppm of water. In the bulk oil without extraneous water, we could not determine the CMC of minor components in the range of concentrations studied. However, in the presence of 1000 ppm of water, only stigmasterol could form association colloids at the CMC of 20 mmol/kg oil. Last, the effect of water content (400 and 1000 ppm) and minor components on lipid oxidation in bulk oil was studied by following the lipid hydroperoxides and hexanal formation during storage at 55 °C. Different water content did not significantly impact the lag time of lipid oxidation compared with the control. Interestingly, water caused prooxidant by decreasing the lag time of lipid hydroperoxides and hexanal formation in bulk oil containing oleic acid, stigmasterol, and Trolox compared with the control of each system. On the other hand, there was not significant impact of water on the antioxidant activity of α-tocopherol, a lipid soluble antioxidant in bulk oil. This study highlights the impact of water content on the surface activity of minor components as well as on the oxidative stability in bulk oil.

Effect of rosemary leaves and essential oil on turkey sausage quality

Jridi, M., *et al., Acta Alimentara 44:* 534–541, published online November 23, 2015, http://dx.doi.org/10.1556/066.2015.44.0025.

The purpose of this study was to evaluate the effect of rosemary essential oil (250–1000 ppm) or its leaves (0.5–2%) on the quality of turkey sausage. The addition of essential oil had no significant effect on the sausage texture and colour parameters. A high rosemary leaves level resulted in an increase in sausage hardness and chewiness and a decrease in lightness (L*) with respect to the control sausage. Sensory evaluation indicated that rosemary essential oil and its leaves increased the taste and the aroma scores of turkey sausage depending on the concentration. The obtained results also showed that rosemary leaves (0.5%) were more effective than essential oil in reducing total plate counts, TBARS, K232, and K270 values during chill storage, in comparison with the control product. This will

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contribute to reducing the use of chemical additives, which are badly perceived by consumers, while increasing the sensory properties of such products.

Effect of extraction time on antioxidants and bioactive volatile components of green tea (*Camellia sinensis*), using GC/MS

Ahmada, M., *et al., Cogent Food Agric,*. published online November 23, 2015, http://dx.doi.org/10.1080/23311932.2015.1106387.

Two green tea types, leaf grade and sanding, were extracted at different time intervals: 20, 40, and 120 min at a constant temperature of 50°C. The extracts were analyzed by GC/MS technique. The major compounds identified were myristic acid, palmitic acid, stearic acid, oleic acid, 1H-purine-2,6-dione, caffeine, linoleic acid, diethyl ester, and 1H-purine-6-amine. Stearic acid, palmitic acid, linoleic acid, and myristic acid were more abundantly present in the leaf-grade variety than sanding. However, some levels of acetic acid, cyclobutanol, hexadecanoic acid, octadecanoic acid, 9-octadecenoic acid, and caffeine were also found in both the tea types. Most of the volatile compounds were detected between 20–40-min time of extraction. The 40-min time of extraction also showed the maximum content of polyphenols and antioxidants in both the tea types. Thus, 40 min was suggested as the most suitable time for maximum extraction of bioactive volatiles, antioxidants, and polyphenols from green tea.

Chemical and sensory quality preservation in coated almonds with the addition of antioxidants

Larrauri, M., *et al., J. Food Sci.* , published online Noveber 23, 2015, http://dx.doi.org/10.1111/1750-3841.13164.

Almonds provide many benefits such as preventing heart disease due to their high content of oleic fatty acid-rich oil and other important nutrients. However, they are susceptible to oxidation reactions causing rancidity during storage. The objective of this work was to evaluate the chemical and sensory quality preservation of almonds coated with carboxymethyl cellulose and with the addition of natural and synthetic antioxidants during storage. Four samples were prepared: almonds without coating (C), almonds coated with carboxymethyl cellulose (CMC), almonds coated with CMC supplemented with peanut skins extract (E), and almonds coated with CMC and supplemented with butylhydroxytoluene (BHT). Proximate composition and fatty acid profile were determined on raw almonds. Almond samples (C, CMC, E and BHT) were stored at 40 °C for 126 d. Lipid oxidation indicators: peroxide value (PV), conjugated dienes (CD), volatile compounds (hexanal and nonanal), and sensory attributes were determined for the stored samples. Samples showed small but significant increases in PV, CD, hexanal and nonanal contents, and intensity ratings of negative sensory attributes (oxidized and cardboard). C had the highest tendency to deterioration during storage. At the end of storage (126 d), C had the highest PV (3.90 meqO2/kg), and BHT had the lowest PV (2.00 meqO2/kg). CMC and E samples had similar intermediate PV values (2.69 and 2.57 meqO2/kg, respectively). CMC coating and the addition of natural (peanut skin extract) and synthetic (BHT) antioxidants provide protection to the roasted almond product.

Structural characterization of β-carotene-incorporated nanovesicles produced with non-purified phospholipids

Michelona, M., *et al., Food Res. Intl.*, in press, http://dx.doi.org/10.1016/j.foodres.2015.11.020.

The technical feasibility of obtaining β-carotene-incorporated phospholipid nanovesicles using non-purified soybean lecithins was studied. For this purpose, three lecithin-types were evaluated. Nanovesicles were characterized by average hydrodynamic diameter, particle size distribution, polydispersity index, ζ-potential, transmission electron microscopy, membrane microviscosity, small angle X-ray scattering and capacity of lipid peroxidation inhibition. In general, the β-carotene incorporation did not promote a significant increase on average hydrodynamic diameter, but vesicles produced from lecithins containing triglycerides showed lower polydispersity. The lecithin-type used to produce nanovesicles did not influence the β-carotene loading capacity, but significantly influenced the microviscosity of liposomal membrane and lipid peroxidation inhibition capacity. Non-enzymatically modified lecithin (containing or not triglycerides) showed similar efficiency and peroxidation inhibition capacity considering β-carotene incorporation. Therefore, low-cost non-purified lecithin can be employed for production of liposomal systems as an encapsulating and/or delivery system to be used in food products.

Influence of fat and phytosterols concentration in margarines on their degradation at high temperature: a study by 1H Nuclear Magnetic Resonance

Sopelana, P., *et al.,* Food Chem., in press, http://dx.doi.org/10.1016/j.foodchem.2015.11.058.

The objective of this work was to study the influence of several factors, especially fat and phytosterols concentration, on the behavior of margarine under thermo-oxidative conditions. For this purpose, margarines with similar compositions in acyl groups, but differing in the concentration of both fat and phytosterols, were heated at 180 °C. The changes in the main components of margarine lipids and the formation of new compounds throughout the thermal treatment were monitored by 1H Nuclear Magnetic Resonance. The results show that the presence of high concentrations of phytosterols seems to have an antioxidant effect, since it slows down the thermo-oxidation rate of margarine and, consequently, the generation rate and concentrations of secondary oxidation products such as some aldehydes, epoxides and alcohols. The oil–water ratio also seems to have an important effect on margarine behavior, in such a way that the lower the fat concentration is, the higher its thermo-oxidation rate.

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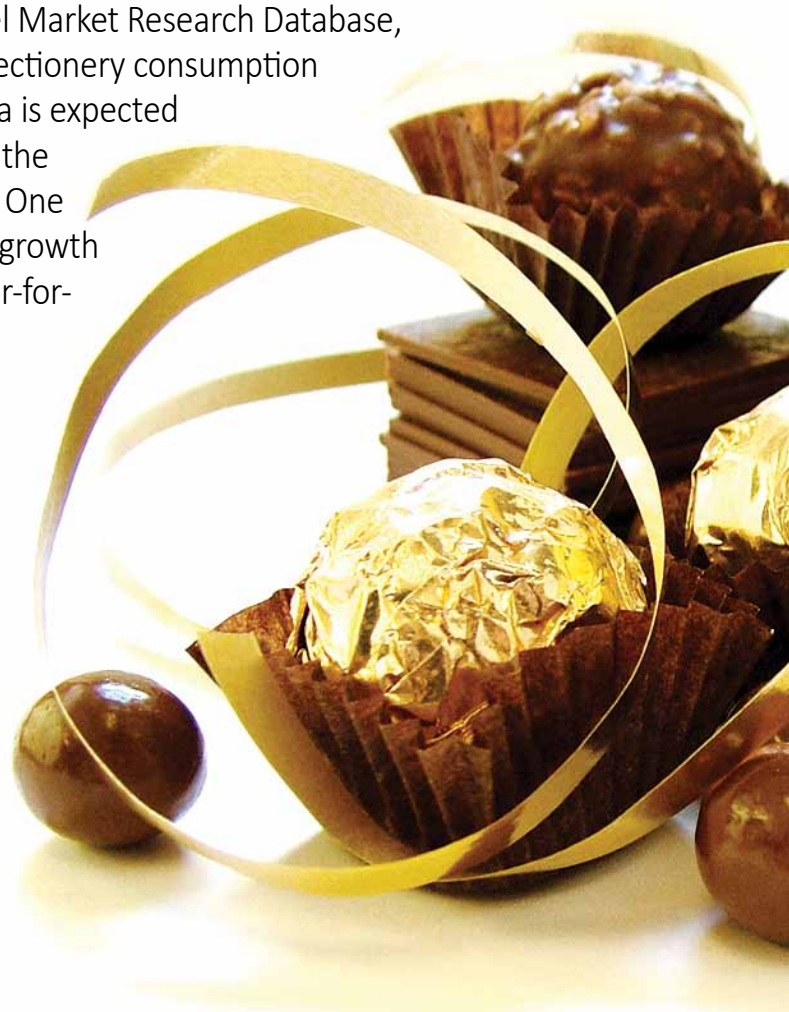
Chocolate confectionery and hands-on workshop

Latin America Update is a regular Inform *column that features information about fats, oils, and related materials in that region.*

Leslie Kleiner

Chocolate confectionery continues to be a growing favorite in many different regions of the world. Latin America is no exception. Based on 2015 data from the Mintel Market Research Database, chocolate confectionery consumption in Latin America is expected to grow during the next five years. One of the areas of growth is in the "better-for-you" category, which includes reduced-sugar and other lighter products.



Given the rising number of consumers searching for health-minded options, countries like Brazil, Chile, Mexico, and Colombia offer opportunities for developing products in this category. Looking at products that were launched before the second half of 2015, we see products such as Vitao Zero Chocolate (Brazil), which is a chocolate confection without added sugar. Other innovative products, such as Nestlé's Aerated Milk Chocolate (Brazil) and Milk Leger Aerated Chocolate Bar (Argentina), employ aeration to deliver a lighter, yet satisfying experience. Dark chocolate is also starting to become recognized in some Latin American countries as a "better-for-you" item, and therefore this particular segment of chocolate confectionery is also expected to grow within the region.

Innovation is a key factor in appealing to Latin American consumers. Examples of innovative treats include chocolate confections with fortification claims, such as Arcor's Tortuguita Chocolate with Vanilla Filling (Brazil), which is fortified with vitamins and minerals. However, not all innovation comes in the form of added claims. Consumers who indulge in more traditional chocolate confectioneries, appreciate innovation in the form of seasonal products. Lately, such seasonal items have been focusing on white chocolate as the main ingredient or as one of various types of chocolate within the confection. Examples include Chocafetts White Chocolate with Candied Coffee (Mexico), Arcor's Cofler Dulce de Leche filled White Chocolate (Argentina), and Nestlé's Sufflair Duo Aerated Milk and White Chocolate (Brazil).

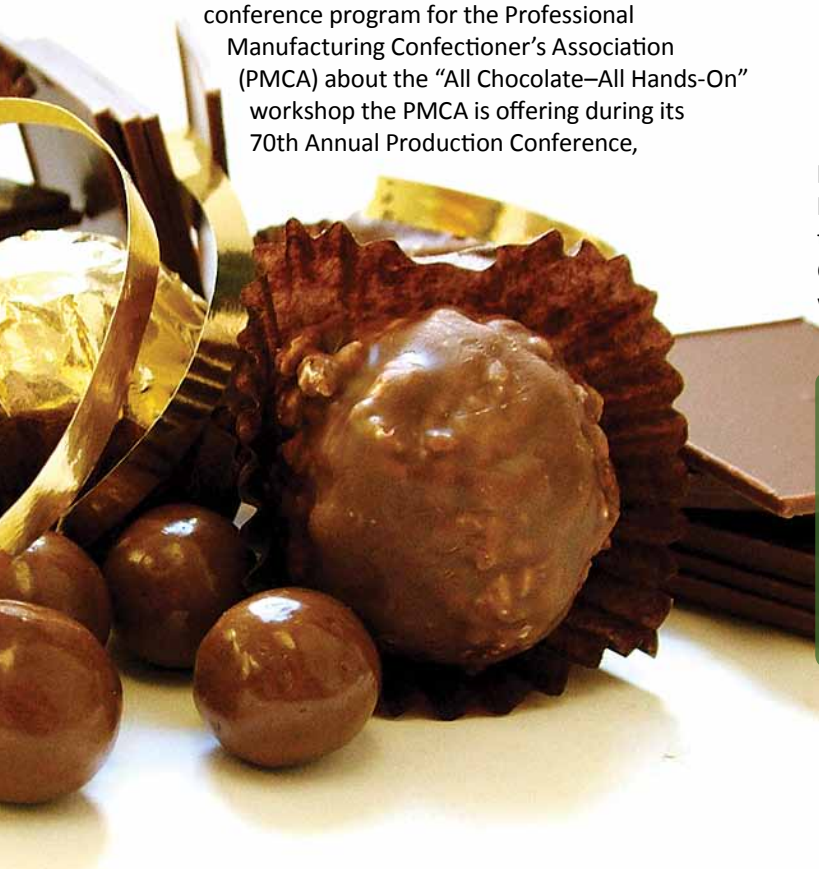
With so many different types of chocolate confections, mastering the art and science of chocolate and keeping abreast with innovation can be challenging. Attending a workshop is a good way to get up close and personal with chocolate. Therefore, I asked Judith Cooley, Principal Scientist at the Hershey Company and Chair of the production conference program for the Professional Manufacturing Confectioner's Association (PMCA) about the "All Chocolate–All Hands-On" workshop the PMCA is offering during its 70th Annual Production Conference, April 11–13, 2016, in Lancaster, Pennsylvania, USA.

"The objective of the workshop is for attendees at all levels of experience to have fun and interact with colleagues while gaining basic knowledge or greater insight into working with chocolate used in a vast number of confectionery and snack products," Cooley said.

She explained that the workshop will be divided into six interactive stations featuring the following topics:

- **Cocoa bean origination.** Participants at this station will gain a greater understanding of the various flavor profiles that result from cocoa seeds grown in different regions of the world. Information on pods, beans, and selection will be included along with sampling of a variety of origin liquors.
- **Chocolate processing.** This station will offer insight into the complex process of transforming cocoa beans into a chocolate product that meets standards for white, milk, and dark varieties. Chocolate tempering. Tempering chocolate correctly for a specific application is a critical process that affects texture, flavor, appearance, and shelf life. Slab and unit tempering will be explained, with a chance for attendees to practice their hand at getting a chocolate in perfect temper.
- **Chocolate enrobing.** Enrobing is basically the process of gently guiding centers through a smooth chocolate waterfall. This sounds easy, but several variables can cause defects, such as poor bottoms, exposed centers, and air bubbles. Industry experts will share their enrobing techniques using a mini enrober.
- **Chocolate molding.** The basics of the molding process will be explained and demonstrated. Workshop participants can practice molding their own bar of chocolate right at the conference.
- **Premium chocolate ganache and truffles.** Understanding the intricacies of ingredient formulation and function, along with perfecting technique, is important to building a great product.

Cooley added that the chocolate workshop is an excellent opportunity to get up close and personal with chocolate, learn from experienced instructors, and network with industry experts. Information about the PMCA's Annual Production Conference and the chocolate workshop is available at http://www.pmca.com/.



Latin America Update is produced by Leslie Kleiner, R&D Project Coordinator in Confectionery Applications at Roquette America, Geneva, Illinois, USA, and a contributing editor of *Inform*. She can be reached at LESLIE.KLEINER@roquette.com.

Industrial Applications

Evaluation of different solvent mixtures in esterifiable lipids extraction from microalgae *Botryococcus braunii* for biodiesel production

Hidalgoa, P., *et al.,* Bioresource Technol., published online November 19, 2015, http://dx.doi.org/10.1016/j.biortech.2015.11.031.

Non-polar and polar solvents as well as their mixtures were tested for the extraction of microalgae lipids and thus, to evaluate their effect on total and esterifiable lipids extraction yields with potential to be converted to biodiesel. The obtained results show an increase in lipids and esterifiable lipids extraction yields when non-polar and polar solvent mixtures were used. The higher esterifiable lipids extraction yield was 19.2% wt (based on dry biomass) using a chloroform–methanol mixture (75% v/v of methanol), corresponding to a 98.9% wt esterifiable lipids extraction. In addition, esterifiable lipids extraction yield of 18.9% wt (based on dry biomass) was obtained when a petroleum ether–methanol mixture (75% v/v of methanol) was used, corresponding to a 96.9% wt esterifiable lipids extraction.

Microalgal culture strategies for biofuel production: a review

Zhu, L., Biofuels, Bioprod. Bior. 9: 801–814, 2015, http://dx.doi.org/10.1002/bbb.1576.

In response to the energy crisis, global warming and climate change, microalgae have received a lot of attention as a promising feedstock for the production of biofuels. However, microalgal biofuels are still unaffordable due to low productivity and their substantial requirements in capital investment and operation costs. Much original research regarding the various microalgal cultivation strategies has been reported, in an attempt to promote microalgal biofuel production. However, current literature indicates the fragmented nature of information available regarding the strategies for the improvement of microalgal production for biofuel conversion. From a systematic perspective, this review highlights the main microalgal cultivation strategies for the achievement of improved biomass and biofuel productivity. It first discloses the current state of microalgal production as a biofuel feedstock, giving general introduction to the topic. Subsequently, it summarizes the current microalgae cultivation technology. Microalgal cultivation strategies are then discussed systematically, including integration with wastewater treatment and CO2 mitigation, batch vs. semi-continuous vs. continuous culture, two-stage continuous cultivation, co-culture, stress culture, and microalgal cultivation with harvest water recycling.

Synthetic Biology

Metabolic engineering of eukaryotic microalgae: potential and challenges come with great diversity

Gimpel, J.A., et al., Front. Microbiol. 6: 1376, 2015, http://dx.doi.org/10.3389/fmicb.2015.01376.

The great phylogenetic diversity of microalgae is corresponded by a wide arrange of interesting and useful metabolites. Nonetheless metabolic engineering in microalgae has been limited, since specific transformation tools must be developed for each species for either the nuclear or chloroplast genomes. Microalgae as production platforms for metabolites offer several advantages over plants and other microorganisms, like the ability of GMO containment and reduced costs in culture media, respectively. Currently, microalgae have proved particularly well suited for the commercial production of omega-3 fatty acids and carotenoids. Therefore most metabolic engineering strategies have been developed for these metabolites. Microalgal biofuels have also drawn great attention recently, resulting in efforts for improving the production of hydrogen and photosynthates, particularly triacylglycerides. Metabolic pathways of microalgae have also been manipulated in order to improve photosynthetic growth under specific conditions and for achieving trophic conversion. Although these pathways are not strictly related to secondary metabolites, the synthetic biology approaches could potentially be translated to this field and will also be discussed.

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AOCS MEMBER NEWS

Seven make list of 100 most influential analytical scientists

Seven AOCS members were among the top 100 most influential people in the world of analytical science to make The Analytical Scientist Power List 2015. Six were contributors to the AOCS Press book, *Extreme Chromatography: Faster, Hotter, Smaller,* edited by William Craig Byrdwell and Michal Holčapek and published in 2011 [ISBN 978-189399766-0].

The seven AOCS members on the list are:

Paola Duga, professor of food chemistry at the University of Messina, Italy, who coauthored the chapter, "Recent Advances in Comprehensive Two-dimensional Liquid Chromatography for the Analysis of Natural Products."

Salvatore Fanali, head of the Capillary Electromigration and Chromatographic Methods Unit at the Institute of Chemical Methodologies, National Research Council (CNR) in Monterotondo, Italy, who coauthored the chapter, "Nano-liquid Chromatographic Separations."

Davy Guillarme, senior lecturer at the School of Pharmaceutical Sciences, University of Geneva, Switzerland, who coauthored the chapter, "The Theory and Practice of UHPLC and UHPLC-MS."

Pavel Jandera, a professor in the Department of Analytical Chemistry, Faculty of Chemical Technology at the University of Pardubice, Czechoslovakia, who wrote the chapter, "Hydrophilic Interaction Chromatography—an Excellent Method for Separation of Polar Samples."

Luigi Mondello, a full professor of analytical chemistry in the Department of Chemistry Science, Biological Science, Pharmaceutical Science, and Environmental Science at the University of Messina, Italy, who coauthored the chapter, "Recent Advances in Comprehensive Two-dimensional Liquid Chromatography for the Analysis of Natural Products.

Jeanne Pemberton, Regents Professor, Chemistry, The University of Arizona, Tucson, Arizona, USA.

Nobuo Tanaka, professor emeritus at the Kyoto Institute of Technology, Japan, who coauthored the chapter, "High-efficiency Liquid Chromatography Separations Achieved by Monolithic Silica Columns."

Michaal Holčapek, who coedited the AOCS book, and another of its contributors (John Yates III) also made the list.

Tips from inform|connect

Tips from inform|connect is a regular Inform *column that features tips and other discussion highlights from the community forum board at http://www.informconnect.org/home.*

Q: When a professional at a company that makes palm-based functional lipids added linoleic acid and an antioxidant mixture of 102 ppm of BHA and 198 ppm of BHT to a fresh fatty acid C16 that had previously demonstrated a 98% oxidation stability at 100˚C after 22 hours, the stability dropped, resulting in a peroxide value of 1. He asked if anyone could explain what happened and/or suggest how he could prevent oxidation and keep the peroxide value under 1.

A: One member noted that the higher energy double-bonded carbons in unsaturated fats are less stable and react with oxygen. This, he explained, "yields free fatty acids and various volatile compounds which are absorbed by the deionized water of your instrument, then dectected as a rise in conductivity."

Another member of the community explained that unprotected linoleic acid is easily oxidized by O2 in air and that the oxidation of the linoleic acid accelerates rapidly once peroxides are formed. He suspected that the addition of linoleic acid might be what catalyzed the oxidation.

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EDIBLE OIL CONSUMPTION TRENDS, RETAIL SALES AND HEALTH CONCERNS

Table 7 shows a steady upward trend in the annual per capita consumption of edible oils. The 2014 per capita consumption of edible oils was 23.2 kg. Although Chinese oil consumption has grown rapidly in recent years, there is still significant room for growth before it matches the per capita consumption levels in Taiwan or Hong Kong, where cooking and eating habits are similar.

TABLE 7. Annual per capita consumption (Kg) in 2005–2014

2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
14.5	17.5	19.3	20.7	20.6	21.4	22.5	21.4	22.5	23.2

Source: China National Grain and Oils Information Center

According to Euromonitor, rapeseed, soybean, peanut, and corn oils made up 63% of the total Chinese retail sales, while sunflower, sesame, and other types of oil represent 8%. Blended oils are considered to be more healthful, as they offer the combined benefits of individual oils. Increasing levels of consumer awareness regarding the health benefits of cooking oil will continue to arouse interest in cooking oil products with health functions. The total retail sales value of such oils almost doubled from 2006 to 2011, which indicates that there is a huge potential for small-package oils. Minor oils with perceived health benefits have attracted much attention, leading to rapid growth in consumption.

Changes in dietary habits and perceptions about which foods are healthful are fueled by continued migration from rural areas in China to the cities. The increasing number of urban people has been exerting significant purchasing power. More consumers would like to move away from traditional and inexpensive bulk-food-grade oils and trade up to higher quality, small-packaged oils. Government policy is also influencing consuming patterns. In 2011, large cities such Beijing and Shanghai banned the retail sale of edible oils in bulk. This policy has led to increasing sales of packaged oils and fats. Meanwhile, changing eating habits of consumers, a demand for high quality fats and oils, and rising per-capita incomes are driving forces that are fundamentally reshaping the overall fats and oils market in China.

Tiankui Yang joined Wilmar International as director of Global R&D Center in October 2009. Yang has extensive research and development experience in edible oils, oilseeds, cereals, foods, and biofuels. From 2008–2009, he was a professor at Dalian University of Technology, where he taught and conducted research in biotechnology and biofuels. From 2004–2007, he headed the technology of Dalian Huanong Group as its chief technology officer. Yang earned his PhD in food science from China Agricultural University (associated with Technical University of Denmark), and his Bachelor of Science (oils & fats) and Master of Science (oils & fats and vegetable proteins) degrees from Henan University of Technology. He can be contacted at yangtiankui@cn.wilmar-intl.com.

Yan Zheng is a research scientist at Wilmar Global R&D center. Zheng received her master's degree in food technology from Harbin Commercial University, China, and her Ph.D. degree in biocatalyst and biotransformation from the Donghua University, China. Her areas of research include non-water phase enzyme technology, industrial bio-catalysis, food/lipid ingredients functionality, and biofuel technology, including phospholipids processing with enzyme technology. She can be contacted at zhengyan1@cn.wilmar-intl.com.

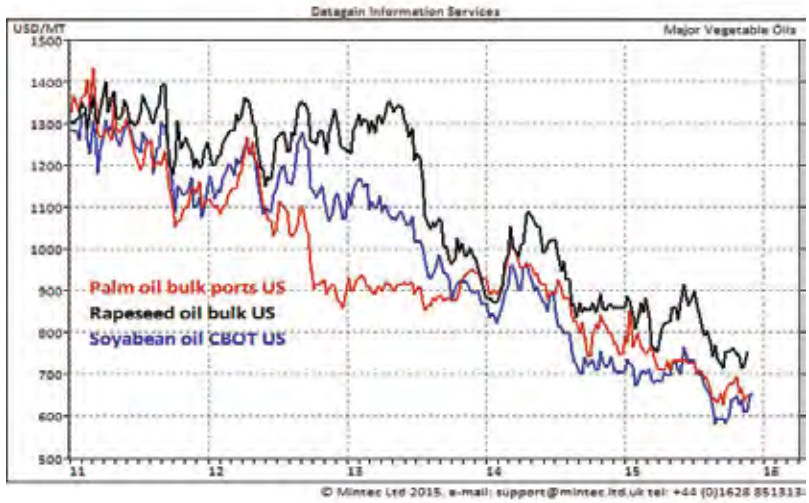
STATISTICAL ANALYSIS FROM MINTEC

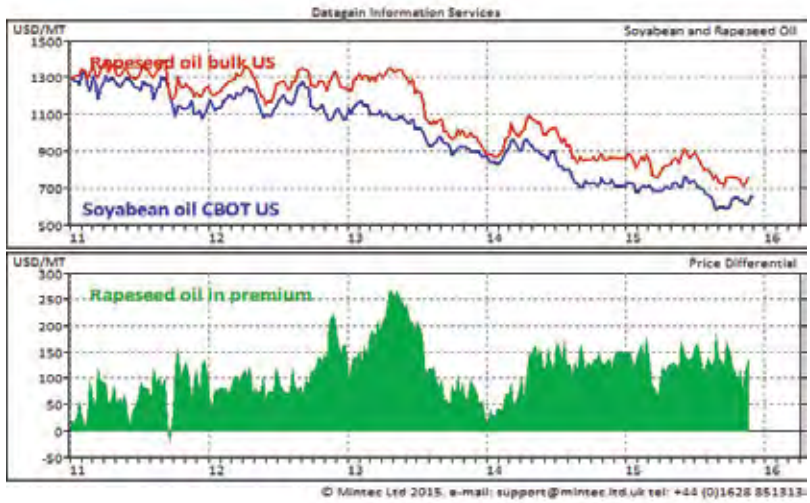
Loraine Hudson

Concerns over the lack of wet weather in Malaysia and Indonesia, due to El Niño weather conditions, drove major oil prices upwards toward the end of 2015. Droughts in South East Asia resulted in a reduction of the forecasts for oil palm production by 18,000 metric tons (MT) and crush by 20,000 MT.

Global palm oil production is forecast at 65.1 million MT (MMT) in 2015/16, up 6% year-on-year; however consumption is forecast to rise by 8% year-on-year to 63.7 MMT. Whilst ending stocks are forecast to remain stable, the stocks-to-use ratio is forecast to fall by 2% year-on-year to 13%, the lowest level since 2013/14 and below the 5-year average of 14%. This means that although production is rising, supplies are expected to be tighter in 2015/16, resulting in higher prices which have been assisted by weakness of the Malaysian Ringgit against the US Dollar.

The price rises in palm oil drove prices of rapeseed and soyabean oils upwards while demand increased, spurred by the Argentinean election on 12th November. The incoming Argentine president announced that export taxes for grains and oilseeds would be reduced to encourage higher exports increasing the possibility of higher supply to the global market.





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Mexico enacts mandatory **GHS standard**

Regulatory Review is a regular column featuring updates on regulatory matters concerning oils- and fats-related industries.

Charlotte Niemiec

The Mexican government has enacted a mandatory standard applying the United Nations (UN) Globally Harmonized System (GHS) for classification and labelling of chemicals in the country's workplace.

The standard's publication in the country's *Official Gazette*, marks the beginning of a three-year transitional period before the law enters into force in 2018.

This will create the first mandatory GHS scheme in Mexico, a change from the current voluntary system.

During the transitional period employers will have to comply with the two existing national standards for the identification and communication of hazards and risks of hazardous chemicals in the workplace. They are codified in the Mexican system as NOM-018-STPS-2000 and NOM-018-STPS-2014. Both will be repealed in 2018.

As with many other GHS activities around the globe, Mexico drafted the standard in an effort to harmonize national requirements with international regimes.

In 2011 the government gave industry permission to voluntarily use a GHS standard, NMX-R-019-SCFI-2011. This alternative to its national system followed a request from the National Association for the Chemical Industry in Mexico (ANIQ).

The new standard is similar to NMX-R-019-SCFI-2011, and adopts the fifth revision of GHS.

It includes a uniform hazard communication for chemical products, labelling requirements and SDS, as well as five annexes:

- Annex A: summary tables of classification and labelling;
- Annex B: labelling symbols, pictograms and warning phrases;
- Annex C: hazard codes;
- Annex D: precautionary statement codes; and
- Annex E: guide for the elaboration of SDSs with a 16-Section format.

The law will apply to all places of work where hazardous chemicals are handled, and exclude pharmaceuticals, food additives, cosmetics articles, pesticide residues in food, and hazardous waste.

The Ministry of Labor and Social Welfare said it made some small amendments to the text following a public consultation, last year. This was to clarify some details.

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