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AOCS

International News on Fats, Oils, and Related Materials

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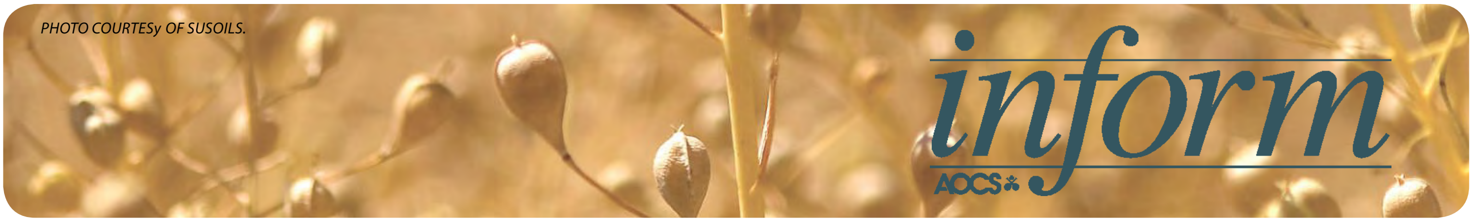

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AOCS Mission Statement
To be a global forum to promote the exchange of ideas, information, and experience, to enhance personal excellence, and to provide high standards of quality among those with a professional interest in the science and technology of fats, oils, surfactants, and related materials.

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Letter from the president

As we come to the end of 2011, it is time to look back and assess what we've accomplished. While the world economy continues to sputter, AOCS continues to see incredible opportunities to provide value to our constituents through our organization.

Our Annual Meeting & Expo in Cincinnati, Ohio, USA, was very successful, as showcased in the July issue of *inform*. The meeting drew more than 1,600 registrants from 45 countries. A common misconception among professionals who *do not* typically attend the meeting is that it focuses only on research and is "too technical" to benefit individuals who manage the businesses we serve.

The registration list from Cincinnati told a different story. Many chief executive officers (CEOs), vice presidents, and senior vice presidents of multinational corporations, in marketing and research and development (R & D), as well as business owners and marketing professionals were in attendance. Past President Keith Grime took the opportunity to stage networking events targeted at the business attendees, and next year's meeting in Long Beach, California, USA, will focus whole segments of the program to the interests of those who manage the business of product development, R&D, and global trade.

At the AOCS processing conference held in İzmir, Turkey, in June, another type of networking event was built around representatives of allied associations. CEOs of scientific societies from Iran, Turkey, Germany, the United States, and Malaysia met to introduce themselves and their organizations. It is perhaps not well known that AOCS liaises with over 600 such organizations worldwide and has done so for many, many years. It is a unique and valuable networking asset that is inherent in the AOCS organization.

In the year to come the internal AOCS organization will be restructured to interact with those organizations on a more deliberate basis, by developing a network through the web that will allow all the societies to interact together through AOCS, truly creating a global community of professionals in the fields AOCS serves.

That same technology will provide access to AOCS archives, from books to magazines to meetings. It will include The AOCS Lipid Library as well as newly generated information from dialog among experts. A deliberate effort to continually populate the site with valuable content will be staffed and funded, to make the site maximally beneficial to members and users.

Dumelin

Finally, the AOCS Governing Board voted to reduce its size from 17 to 12 and to restructure its mode of operation. This action represents the culmination of the changes set in motion in 2005, when the Society faced a bleak financial statement. Many changes were made, and the very last is to change the structure of governance to allow each director of the Society to have a "hands-on" impact on the organization and how it is run.

I am happy to report at the end of this busy and productive year that AOCS continues to work toward its mission of serving you in a fiscally responsible manner, while constantly improving what the Society has to offer.

Best wishes to my AOCS colleagues as we near the holiday season. I look forward to an exciting 2012 as we begin to see the fruits of the initiatives we've begun in 2011.

Erich E. Dumelin
AOCS President 2011–2012

Corrections

The September issue of *inform* listed one of the companies in the roster of 2011–2012 AOCS Approved Chemists incorrectly. The correct name is POS Bio-Sciences.

■■■

The sidebar titled "About Isoflavones" on page 543 of the October issue of *inform* incorrectly attributes a quote from work led by Kenneth D.R. Setchell to an article in the *Journal of the American Medical Association*. The quote, in the fourth paragraph, instead is from the *Journal of the American College of Nutrition*. We regret the error.

■■■

Pete Cartwright (N J Feed Lab Inc., Trenton, New Jersey, USA) won first place in the AOCS Laboratory Proficiency Program/marine oil fatty acid profile category. We regret that his name was not in the October issue listing.

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Letter from our departing executive vice president

Greetings, Dear Friends,

As this will be the last "Letter from the Executive Vice President" I will write, please bear with me while I reminisce for just a little while.

I came to AOCS in 1988 from a professional group based in the Chicago area, which was my home. I had an initial interview with Jim Lyon in Champaign. Two things I remember about that trip to Champaign: The muffler fell off my old car in the AOCS parking lot, and I really, really wanted to find a place to get ice cream! Some things don't change, I guess!

I had an interview with the Education Committee at the Hilton Chicago O'Hare Airport hotel. I remember Ed Perkins (who wouldn't!) being there. My first AOCS official work duty was to attend the Strategic Planning session in St. Louis. I arrived late in the evening from Chicago, since I was still working at my other job. There sat Ed Perkins in the hotel lobby, waiting to see that I'd arrived safely. I was somewhat surprised at his concern since Ed had come off somewhat "gruff," shall I say, during the interview process. It was pretty easy to see that he was only crusty on the outside. . . .

I was hired for the newly created position of AOCS Education Director. Jim Lyon and the Board at the time had hired a University of Illinois professor as a consultant to study what AOCS needed to deal with the expanding international meetings. The consultant's recommendation had been to create a new position. That same consultant, Dr. Charles Kozoll, ended up as my advisor at the University of Illinois through the long years during which I pursued my doctorate, and he stuck with me until the end even though he'd retired by then!

My job was to work with members to plan programs for AOCS meetings as well as to manage the logistics staff. As such, I was on the road a lot. I planned and attended meetings in China, Malaysia, Japan, Indonesia, Holland, Germany, Australia, New Zealand, India, and many other countries as well. I found that there were wonderful people in all of those places who held AOCS in the highest esteem.

At home, my friends and relatives would ask me if I went sightseeing in the great places I traveled. I would explain that I couldn't really extend my stays to do that because I had family, work, and school responsibilities. But then I would add that while a tourist may go to another country to see sights, I went to other countries to see people. The sights will always be there, but the people were and are unique!


Wills Hinton

As the years went by, I did end up seeing a lot, much of it at a pretty fast pace. In Turkey I saw Hagia Sophia and the Blue Mosque at a run in order to fit them into a meeting break. I did the same in Beijing at the Forbidden City. In neither case did I speak the same language as the driver, which taught me something about life: Language is not a barrier to understanding—lack of willingness to communicate is a barrier to understanding.

I'm proud of what I've been part of at AOCS, and I'm also grateful for the time I've had with all of you. I have to say that I've worked with a parade of the most wonderful people on earth (and I never exaggerate) in the role of AOCS president , and I feel the need to name them, just to prove my point: Michael Cox, Tom Foglia, Mark Matlock, Larry Johnson, Mike Haas, Howard Knapp, Phil Bollheimer, Cas Akoh, Ian Purtle, Keith Grime, and Erich Dumelin. Wonderful, smart people.

And then there is the AOCS staff. Those people are smart, hard-working, and dedicated to AOCS. My special thanks are due to Jeff Newman and Gloria Cook, who were right in there dragging this place back from the brink. They, along with the Budget Committee (The Fun Committee) and Board in 2005, two of whom, Dick Farmer and George Liepa, are deceased, put into place the structure that has left us in excellent operating condition through these tough economic times.

I leave AOCS with the assurance that finances are in order and the staff is strong and ready to grow in number and initiatives on your behalf. The Foundation, thanks to Mike Boyer and Amy Lydic, is funding R&D, and, as always, they would be grateful for your support.

Really, what a great experience it has all been. Thanks for the opportunity. I am truly grateful.

Jean Wills Hinton
AOCS EVP 2002–2011

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AOCS
2710 South Boulder Drive
P.O. Box 17190
Urbana, IL 61803-7190 USA
Phone: +1 217-359-2344
Fax: +1 217-351-8091
Email: publications@aocs.org

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Versatile CAMELINA

The future of biofuel and much more

Eric J. Murphy

Eric J. Murphy is a tenured associate professor in the Department of Pharmacology, Physiology, and Therapeutics at the University of North Dakota, USA, and chief scientific officer and executive vice president for research and development at Agragen, LLC, a Cincinnati, USA-based biotechnology company, and its fully owned subsidiary, Unicrop Oy, a Helsinki, Finland-based biotechnology company—both of which use Camelina sativa *as a platform. He has published more than 80 peer-reviewed papers and co-edited the book* Lipid-Mediated Signal Transduction *with Thad Rosenberger. Murphy has served as editor-in-chief of* Lipids *since 2006 and as an associate editor with the* Journal of Neurochemistry *since 2004. He can be contacted at eric.murphy@med.und.edu.*

Camelina is the future of fuel. This is a bold statement, yet with its increasing demand as a here-and-now source of biofuel feedstock, this statement is more firmly based in reality now than ever before. Camelina-derived vegetable oil is a key emerging biofuel feedstock for next-generation biofuels and for traditional renewable biodiesel markets. The estimated demand for fuel for the aviation sector in the United States alone is 17 billion gallons (64 billion liters) per year, while the worldwide renewable diesel market (biodiesel and traditional diesel derived from vegetable oils) is more than 2 billion gallons per year. To meet these demands, it is critical to have a vegetable oil that can be produced economically on a large scale without any government subsidy. Camelina-derived oil meets this litmus test.

The increased demand for camelina oil as a feedstock for biofuels is in many ways largely based on the food or fuel debate. Unlike traditional food crops that have crossed over to fuel production, such as corn, soybeans, and canola, camelina is not a food crop in the United States. In addition, its ability to produce high yields while growing on marginal lands with minimal chemical inputs means that it will not displace food crops from fertile land. An added bonus is that the resulting high-protein, high-energy meal can be used in livestock rations, thereby reducing the need for traditional food crops in these rations. In short, camelina is a sustainable crop for biofuels production.

Camelina: What is it?

Camelina sativa is a member of the family Brassicaceae, which includes mustards, rape, cabbage, kale, brussels sprouts, and cauliflower. Similar to these plants, camelina contains glucosinolates, but these glucosinolates are unique to camelina and, like all glucosinolates, offer a natural protection against consumption by insects, thereby reducing insect pressure. It is a high-yield oilseed crop that produces seeds containing approximately 40% oil, yet its meal has a high protein content of nearly 38%. Thus, it is an excellent oil producer for biofuels and provides a residual high-protein meal for use in livestock rations.

Camelina has been cultivated for more than 3,000 years in Europe, and the Romans used its oil as a lamp oil and its meal for livestock feed. The bulk of modern camelina production has been limited to Eastern Europe and Finland, where the oil is niche-marketed as a healthful edible oil. Camelina is a robust seed producer with an oil profile that contains nearly 40% α-linolenic acid (ALA, 18:3n-3) and 20% linoleic acid (LNA, 18:2n-6). (See Table 1.)

Unlike flax oil, camelina oil is stable owing to a high level of natural antioxidants and contains a more balanced amount of n-3 and n-6 fatty acids. The oil also contains fatty acids of up to 24-carbon chain length that

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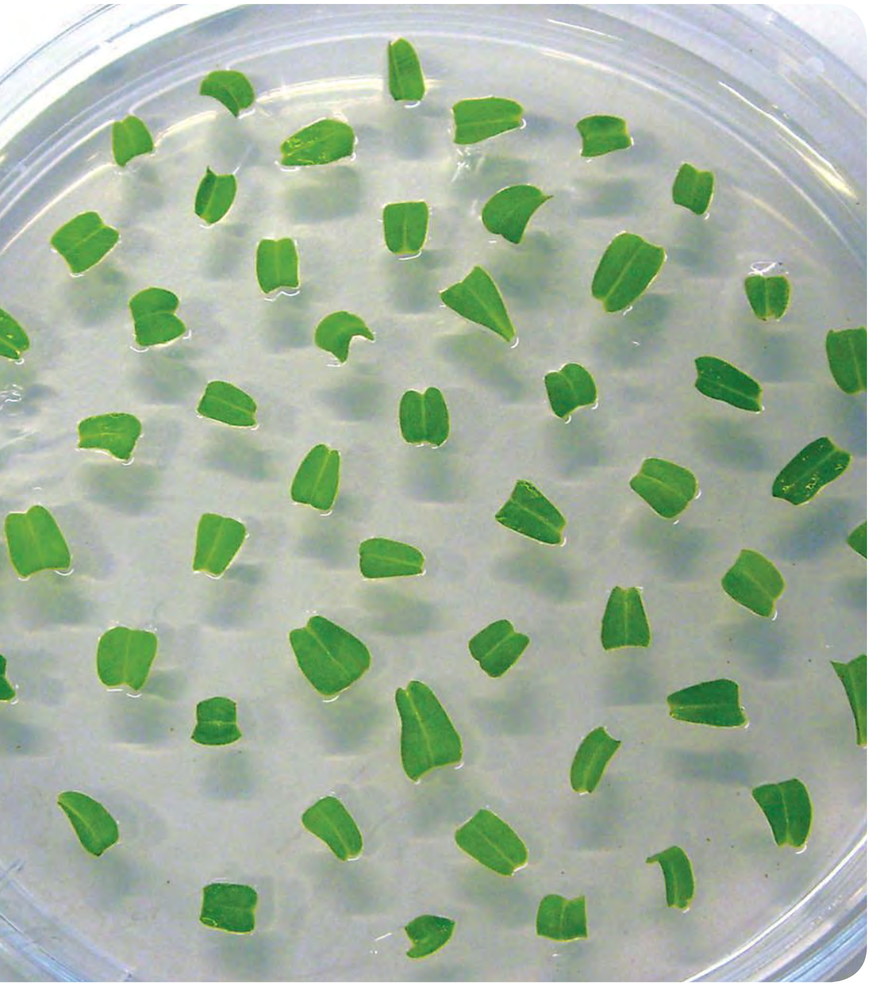

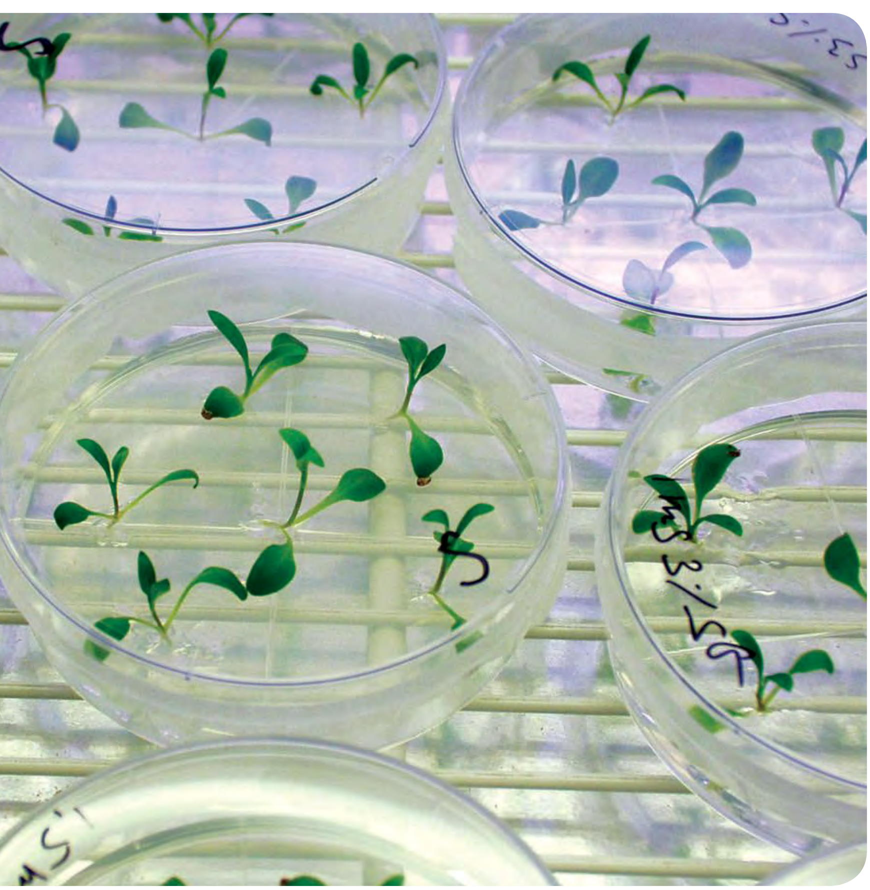

Transgenic camelina is produced by transforming leaflet explants (upper left) into sprouts, which are grown in agar (lower left) and later transplanted to soil (above) for greenhouse growth. This allows many plants with a particular genetic modification to be produced from just a small amount of material. Photos courtesy of Unicrop/Agragen.

TABLE 1. Oil profile of field-grown and greenhouse-grown camelina[a]

Fatty acid	Greenhouse-grown		Field-grown
Lauric 12:0	BLD	BLD	BLD
Myristic 14:0	0.1	0.1	BLD
Palmitic 16:0	6.5	6.6	5.3
Stearic 18:0	3.1	3.0	3.0
Oleic 18:1n-9	17.9	19.2	18.7
Linoleic 18:2n-6	17.4	17.4	16.0
Linolenic 18:3n-3	27.8	25.6	38.1
Arachidic 20:0	2.2	2.1	1.4
Eicosenoic 20:1n-9	14.6	16.4	11.6
Eicosadienoic 20:2n-6	1.8	1.9	1.8
Eicosatrienoic 20:3n-3	1.5	1.3	1.3
Behenic 22:0	0.5	0.4	<1
Erucic 22:1n-9	3.6	3.7	2.5
Lignoseric 24:0	0.2	0.1	<1
Nervonic 24:1n-9	2.9	1.4	<1
Camelina parent line	Blaine Creek	GP68	Celina

[a]BLD, below limit of detection; <1% indicates trace fatty acids; all values represent mole%. Note: Other field-grown camelina varieties have 18:3n-3 content in the range of 34–41%.

are derived from elongation of mainly 18:1n-9, but also of 18:2n-6 and 18:3n-3, indicating a relatively robust level of elongase activity.

More than fuel: camelina meal in livestock rations

Production of large quantities of oil for biofuels results in a substantial amount of meal as a by-product. Camelina meal is an excellent source of protein and energy owing to the residual fatty acid content. Meal produced by Great Plains Oil and Exploration (GPOE; Cincinnati, Ohio, USA), has a residual oil content of about 8% (by wt), and this oil is also rich in n-3 fatty acids. (Great Plains Oil and Exploration is a sister company to Agragen LLC, a Cincinnati-based biotechnology company for which I am chief scientific officer and executive vice president for research and development.) In laying hens, this level of residual n-3 fatty acids increases the egg n-3 fatty acid content, including heart-healthy eicosapentaenoic acid (EPA, 20:5n-3) and docosahexaenoic acid (DHA, 22:6n-3). GPOE's proprietary production process produces a meal in which myrosinase, the enzyme that breaks down glucosinolates to isothiocynates and other antinutritive compounds, is inactivated, thus limiting the level of these antinutritive compounds in the meal. The net result is a more healthful meal for livestock, which was demonstrated in laying hens in which a ration containing 20% camelina meal had no adverse impact on hen health as determined by weight gain or egg-laying days.

However, to be consistent with an inclusion rate of not more than 10% camelina meal in rations for broiler chickens and cattle set by regulatory agencies, we requested from the US Food and Drug Administration (FDA) the same inclusion rate for camelina meal in laying hen diets and received from the FDA a letter of no objection for laying hen rations to contain up to 10% camelina meal. The ultimate large-scale production of camelina for biofuels provides a high-quality meal as a by-product that will provide options for livestock producers to reduce the amount of other grains also used for human consumption in livestock diets, such as barley or corn in cattle or soy meal in poultry.

Lessons from camelina: trials and tribulations of introducing a new crop

While Agragen, LLC and Unicrop, Oy (Helsinki, Finland) have more than 14 years of experience in using biotechnology approaches to introduce agronomic improvements to camelina via our patented technology platform, GPOE has worked diligently to introduce a new crop to US and Canadian farmers, while also expanding operations around the globe. Growing more than 100,000 acres (40,000 hectares) of camelina in 12 states in the United States and four Canadian provinces, GPOE has been at the forefront of introducing camelina for large-scale agriculture. As the world's largest producer of camelina seed stock and producer of camelina-derived oil and meal, GPOE has experienced the pitfalls of introducing a crop that has had minimal development of best farming practices. It is estimated that in the United States alone, there are 20 million acres of marginal land that could be used to grow camelina. Because of its 90-day growth cycle from emergence to harvest, camelina offers farmers who grow cotton and soybeans a double-crop

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In the greenhouse, transgenic camelina goes on to flower (left) and produce seed pods (above) of its own. Photos courtesy of Unicrop/Agragen.

option in certain regions of the country such as Texas, Oklahoma, and Arkansas. This dramatically increases the number of available acres for camelina in the United States alone.

Camelina grows well on marginal lands and requires minimal inputs in terms of fertilizer or herbicide applications. Combined with no need for spraying and single-pass harvesting, the planting and harvesting of camelina requires minimal field work, resulting in a low carbon footprint for its growth. Because it grows well in areas with 6–8 inches (15–20 cm) of precipitation and on marginal lands, camelina can be grown in regions with poorer soils not suitable for corn or soybeans.

In areas such as the Pacific Northwest (PNW) of the United States, where cropping options are limited, camelina offers a good option for farmers as a rotational crop. It is an excellent rotation option for dry-land wheat operations. When used as a rotational crop with wheat, the yield of the wheat crop following camelina increases up to 15%. However, GPOE has experienced crop failures in this region due to residual amounts of class-2 herbicides in the soil. This indicates that camelina is highly susceptible to class-2 herbicides, which are heavily used in wheat operations in this region. This presents a unique problem for camelina in the PNW, one which Agragen worked to solve using a biotechnology approach.

Biotechnology and camelina: lessons learned

When initially presented with the puzzling problem of PNW crop failure, we immediately speculated that this failure was due to residual class-2 herbicides in the soil. This was a problem that scientists at Agragen and Unicrop solved using biotechnology to engineer specific mutations in the gene encoding the enzyme acetolactate synthase (ALS). ALS is the first committed step for branched-chain amino acid biosynthesis and the target enzyme inhibited by class-2 herbicides. By combining specific amino acid changes in the active site, we achieved a herbicide-dependent increase in tolerance between 1,000- and 10,000-fold in two different varieties of camelina.

We have also used a biotechnology approach to introduce specific changes in camelina fatty acid composition and in its oil content. Again, these strategies use multiple gene constructs and our patented high-throughput transformation protocol. We have produced a high lauric acid (12:0) camelina while preserving the ALA (18:3n-3) content. This is important for using the meal as a high-energy, residual n-3 fatty acid source for poultry applications. With an academic third party we have introduced specific genes in the triacylglycerol biosynthesis pathway and have entered into collaboration with another academic partner to enhance the oil content of camelina using a novel strategy.

Agragen's and Unicrop's strong intellectual property portfolio in terms of issued patents and in proprietary technology in camelina plant science offers a number of different partners the capacity to rapidly make agronomic changes in the plant using our nonselection transformation technology. This strategy is important for downstream commercialization efforts to produce a meal without any genes that impart antibiotic resistance. Our rapid, high-throughput transformation technology is highly effective with a very high level of transformation efficiency. This is important because common strategies for transformation of camelina are ineffective, although a number of laboratories and competitors have had success using a floral dip transformation strategy. In our hands this method has not been overly successful in meeting the needs of a commercial high-throughput operation, and its use for commercial applications may be limited by our recently awarded patents for our transformation method in the United States and the European Union. Nonetheless, the floral dip method does offer noncommercial entities interested in camelina options with regard to transformation.

Beyond biofuels: plant-made pharmaceuticals

Agragen, LLC was founded as a plant-made pharmaceutical company with the vision of producing biological pharmaceuticals at a much lower price than the traditional method of producing drugs in mammalian cells. After our acquisition of Unicrop, Oy, we shifted our emphasis to producing cytokine trap molecules for use in a variety of disease states. Why is camelina an ideal platform for producing these biological pharmaceuticals? Simply, camelina is for all essential purposes a self-pollinating plant and a nonfood crop. Hence, the possibility that pharmaceutical-producing camelina might cross with weeds or other plants is extremely limited, and its use as a crop only for biofuels limits the liability seen with other food crops such as corn or rice.

Agragen's lead compound, AGR131, is a cytokine trap designed to reduce the levels of tumor necrosis factor alpha in patients with inflammatory conditions, such as rheumatoid or psoriatic arthritis. It binds the target cytokine with an affinity equal to or greater than Enbrel, a well-known drug in this drug class. Using our patented protein expression system combined with our patented rubisco [ribulose-1,5-bisphosphate carboxylase/oxygenase] promoter technology, we have developed a very efficient sprouting expression system, putting our expression of proteins on par with yeast or slightly better than mammalian cells. Additional proprietary technology limits the addition of plant-derived sugars, overcoming a significant challenge that had limited the growth of the plant-made pharmaceutical industry. Because we harvest the seed and use our sprouting technology, we can efficiently recover the protein from the sprouts with yields approaching 85% and a purity of the final protein product exceeding 99%. Thus, although camelina is the future of fuel, it very well may be the future of biological pharmaceutical production, lowering the cost point of these drugs to enhance their affordability. Who knew that camelina would be so versatile? ■

CAMELINA

A designer biotech oilseed crop

Traditionally, vegetable oils have been used primarily for food purposes; however, an increasing amount is being used for transportation biofuels, including biodiesel and jet fuel, leading to growing competition between the two uses. Development of a nonfood oilseed crop as a renewable source of fuel that can grow well on nonprime agricultural land is necessary to alleviate our dependence on petroleum (Lu *et al.*, 2011).

Jillian E. Collins-Silva, Chaofu Lu, and Edgar B. Cahoon

Jillian Collins-Silva is a postdoctoral researcher in Edgar Cahoon's lab in the Department of Biochemistry at the University of Nebraska-Lincoln (USA). She can be contacted at jcollins5@unlnotes.unl.edu. Chaofu Lu is an assistant professor in the Department of Plant Sciences and Plant Pathology at Montana State University (Bozeman, USA). He can be contacted at clu@montana.edu. Edgar B. Cahoon is director of the Center for Plant Science Innovation and a professor in the Department of Biochemistry at the University of Nebraska-Lincoln. He can be contacted at ecahoon2@unlnotes.unl.edu.

Camelina sativa (sometimes called false flax or gold-of-pleasure) is an emerging Brassicaceae oilseed crop, grown in the northwestern regions of the United States and Canada, that historically has been cultivated in parts of Europe. The latest interest in developing this plant as a viable oilseed crop can be ascribed to a number of attributes, including its high oil and protein content, which allow the meal to be fed to livestock, and its ability to grow well on less productive land with less water and fertilizer inputs compared to other oilseed crops. Camelina can be considered a practical agronomic oilseed crop that could easily fit into currently used agricultural infrastructure and in rotation with other crops such as wheat. These unique attributes resulted in a large reduction of greenhouse gas emissions in a recent life cycle analysis study (Shonnard *et al.*, 2010). Moreover, camelina oil has been used successfully in a renewable jet fuel blend in test flights by a number of airlines and the US military.

Although the oil that naturally accumulates in camelina seed can be used in fuel blends, its oil composition is not ideal for any single purpose without alteration or additives (Table 1). Camelina oil is high in polyunsaturated fatty acids, rendering it prone to oxidation. As a result, modification of its oil is required for camelina to become a competitive, profitable oilseed crop. Fortunately, camelina can be genetically engineered through a simple method developed by Chaofu Lu's group at Montana State University (Bozeman, USA) using *Agrobacterium tumifaciens* (Lu and Kang, 2008). By down-regulating the camelina Δ12-oleate desaturase (*FAD2*) genes in seeds, the same group demonstrated that the engineered camelina oils contained increased amounts of oleic acid ($18{:}1^{\Delta 9}$) and decreased levels of linoleic ($18{:}2^{\Delta 9, 12}$) and α-linolenic ($18{:}3^{\Delta 9, 12, 15}$) acids (Kang *et al.*, 2011). Further increase of oleic acid was attained by Edgar Cahoon's group at the University of Nebraska (Lincoln, USA) through simultaneously down-regulating the *FAD2* and the fatty acid elongase (*FAE1*) genes. The increased oxidative stability of this high-oleic acid oil makes it well suited for biodiesel use compared to conventional camelina oil.

Genetic improvements such as these can be accomplished with relative ease and in a shorter time using camelina compared to more established oilseed crops such as soybean. The stable introduction of genes into the genome of a host plant is a process referred to as genetic transformation and is a key component of plant metabolic engineering. Camelina can be transformed by dipping the flower buds into a solution of *Agrobacterium* that harbors the desired gene(s), and the transformation efficiency can be greatly increased when this process is done in a vacuum chamber. This transformation method requires minimal training and no tissue culture expertise, and the first transgenic seeds can be harvested within six to eight weeks after *Agrobacterium* treatment. By comparison, soybean transformation requires dedicated, skilled technicians working mostly in tissue culture and takes eight to ten months for the first transgenic seeds to be harvested. Camelina also has a shorter life span than soybean, which

The relatively short growth cycle of camelina makes it an excellent model for translating laboratory results to the field. Photo originally published at http://www.brownenvelopeseeds.com/. Reprinted with permission.

allows for more rapid transgenerational evaluation of traits. The limited investment in time and resources needed to introduce trait genes make camelina an attractive metabolic engineering platform to achieve novel oil compositions.

Rapid and efficient metabolic engineering of camelina is further facilitated by the development of an extensive genetics toolbox, including vector systems for the delivery of multiple genes, a collection of antibiotic and herbicide resistance genes and fluorescent proteins for selection of transgenic plants, and a series of promoter elements that allow introduced genes to be expressed only in seeds. With this toolbox in place, it is now feasible to introduce large numbers of genes into camelina to reconstruct complicated biochemical pathways for higher value oils from plants with limited agronomic potential or even from organisms other than plants. Examples of this include ongoing research in the Center for Advanced Biofuel Systems (CABS), an Energy Frontiers Research Center supported by the US Department of Energy. CABS researchers are working to identify critical biosynthetic and metabolic genes for short- and medium-chain fatty acids from plants such as *Cuphea* species that naturally produce vegetable oils rich in C8 and C10 fatty acids (Dehesh, 2001). By transferring the correct combination of Cuphea genes into camelina for seed expression, it is anticipated that oils will be generated that mimic the hydrocarbon composition of jet fuel. Similarly, in the European Commission Framework Programme 7 ICON project, researchers are identifying genes from plants such as jojoba, maize, and *Arabidopsis* and from organisms, including *Euglena* and bumblebees, that can be transferred to camelina to produce wax ester-type

CONTINUED ON NEXT PAGE

TABLE 1. Fatty acid content of canola, soybean, and camelina[a] (% of oil)

Fatty acid	Canola	Soybean	Camelina
Palmitic (16:0)	4.6	10.5	6.8
Stearic (18:0)	2.1	4.1	2.7
Oleic (18:1)	64.3	22.5	18.6
Linoleic (18:2)	20.2	53.6	19.6
Linolenic (18:3)	7.6	7.7	32.6
Arachidic (20:0)	0.7	Trace	1.5
Eicosenoic (20:1)	Trace	Trace	12.4
Erucic (22:1)			2.3
Other fatty acids	0.5	1.6	3.5

[a]Adapted from Moser, B.R., and S.F. Vaughn, Evaluation of alkyl esters from *Camelina sativa* oil as biodiesel and as blend components in ultra low-sulfur diesel fuel, *Bioresource Technol. 101*:646–653 (2010).

oils for biobased lubricants. Undoubtedly, the list of novel industrial oils produced in camelina will grow and metabolic engineering targets will likely expand to include high-value protein and small-molecule co-products that enhance the overall value of camelina seeds.

Despite its promise as a metabolic engineering platform, a number of challenges lie ahead for the commercial realization of biotech camelina. Complementing genetic engineering efforts, researchers are working to improve agronomic traits such as yield, seed oil content, and herbicide resistance through marker-assisted breeding. Heretofore, little attention has been directed at germplasm improvement in camelina despite its long history as a crop. Given the large enhancements in yield and seed oil content that have been achieved through breeding in its close relatives rapeseed and canola, we believe that camelina's full genetic potential as an oilseed crop has yet to be tapped. In addition, more knowledge of the biochemical and genetic

information

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control of carbon flux in seeds and improvements in gene insertion technologies will facilitate more predictive metabolic engineering. Ultimately, markets and processing infrastructure will need to be in place for the commercial success of biotech camelina.

In addition to its economic potential, the ease of transformation and relatively short growth cycle of camelina make it an excellent model for translating laboratory results to the field. Though it is a hexaploid and lacks a published genome sequence, it is closely related to the widely used model plant *Arabidopsis thaliana*, from which large amounts of genetic information can be gleaned. As a crop species, it is ideally suited for extrapolating basic findings in Arabidopsis to the development of traits, such as drought tolerance and disease resistance, that impact agronomic performance. In this way, camelina can provide proof of principle under real field conditions for the plethora of discoveries that have been made in Arabidopsis but have remained untested outside of growth chambers and greenhouses.

Overall, we believe that camelina can become an important cash crop for the United States, especially with focus on its use as a metabolic engineering platform for biofuel and other industrial products. As a high-oil crop that is productive on land with modest rainfall and marginal fertility, camelina is a promising renewable resource to lessen our dependence on petroleum. ■

A new generation of renewable fuels is on the HORIZON

Wayne Seames

Wayne Seames is the Chester Fritz Distinguished Professor of Chemical Engineering and Director of the Sustainable Energy and Supporting Education (SUNRISE) program at the University of North Dakota, Grand Forks, USA, where he has served on the faculty since 2000. He is the lead inventor of a suite of technologies used to convert triacylglyceride oils into renewable fuels and chemicals. He can be contacted at wayne.seames@engr.und.edu.

A new generation of technologies to generate renewable fuels is nearing commercialization. Some of these are focused on producing ethanol and other alcohols from cellulosic biomass using fermentation technologies. These alcohol-based fuels can be used as a substitute for gasoline.

Another group of technologies is focused on producing fuels that replace kerosene and diesel fuels. These technologies take advantage of the chemical composition of crop oils, such as camelina, to generate organic chemical mixtures that are more similar to existing kerosene (jet fuel) and diesel products than current biofuels such as biodiesel. Crop oils contain a group of chemicals known as triacylglycerides (TG).

A TG molecule consists of three carbon chains ending in a carboxylic acid group, with each carbon chain (known as a fatty acid) connected to a glycerol backbone. Plants and animals naturally synthesize TG as a means to store energy, as do some algae and bacteria.

Two process schemes are nearing commercialization for the production of fuels to replace kerosene and diesel: hydrotreating and noncatalytic cracking. Both process schemes manipulate TG oils to generate renewable fuels and by-products.

Hydrotreating

As the name implies, hydrotreating involves the reaction of TG oils with hydrogen. The TG oil and hydrogen are fed into a reactor where a combination of heat, pressure, and time induce chemical reactions that will (i) remove the fatty acids from the glycerol backbone and (ii) replace the carboxylic acid group on the fatty acids with a hydrogen atom, producing hydrocarbons. A catalyst is typically used to increase the efficiency of the hydrotreating reactions. Some versions of the hydrotreating process also use a catalyst to induce some of the fatty acids/hydrocarbons to rearrange to introduce side chains onto the base carbon chain, a process known as isomerization. The catalyst formulation is also used to encourage any double bond-connected carbon pairs to transform into single bond-connected carbon pairs. After hydrotreating/isomerization, the reactor outlet mixture is separated into product fractions. In some versions, reactions to cleave some of the carbon bonds are performed during or interspersed with the purification steps to decrease the average carbon chain length of the fuel. This carbon bond cleavage process is known as cracking. Hydrotreating processes typically produce diesel, kerosene, propane, and syngas products.

Recently, a kerosene product known as synthetic paraffinic kerosene (SPK, a renewable kerosene product with limited aromatics content) was produced from camelina oil and used by the US Air Force and Navy in full-scale performance tests. The SPK was mixed 50:50 with petroleum-derived military specification-grade JP-8 jet fuel, then tested in current military aircraft. Based on the success of these tests, a number of commercial airlines have begun testing 50:50 SPK blended fuels in their aircraft (see *inform* 22:497–499, 2011).

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This Gulfstream G450 jet landed in Paris, France, in June 2011, after flying from New Jersey, USA, on a 50:50 blend of camelina oil-based and petroleum-based jet fuels. Courtesy of Honeywell Aerospace.

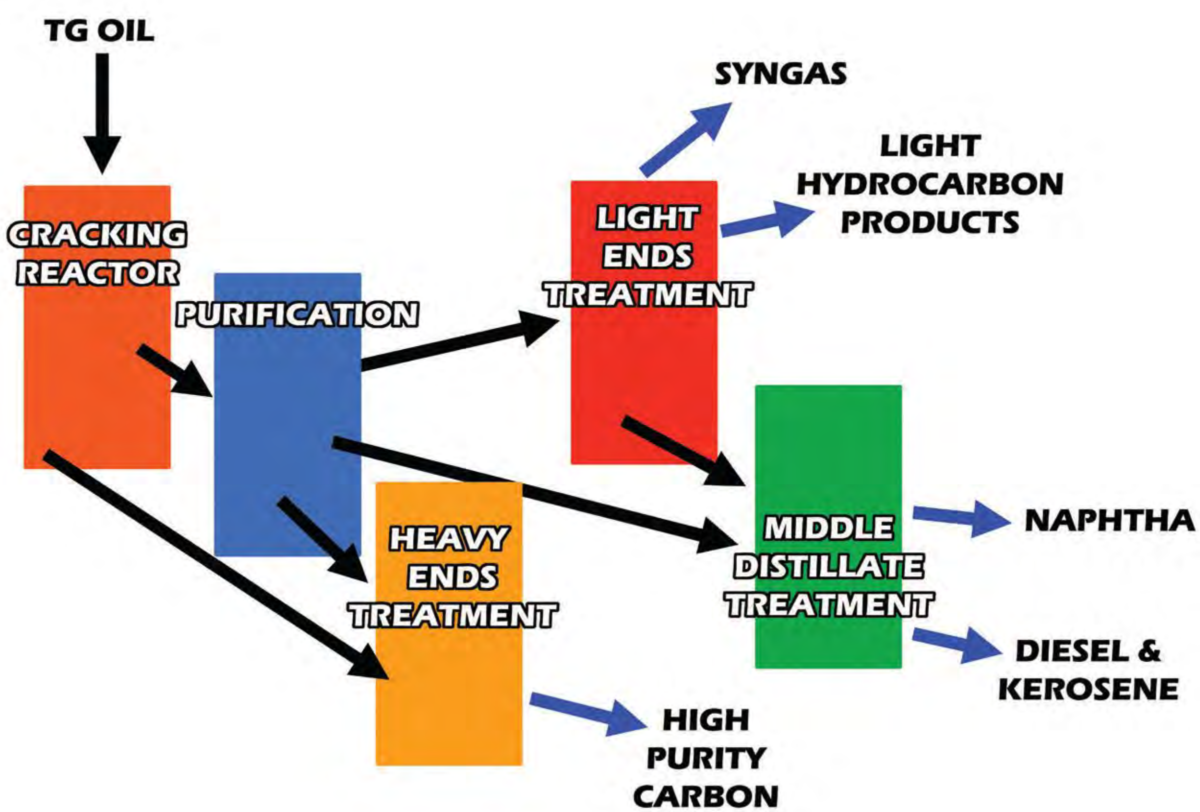

***FIG. 1.** The noncatalytic cracking process.*

Commercial production facilities based on hydrotreating process technology are likely to be in service within the next couple of years. These fuels will supplement existing petroleum sources without requiring substantial changes in the infrastructure supporting current fuel generation, storage, and supply systems.

ing or blending TG oil feedstocks in response to market conditions.

Third, the noncatalytic cracking process produces fuel products that contain aromatics in concentrations that are similar to those contained in petroleum jet and diesel fuel products. For example, a complete Jet A commercial

TWO PROCESS SCHEMES ARE NEARING COMMERCIALIZATION FOR THE PRODUCTION OF FUELS TO REPLACE KEROSENE AND DIESEL: HYDROTREATING AND NONCATALYTIC CRACKING.

Noncatalytic cracking

The other process that is nearing commercialization is the University of North Dakota's noncatalytic cracking process (patents pending). In this process (Fig. 1), TG oil is fed into a reactor where heat, pressure, and time are used to induce cracking reactions in the TG molecules.

This generates a complicated mixture—we've identified more than 250 separate chemical compounds in the reactor products—that is dominated by short-chain fatty acids, paraffins (hydrocarbons with all single-bond carbon-pair connections), and aromatics (compounds containing a six-carbon ring with three double-bond carbon-pair connections). The reactor product stream is then separated into intermediate product fractions and further processed into a final suite of fuels and by-products. The noncatalytic cracking process typically produces diesel, kerosene, naphtha, light hydrocarbon fuels, and syngas. Another by-product stream is a suite of very heavy, viscous compounds, typically labeled as "tars." These are long-carbon-chain chemicals that are formed when multiple fatty acid fragments, produced during cracking, combine. These tars can be recovered and converted into purified carbon products such as high-purity granulated carbon for spark plug rods and carbon nanotubes or into a mesophase pitch that can be spun into carbon fibers.

There are some advantages in noncatalytic cracking. First, an external hydrogen source is not required. The cracking process generates hydrogen as it produces aromatic compounds. This hydrogen can be recovered from the syngas and used to convert the carboxylic acid groups in fatty acids into hydrocarbons, where required.

Second, the first step in the process—cracking—does not use a catalyst. Because of this, the process can tolerate more impurities in the feedstock TG oil than processes that use a catalyst, such as hydrotreating processes. This is not a concern for edible crops, such as soybeans or corn, since these sources will likely treat their TG oils for human consumption. But this can substantially reduce the costs for extraction and treatment of nonedible crops such as camelina. This feature also means that noncatalytic cracking facilities will be feedstock flexible, capable of changing or blending TG oil feedstocks in response to market conditions.

jet fuel can be produced solely from this process. There is no requirement to mix this renewable jet fuel with petroleum jet fuel, as with SPK. Thus, these fuels can completely replace or be indiscriminately blended with existing petroleum fuels without impacting the infrastructure supporting the generation, storage, and transportation of existing fuels.

One of the challenges for renewable fuel producers is the low gross profit margins that can be realized in the fuels market. Petroleum refining is extremely efficient, and fuel sales prices can be sustained at levels that are challenging for renewable alternatives. The noncatalytic cracking process provides greater flexibility to generate higher margin by-products than many other processes. For example, instead of converting all of the short-chain fatty acids generated during cracking into hydrocarbons, they can be extracted from the cracking reactor product, purified, and sold as separate chemical products.

As with hydrotreating, commercial facilities are expected within the next few years. Both noncatalytic cracking and hydrotreating processes will initially use crop oils such as camelina as their feedstocks. Technologies to produce TG oils from other sources of TG oils, such as microbe- and algae-derived oils, are expected to evolve to allow high volumes of oil to be cost effectively produced. When this occurs, both noncatalytic cracking and hydrotreating pathways will be able to accommodate these feedstocks as well.

Other technologies

Researchers are pursuing a number of other strategies for the generation of renewable fuels. One pathway is often labeled the "thermochemical pathway." Biomass material is reacted under specific conditions of heat, pressure, and time to break down the TG oil through pyrolysis or gasification. These reaction processes are similar to cracking. The gasification versions generate a syngas that is then fed to catalytic reaction steps that induce the recombination of the syngas molecules into larger molecules to generate liquid transportation fuels. Another strategy is to use yeasts, microbes, or algae to directly synthesize hydrocarbons that can be purified into fuels. ■

Hydrogen peroxide in home-care formulations

Elena Petrovicova

Detergent formulations for fabric washing must remove a wide variety of stains and soils from different fabric types under a broad range of wash conditions. Principal components of detergent formulations such as surfactants, builders, and enzymes remove primarily oily, greasy, particulate, and proteinacious soils and stains. However efficient, modern detergents still cannot remove some stains effectively without the aid of bleaching systems. A bleaching system in the context of this article refers to materials that possess useful oxidative properties. Such materials can be included directly in a detergent formulation to remove bleachable stains such as those associated with tea, coffee, red wine, and various fruit and vegetable products. They can also be offered as laundry prewash and additives that have been formulated to boost the stain removal efficacy of detergents.

In recent years, manufacturers have offered a variety of products and regimens for more effective stain removal. Such regimentation of the laundering process, supported by innovation in laundry prewash and in-wash additives, has significantly boosted laundry detergent industry growth and fueled the need for the development of more effective but safe bleaching actives (Fig. 1).

Despite the large amount of research and data that has been generated over several decades and the numerous bleaching agents that have been identified and manufactured, only a few of these agents have made it into consumer household products or gained significant commercial importance. These are chlorine bleaches, primarily sodium hypochlorite, and peroxygen (oxygen-based) bleaches, including sodium perborate, sodium percarbonate, liquid hydrogen peroxide, and peracid precursors.

Chlorine bleaches

Liquid chlorine bleach, or sodium hypochlorite (NaOCl), was the only household bleach available in the mid-1950s. It has remained virtually unchanged over the years, with only minor improvements in quality that have resulted from better manufacturing techniques. NaOCl is still the most commonly and widely used bleach in the United States.

Aqueous solutions of NaOCl are strong bleaching agents and powerful disinfectants. Their low cost and high availability make them affordable in most regions of the world. However, despite their historical dominance and low cost, they have some distinct disadvantages:

- They damage colored, silk, and wool fabrics and are therefore limited to use in white laundry.
- They have a strong odor.
- Accidental spillage or misuse can cause irreparable damage to fabrics.

Bleaching with NaOCl is also the subject of much debate due to the potential generation of chlorinated by-products, which are deemed harmful to the environment and have negative effects on septic tanks. As a result, peroxygen bleaches are gaining traction not only in laundry but also in many other applications due to a combination of better environmental compatibility and better fabric or surface safety with fewer deleterious effects.

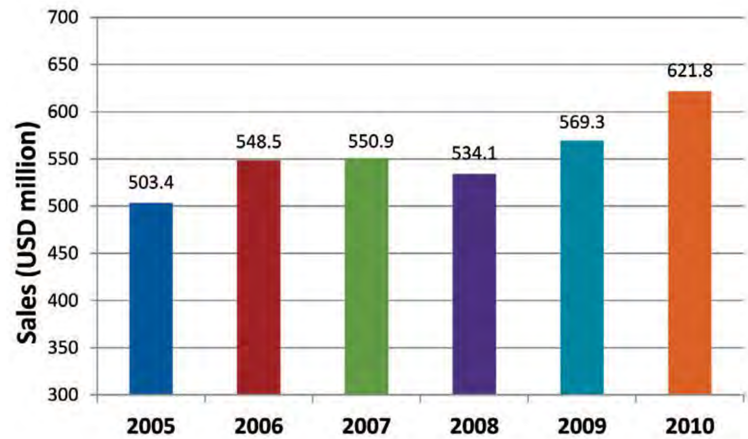

FIG. 1. *Sales of in-wash and pre-wash spot and stain removers in the United States between 2005–2010. Source: Euromonitor May 2011.*

Peroxygen bleaches

Hydrogen peroxide (HP), H_2O_2, is a common bleaching agent as well as the starting material for almost all other oxygen-based bleach systems. Its consumption in the United States is currently in the range of 2.2 million tons (2.0 million metric tons). H_2O_2 is a very weak acid; it is only slightly dissociated (pK_a = 11.6), and it is relatively stable in undissociated form.

Sodium perborate (SPB) has been the predominant source of hydrogen peroxide in powder laundry formulations. SPB was first produced at the turn of the last century and has been used in European powder detergent formulations since then. In North America, SPB appeared only in 1980s, with the advent of fast-dissolving SPB monohydrate.

Dissolved in an aqueous medium, sodium perborate, $NaBO_3 \cdot H_2O$ (also available as tri- and tetrahydrate), is hydrolyzed producing HP and sodium borate. It is considered, for the most part, stable and easy to handle and formulate into consumer products. However, it is not very effective below 160°F (71°C) at short US washing cycles lasting only 10–15 minutes. Despite many efforts to increase the activity of SPB to achieve its full performance potential at lower water temperatures, it remains only a fair stain remover under US washing conditions. It is more commonly used in Europe, where washing machines are manufactured with heating coils that can raise water temperature to the boiling point.

Until recently no aqueous liquid detergent formulation on the market contained HP. The situation changed in 1997, with the introduction of liquid bleach boosters containing liquid peroxide. Stabilization of peroxide in these aqueous products is achieved by an acidic pH, which is known to slow peroxide decomposition. In washing processes, the HP is activated by the alkalinity of the detergent. Some newer stabilizer packages make it possible to formulate weak alkaline HP solutions at concentrations up to 6%.

Sodium percarbonate (SPC) is another source for delivery of HP. Unlike SPB, it is not a true peroxygen compound, but rather a perhydrate ($Na_2CO_3 \cdot 1.5H_2O_2$). The integrity of the adduct is due to bonding between carbonate anions and HP molecules within the crystal. Its rather confusing name has arisen because of historical uncertainties over its structure. In solution, SPC dissociates into sodium carbonate and HP, which further decomposes to molecular oxygen and water, making it an environmentally desirable material. The bleaching performance of SPC is considered, on an equal available oxygen basis, to be similar to SPB.

Peracids are considered to be excellent peroxy-based bleaches, the most important being peroxyacetic acid. However, they have a poor compatibility in formulations and are not very stable in anything other than acidic pHs. Consequently, they require special handling during transportation and storage; thus, their main use is limited to commercial and industrial laundering and bleaching processes.

One possible future source of HP in detergent formulations could be the use of oxidase enzymes, such as glucose oxidase, which uses glucose substrate to generate HP. Patents have already been published using this approach to generate peroxide. The advantage could be the replacement of solid peroxide sources with a substance with greater long-term stability and perhaps more activity than current, alkaline-stable equivalents.

Stain removal and peroxygen bleaching mechanisms

Stains are discolorations caused by intensely colored substances, which even in small amounts can affect the color and appearance of a fabric. Colored stains are usually either vegetable in origin (typically anthocyanin, carotenoid, or porphyrin in structure) or caused by artificial food colorants and cosmetic ingredients. Very often, stains are complex mixtures of food preparations and beverages. The main tasks of bleaches are to remove colored stains from fabric or aqueous solution by decolorizing them either in solution or on the fiber. This is achieved by chemical degradation of the chromophoric units present in colored soils. In the course of reaction, conjugated double bonds, for example, are disrupted so that the color disappears. Large molecules are broken down and polar groups are introduced, so that the stain becomes more hydrophilic and easier to remove or disperse.

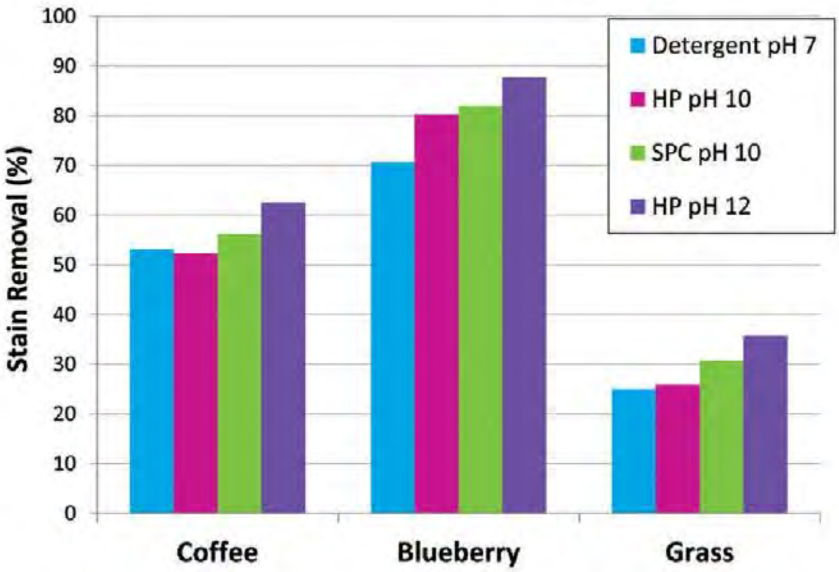

***FIG. 2.** The effect of washwater pH on stain removal with hydrogen peroxide and sodium percarbonate added along with nonenzymatic detergent.*

Oxidation with peroxygen bleaches involves three reactions:

i. Introduction and dissolution of the bleaching agent,
ii. Bleaching in solution of stains desorbed from the fibers, and
iii. Bleaching of stains located within the fibers.

Bleaching in solution has been shown to obey pseudo first-order kinetics. However, the kinetics and mechanisms for bleaching of stains residing in fibers are not sufficiently understood. Bleaching kinetics are complicated by the simultaneous existence of two processes: stain removal by nonoxidative detergency and oxidative destruction of stains.

HP-based bleaches have the advantage of being more fabric- and color-safe. They can also be used without seriously diminishing the effectiveness of enzyme products. The high oxidative potential of hypochlorites—the very property that makes them good bleaches—makes them nonselective and capable of oxidizing a broad spectrum of fabric dyes and fading them in the normal wash time.

In alkaline solution, HP dissociates:

$$H_2O_2 \rightarrow H^+ + HO_2^-$$

Although there is still debate, the generally accepted view today is that perhydroxyl anion, HO_2^-, a powerful nucleophile, is the most important active bleaching species. For most effective stain removal, pH values >10.5 and temperatures higher than 50°C are required. For use at lower temperatures, longer reaction times (soaking) or the addition of an activator can be employed to improve bleaching.

Activators are used to generate more active bleaching species by mixing acyl compounds with HP and generating peroxyacids. The acyl group, RCO^-, is capable of being perhydrolyzed by the perhydroxyl anion from a suitable precursor to form a peroxyacid, RCO_3H. Some of the few commercial activators are tetraacetyl ethylene diamine (TAED), nonanoyloxy benzenesulfonic acid sodium salt (NOBS), and lauroyloxy benzenesulfonic acid sodium salt (LOBS). The major barriers for activators into the commercial market are: (i) cost, (ii) the ability to control their bleaching potential due to the damage they might cause to the fabric, and (iii) toxicity, sensitization, and environmental impact.

Bleach catalysts, based on metal complexes, also show high potential as enhancers for peroxide bleaching. Their commercial future remains uncertain until the problem with fabric damage is solved. For further reading on some of these materials refer to the information provided on p. 622.

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Factors influencing peroxygen bleaching

In addition to temperature and concentration, other important factors have the potential to improve efficacy, such as pH, surfactant, and builder presence. Depending on the formulation, some bleaches might be used in a well-buffered system; that is, in conjunction with carbonates or silicates, or with surfactants, such as in a heavy-duty powder detergent or powder laundry additives. Builders help retain sufficient alkalinity and pH values greater than 9 in wash water and enhance bleach performance.

In a case of liquid peroxide formulation, a slightly acidic pH provides long-term physical and chemical stability of an HP-containing formulation. However, such pH typically does not provide the most optimal bleaching conditions. Detergent, if used in combination with an HP-containing product, will provide mild alkaline conditions, usually between pH 7 and 9, thus further improving the bleaching performance of HP. The efficient removal of some stains might require pH > 10 and might be achieved by using systems that provide a pH "shift" to a highly alkaline pH range during the bleach application.

Fig. 2 illustrates the effect of washwater pH on removal of some dried-in stains with HP and SPC added along with nonenzymatic detergent. Generally, stain removal increases with increasing pH, and the extent of this effect is stain dependent. That is because pH affects the degree of deprotonation of the stain and with that the degree of susceptibility of the stain to the bleaching agent. Adhesion of the stain molecules to the fabric, the degree of which is fabric dependent (cotton, synthetic, or blend), may change its conformation and its accessibility to attack. Stain removal also depends on the physical state and the location of stain. The bleaching of stain residing within fibers is much more difficult than bleaching in the solution. The bleaching rates are much slower because the bleaching mechanism likely involves diffusion-dependent steps: (i) the stain diffusion from fibers into the bath where it is bleached or (ii) the bleaching agent diffusion into the fibers and bleaching the stain within the fiber.

Taking into consideration fundamental properties and behavior, HP can be formulated effectively within liquid-based cleaning products. For the use in powdered products, SPC or SPB can be used as very stable and useful delivery vehicles for generating the HP bleaching moiety. HP-based bleaches are gentler to colors and fibers, are odorless, and have very low environmental impact. HP is a safe and convenient material that is finding widespread use in household cleaning products.

Elena Petrovicova is research manager at Church & Dwight Co. Her work there involves research and development on new fabric-care products, including detergents, pretreaters, and in-wash boosters. Before coming to Church & Dwight, she worked in a variety of research capacities at Unilever Research, Edgewater, New Jersey, and TRI in Princeton, New Jersey, USA. She can be contacted at Elena.Petrovicova@churchdwight.com.

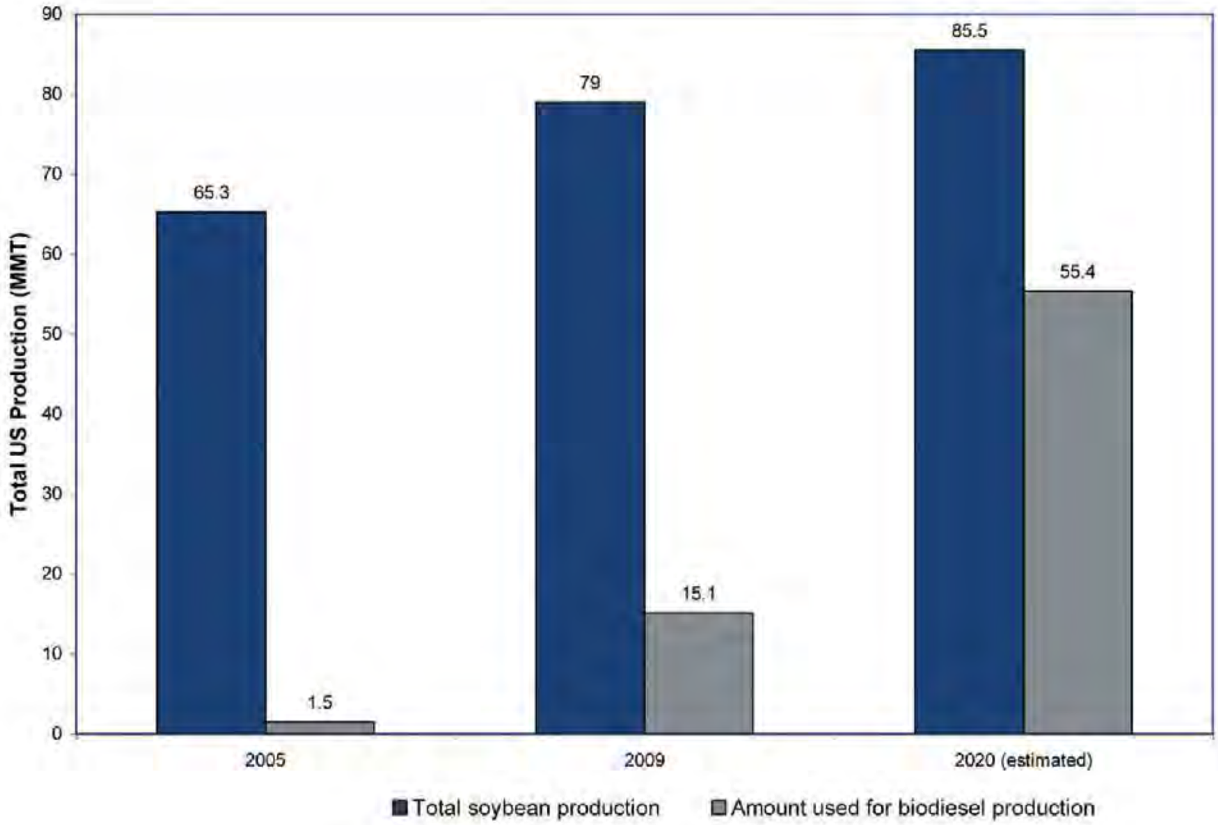

Fig. 1. *Total soybean production vs. that used for biodiesel. MMT, million metric tons. Courtesy of GBI.*

Biodiesel market in the Americas—challenges and opportunities

Mohinder Sawhney

At least 17 countries and 36 states in the United States have mandates for blending biofuels into vehicle fuels, and several new biofuels targets and plans are defining the future levels of biodiesel use. Driven by policy support as well as governmental mandates, the global market for biodiesel has entered a phase of rapid, transitional growth, leading to uncertainty as well as opportunity.

Global production of biodiesel increased from 826 million liters in 2001 to 17,800 million liters in 2010, at a compound annual growth rate (CAGR) of 40.6%. Supported by governmental efforts to increase energy independence and meet rising energy demands, the global biodiesel market is expected to produce 45,500 million liters of biodiesel in 2020, representing a compound CAGR of 9.9% during 2010 to 2020.

Europe is the leading biodiesel market, with a production share of 52.8% followed by the Americas with 33.9% and Asia Pacific with 3.5% in 2010. The European share in global biodiesel production has been declining since 2001 while the share of the Americas and Asia Pacific has increased. The top five biodiesel-producing countries, in descending order, are Germany, the United States, France, Argentina, and Brazil. These countries together constitute 65.9% of the world's total biodiesel production.

North America

The United States produced 11.9% of the world's biodiesel in 2010. The US biodiesel market is expected to reach 2,140 million liters in 2011 and 4,850 million liters in 2020 as various incentives and policy measures promote the production and use of biodiesel. The Renewable Fuel Standard (RFS2) plan mandates that 136,364 million liters of renewable fuel (mostly from corn and cellulose) will be used by

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TABLE 1. Soybean production in the United States[a]

Year	Total soybean production (MMT)	Amount used for biodiesel production (MMT)
2005	65.3	1.5
2009	79.0	15.1
2020 (estimated)	85.5	55.4

[a]MMT, million metric tons

2022. This has helped to increase the local demand for biofuels and will attract investments and create business opportunities on a global scale.

Soybeans (a first-generation biodiesel feedstock, as defined in the sidebar, p. 629) have been a very important source for the production of biodiesel in the United States (see Table 1). In 2005, 2.3% of overall US soybean production was used manufacturing biodiesel. The percentage rose to 19.2% in 2009. The higher CAGR for the use of soybean for biodiesel production vs. that for overall soybean production emphasizes the increasing use of soybeans for biodiesel production. To meet the demand for biodiesel in 2020, the United States needs to produce 85.5 million metric tons (MMT) of soybeans for all purposes, which includes 55.4 MMT for biodiesel production.

Such a sharp increase in biodiesel production by 2020 will require setting aside a larger land area for the cultivation of soybeans and/or other biodiesel feedstocks. The two major feedstocks for biodiesel production in North America—soy and rapeseed—are both land intensive, producing only 470–940 liters of biodiesel per hectare. At that yield, devoting all of the agricultural land in the United States could produce only 40–80% of the country's diesel fuel consumption requirement.

GBI Research anticipates that by 2020, the total harvested area required for biodiesel production in the United States for all purposes will be 82.8 million acres (33.5 million hectares). The major challenge for the US biodiesel industry is the increasing price of soybeans. This increase in price is explained partly by the lower yield (metric tons per hectare) of soybeans as compared to corn (which is necessary for producing ethanol), and partly by the expansion of corn production in the United States, to the detriment of soybeans, to meet the surging demand by the emerging ethanol industry.

The import and export volumes of soybeans are significant, as they indicate a country's potential to produce soybeans for biodiesel conversion. In the United States, the export volume is considerably higher than the import volume. This shows that the United States has the potential to supply soybeans in response to the increasing global demand for biodiesel feedstocks; however the increasing domestic demand for biodiesel poses a potential threat to the US trading of soybeans. The increase in domestic demand for biodiesel pulls out the supply of soybean from external markets, which creates a setback for United States overseas trading.

In some parts of the US and Canada, camelina is emerging as an oilseed feedstock for biodiesel for use in aviation fuel, as it can be grown on wheat fields that would otherwise be left fallow without harming the soil and usually improving its fertility. Camelina is one of the few affordable, reliable, sustainable, and available feedstocks suitable for jet fuel.

Jatropha seeds, a second-generation biofuel feedstock, are a promising candidate as a biodiesel feedstock. In the last few years, activities in this area have been accelerating in Mexico, where conditions are conducive for jatropha cultivation. Jatropha is not grown in economically important quantities in other North American countries. Unlike first-generation biodiesel and biofuel crops such as soy or corn, jatropha is a nonfood crop and can be grown in nonagricultural and marginal lands not suitable for food crops. Furthermore, it can use wastewater for growth. Fertilizer and pesticide requirements and crop management costs are relatively lower for jatropha than for many other energy crop, and it is a perennial. Hence, it needs to be planted just once and it will yield oil for over 30 years. Also, as a tropical crop, jatropha is about 1.5–8 times more productive per hectare than soy.

Algae, a promising third-generation biodiesel source, has the potential to produce 8–50 times more biodiesel (or gasoline, jet fuel, etc.) per acre than soy, making it a topic for extensive research and development. According to Bloomberg, biofuel processed from algae may comprise as much as 50% of the total fuel burned to power passenger flights in the near future. The United States has announced plans for using algae as a feedstock for future generation biofuels and is promoting the biofuel industry by providing grants and sponsorships. In addition to the various funds granted by the US Department of Energy (DOE) for research projects on biofuels, the most recent award of $24 million was granted to three research projects aimed at commercializing biofuels derived from algae. The National Bioproducts Program algal biofuel initiatives; the DOE National Renewable Energy Laboratory (Golden, Colorado); the Sandia National Laboratory (Livermore, California); and the Pacific Northwest National Laboratory (Richland, Washington) have launched a joint project for the development of algal biofuels under a joint United States–Canada initiative aiming to produce sustainable biofuels.

In Canada, the government mandated 2% biodiesel content in diesel by 2011, effective July 1, 2011. The development of next-generation biofuels in Canada is a key area of interest for potential investors. Strong government support and initiatives will drive foreign investments in the Canadian market along with the presence of a highly qualified workforce and resources in algal biology and the production of biofuels. Together, these factors make Canada a potential contributing source of knowledge and technology in algal biodiesel systems on a global level. The use of microalgae as an alternative feedstock, which is on a rise, will leverage conventional food crops for biodiesel production.

The introduction of new hybrids and biotech traits for canola (a first-generation biodiesel feedstock), along with improved agronomic practices, has allowed Canadian farmers to improve canola yields over the past 15 years to meet both food and fuel demands. According to Statistics Canada, canola yields have risen 50% from an average of 1,240 kilograms per hectare in 1995 to 1,848.6 kilograms per hectare in 2010.

South and Central America

In South America, Brazil and Argentina continue to dominate. These two countries accounted for 21.3% of global biodiesel production in 2010. Colombia is also showing potential as a biodiesel producer and exporter.

By the end of 2020, Brazil will produce 85.6 thousand barrels per day of biodiesel. The Government has mandated a 2% blend (B2) of biodiesel with petrodiesel in early 2008, and 5% (B5) by 2013. However, the mandated blend requirement for biodiesel in Brazil was increased from B2 to B5 in January 2010, three years ahead of initial scheduled targets. President Luiz Inácio Lula da Silva has launched a major industrial program to speed the economic growth of Brazilian companies, and other investors are expected to pour $8.1 billion into the country's biofuel sector by the end of 2014. GBI Research interviews with various experts found that there will be significant investment in ethanol and biodiesel plants in the coming years, resulting in 70 new ethanol plants and 46 new biodiesel plants in Brazil by the end of 2012.

In Brazil, soybean oil accounts for 82% of biodiesel production, animal fats constitute 14%, and cottonseed oil contributes 2%,

CONTINUED ON PAGE 629

Three generations of biodiesel

- *First-generation biodiesel*—Biodiesel produced from commodity oils traditionally used for food, such as soybean, palm, canola and rapeseed
- *Second-generation biodiesel*—Biodiesel made from lignocellulosic nonfood feedstocks, such as jatropha
- *Third-generation biodiesel*—Biodiesel produced from genetically modified feedstocks, such as algae.

with other oilseed crops such as castor bean and palm oil used in insignificant quantities. Furthermore, the Brazilian Biodiesel Union has recently requested the Government to adopt measures to increase the blend requirements to B20 by 2020. Brazil's soybean processing, refining, and bottling capacity is expected to grow, with soybean oil consumption estimated at 5.7 MMT in 2011–2012 out of which 2.2 MMT is expected to be used for biodiesel production.

Argentina's biodiesel industry has similarly witnessed rapid growth with strong blend mandates to stimulate domestic production, exporting excess volumes to international markets, especially Europe. By the end of 2011, Argentina is projected to produce about 2.5 MMT of biodiesel and 3 MMT in 2012.

Biodiesel production in both North and South American countries relies heavily on subsidies, tax credits, and preferential taxes to help offset the high cost of biodiesel production. Import restrictions are also used to promote the emerging biodiesel industry in American countries. Most have made it an essential requirement to blend biodiesel with conventional fuels, which, in turn, provides a guaranteed market for biodiesel.

Mohinder Sawhney is an analyst, Alternative Energy & Clean Technology at GBI Research, a UK-based business information company that provides global business information reports and services. GBI's team of analysts, researchers, and solution consultants use proprietary data sources and various tools and techniques to gather, analyze, and represent the latest information essential for businesses to sustain a competitive edge. For more information, contact info@gbiresearch.com.

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This tobacco field in Brazil is ready for harvesting.

Developing tobacco's potential as a novel, high-yielding, renewable energy plant

Corrado Fogher, Nicoletta Di Norscia, and Sergio Tommasini

Little attention has been paid to the potential of tobacco as an oilseed crop because it is traditionally grown for its leaves. To date, tobacco breeding has selected against seed characteristics because plant energy directed to seed production detracts from leaf production.

In 1997, we started a breeding program to increase seed production in *Nicotiana tabacum* in an effort to produce recombinant therapeutic proteins in tobacco seeds. This work grew into an effort to develop tobacco as the next major oilseed crop. In our breeding program we have already selected lines with seed and oil yields per hectare that exceed those of traditional energy (oilseed) crops (Table 1).

With current production practices and using optimized tobacco varieties reported in Table 1, a seed yield of 5.7 metric tons (MT) of tobacco seed per hectare (Table 1) could yield 2,000 liters of oil per hectare.

The art of growing tobacco

Tobacco is already commonly cultivated throughout many climatic zones and soil types, so any changes in agronomic production practices required to grow tobacco as an energy crop would not be as extensive as the introduction of a new crop.

Tobacco can be grown on marginal soils—although like most plants it can grow better with emendations of plant nutrients—so tobacco grown for energy production would not likely displace food crops from fertile soils. Furthermore, if genetically modified varieties

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TABLE 1. Comparison of energy crops

	Rapeseed	Sunflower	Soybean	Tobacco
Seed yield (MT/ha)	3.3[a]	1.9[a]	1.5–3.3[a]	5.7[b]
Oil content of seeds (%)	33.2–47.6	32–45	21–22	39–41
Oil production (MT/ha)[c]	0.8–1.14	0.49–0.68	0.25–0.58	1.77–1.87
Oil density (kg/L)	0.9115	0.9161	0.9138	0.9175
Volume of extracted oil (L/ha)	965–1,250	534–742	274–635	1,930–2,038

[a]Based on 2004 average EU-25 production (from "Agriculture in the European Union—Statistical and economic information 2005"). MT, metric tons.
[b]Based on field trials of improved high-yielding tobacco varieties in Italy.
[c]Assuming 80% extraction efficiency.

are developed for energy production, they will not enter the food chain.

Agronomic production trials are currently underway in several countries to develop systems of direct seeding of tobacco into fields, as opposed to transplanting germinated seedlings, and multiple harvesting especially in temperate areas. Extensive trials in Egypt demonstrated a production of 8–11 MT of seed per hectare over a period of 12 months.

Historically, breeding efforts in tobacco have focused on biomass yield (primarily leaves) and leaf characteristics such as nicotine content and leaf size. Shifting selection to the development of high seed-yielding varieties—using conventional breeding, marker-assisted breeding, mutagenesis, and recombinant DNA tools for discovery and exploitation of genes controlling energy-related traits such as oil content/composition, seed size, and seed yield—should allow for rapid gains in seed and oil yields. The potential for improvement is great because the germplasm basis of tobacco is very extensive and largely unexploited. Further, tobacco is highly amenable to genetic modification. In fact, it is often used as a "model plant" for genetic transformation. The life cycle of tobacco varies greatly, from four to seven months, and each plant produces several hundred thousand seeds. Therefore, by using the wide variety of biotechnology and genomic tools available to facilitate fast-track breeding, rapid progress can be made in developing varieties of tobacco dedicated for high-energy production.

The *Nicotiana* genus comprises over 80 distinct species, many of which are wild progenitor species of cultivated tobacco (*N. tabacum*). These species potentially contain desirable characteristics, which could be transferred to tobacco, that would influence production of greater numbers of seeds or larger seeds with more storage reserves, because greater fecundity and seed storage reserves are survival advantages in the wild.

Possible alternative products from tobacco

Cold-press extraction tests have shown that of the 38–40% oil contained in tobacco seeds, about 86% can be extracted, leaving an oil cake containing 6% oil and 35% protein. The oil cake may be useful as a high-energy livestock feed source (Fig. 2).

Some studies have shown a harvest of 29.2 MT of dry tobacco biomass per hectare (Long, R.C., *et al.*, 1984). The biomass can be used to produce fuels through gasification, or as a source of cellulosic ethanol.

The oils could also possibly have potential industrial use in chemicals, paints, and cosmetics, and as a very rich source of linoleic acid. (Table 2).

Biochemistry and genetic manipulation

The seed storage lipid triacylglycerol (TAG) biosynthesis is located in the endoplasmic reticulum with glycerol-3-phosphate and fatty acyl-coenzyme A as the primary substrates. There are several enzymes involved in the storage lipid bioassembly, and metabolic engineering offers the opportunity to change the fatty acid profile of the tobacco

CONTINUED ON PAGE 634

FIG. 2. *Tobacco products: seed, oil and cake.*

0 to 5%
5 to 10%
10 to 30%
30 to 50%
50 to 75%
75 to 85%

TABLE 2. Oil composition comparison

FA name	FA struc	Tobacco Oil	Rapeseed Oil	Sunflower Oil	Soybean Oil
caproic acid	C6:0	ND	ND	ND	ND
caprylic acid	C8:0	ND	ND	ND	ND
capric acid	C10:0	ND	ND	ND	ND
Lauric acid	C12:0	ND	ND	ND-0.1	ND-0.1
myristic acid	C14:0	ND	ND-0.2	ND-0.2	ND-0.2
Palmitic acid	C16:0	8.0-9.7	1.5-6.0	5.0-7.6	8.0-13.5
Palmitoleic acid	C16:1	0.1-0.2	ND-3.0	ND-0.3	ND-0.2
margaric acid	C17:0	ND	ND-0.1	ND-0.2	ND-0.1
Margaroleic acid	C17:1	ND	ND-0.1	ND-0.1	ND-0.1
Stearic acid	C18:0	2.4-3.2	0.5-3.1	2.7-6.5	2.0-5.4
Oleic acid	C18:1	10.6-12.1	8.0-60.0	14.0-39.4	17.0-30.0
Linoleic acid	C18:2	75.0-76.8	11.0-23.0	48.3-74.0	48.0-59.0
Linolenic acid	C18:3	0.9-1.4	5.0-13.0	ND-0.3	4.5-11.0
Arachidic acid	C20:0	0.1	ND-3.0	0.1-0.5	0.1-0.6
Eicosenoic acid	C20:1	0.2	3.0-15.0	ND-0.3	ND-0.5
Eicosadienoic acid	C20:2	ND	ND-1.0	ND	ND-0.1
Behenic acid	C22:0	ND	ND-2.0	0.3-1.5	ND-0.7
Erucic acid	C22:1	ND	2.0-60.0	ND-0.3	ND-0.3
Lignoceric acid	C24:0	ND	ND-2.0	ND-0.5	ND-0.5

*inform*ation

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oil. To improve the accumulation of storage lipids in plant reserve tissue it is important that any transgene(s) be expressed under the control of gene promoters that are highly specific for the seeds. Construction of ACCase (acetyl CoA carboxylase), ACP (acyl carrier protein), DGAT (diacylglycerol acyltransferase) and desaturase transformation vectors for seed-specific expression (pGLOB promoter, Reggi, S., *et al.*, 2005; Shewmaker, C., *et al.*, 1999) and transit peptide for plastid import (native or from other genes) or endoplasmic reticulum anchoring signal (KDEL) have been used in tobacco transgenic lines for adaptation of the oil to specific sectors.

The oxidative stability of the oils is another important characteristic for their quality assessment, and this can be improved by enhancing the accumulation in the seed of compounds such as carotenoids, xanthophylls, sterols, and tocopherols.

What constitutes an energy plant?

Economically desirable energy crops are ones that can produce a stable, high yield of energy per hectare, with low input. One approach to capture the maximal amount of energy per hectare is to grow a plant that provides more than one source of energy. For example, a crop that can be grown for its oil as well as its biomass would be cost efficient. The oil could be formulated into biodiesel or heating oil, and the biomass could be used to produce either ethanol or liquid fuel, through gasification.

Commodity energy plants (palm, soybean, rape, and sunflower) all have well-established agricultural cultivation systems with which producers are familiar. Many of the new energy crops (e.g., jatropha) being considered, though, need alternative cultivation systems that are not yet widely used by farmers, are perennials that can limit the grower's choice of crops by occupying land for several years, and could displace land currently used for producing food.

Therefore, a crop that can provide multiple energy raw material products (feedstocks), does not compete with land used for food, is easily accepted by farmers because it is a familiar crop, does not require a lot of inputs, and has an excellent energy yield per hectare would be an ideal energy crop.

The future

One of the most critical steps in developing or domesticating a new energy crop is to establish agronomic production, management, and harvest practices that allow the value of the crop to be realized. Tobacco can be grown in marginal land, such as on hillsides, or with poor soil quality, as it is already grown in African and South American tobacco-producing countries (Fig. 1). Although tobacco is already considered a "domesticated" agricultural crop, production of tobacco for energy will likely be very different from production of tobacco for tobacco products. Our tests of several agricultural production scenarios for tobacco as an energy crop are almost complete. Tobacco produced for human leaf consumption is first sown in greenhouse beds or trays and then hand-transplanted into the field. This labor-intensive method will simply not be feasible to produce tobacco on large areas as an energy crop. Field studies have been done by Sunchem (www.sunchem.it) to determine the feasibility of direct seeding of tobacco seeds into field beds.

A full evaluation of the economic feasibility of tobacco as an energy crop will determine whether this crop fits the criteria of sustainability, and a research thesis at the international University of Monaco (UIM) will further analyze the global market for biodiesel, providing a framework for decision makers who are considering new policies or launching new investments in the biodiesel industry, while helping to identify performance indicators that will clarify whether biodiesel is a potential business opportunity.

Corrado Fogher is associate professor of genetics and plant breeding at the Faculty of Agricultural Science of the Catholic University of Milan, and research director of the agricultural biotechnology company, Plantechno. He can be reached at www.plantechno.com. Nicoletta Di Norscia is a Ph.D. student at the International University of Monaco (UIM) and University of Nice Sophia Antipolis (UNS-IAE). She is currently elaborating and testing a tool of performance indicator for the biodiesel market and can be contacted at ndinorscia@monaco.edu. Sergio Tommasini is managing director of Sunchem Holding Co., where he has guided the project team for Sunchem global energy (www.sunchem.it) since 2010. He can be contacted at: sergio.tommasini@gmail.com.

Did you know?

In September, the US Department of Energy's Advanced Research Projects Agency granted the Lawrence Berkeley National Laboratory's Earth Sciences Division $4.9 million to engineer tobacco plants to produce molecules in their leaves that can be used as high-density liquid transportation fuels. The goals are to introduce genetic traits, some from cyanobacteria and green algae, that will confer hydrocarbon biosynthesis, enhance carbon uptake, and optimize the plant's utilization of sunlight. Advanced cultivation techniques will also be deployed to maximize biomass. [*Biofuels Digest*] tinyurl.com/ARPATobacco.

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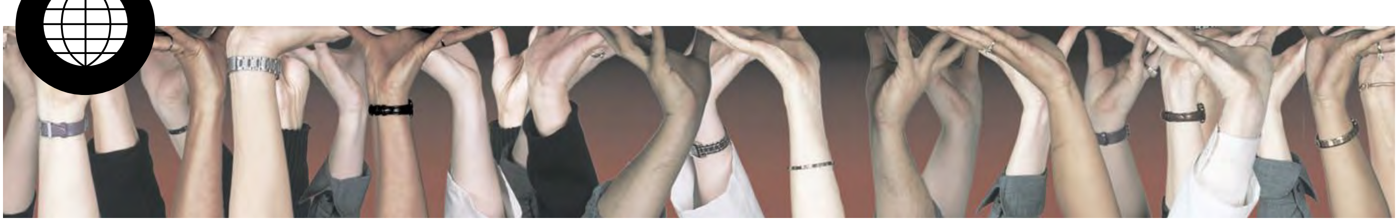

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Zero *trans*-fat oils: an unexpected cleaning challenge

Robert J. Ryther

Government regulations that limit the use of *trans* fats and require manufacturers to include the *trans*-fat content of foods on their labels have resulted in a wide-scale shift toward the use of zero *trans*-fat oils in processed foods.

What no one could have anticipated was the significant cleaning challenges that manufacturers experienced on introducing these new oils into their products. Many users observed that the zero *trans*-fats oils in some foods were considerably more difficult to clean off of processing equipment, resulting in a significant increase in cleaning time and costs.

Because zero *trans*-fat oils are less stable than partially hydrogenated or saturated fats when heated, they leave a residue on processing surfaces. As new zero *trans*-fat oils break down at high temperatures, they react to form molecular networks, or polymers, within the oil, unlike what happens on the same surfaces when high *trans*-fat oils or animal fats are used. It is well known that the high percentage of unsaturated fats in these oils (especially the triple-unsaturated α-linolenic acid component) leads to a more rapid breakdown than occurs with more stable oils. As a result, food production facilities using zero *trans*-fat oils discover that when these oils are left on surfaces for an extended period of time, a sticky, varnish-like polymerized soil forms (Fig. 1).

Although this soil varies with the cooking method that is used, the amount of zero *trans* fat that is included in the recipe, and the frequency of cleaning, zero *trans*-fat residues can cause a thick soil buildup over time that becomes a sticky, gummy, or a very hard varnish-like coating. These soils can collect throughout a facility where the misting of the zero *trans*-fat oil from ovens or fryers occurs, as well as in processing and packaging areas where these zero *trans*-fat oils come into contact with equipment. Traditional cleaning products cannot penetrate zero *trans*-fats residues and emulsify the soil once it has polymerized.

Facilities have encountered soil buildup on walls, floors, ceilings, catwalks, fryer hood vents, refrigeration coils, and the surfaces of packaging equipment. Refrigeration coils are particularly difficult to clean because they are composed of very thin pieces of soft metal that are easily damaged.

Such buildups not only are unsightly but also compromise safety—particularly food safety—as clean processing equipment is fundamental to food safety. Zero *trans*-fat soils can also be a fire hazard due to the combustible nature of the polymerized oil, and the slippery surfaces that result can negatively impact worker safety. To solve such problems, many facilities that use zero *trans*-fat oils have significantly increased manual cleaning and, in some cases, even tried using particle-blasting methods to remove the residue.

In 2008 Ecolab, in partnership with its customers, embarked on an effort to understand the nature of zero *trans*-fat soils; it discovered that the key to breaking down the soil involved getting at the cross-link centers of the oilseed-based triglyceride soils and effectively unzipping the oil polymer that formed. The resulting patent-pending Exelerate® ZTF technology works by using solvent-surfactant blends to wet and swell the hardened soil. This permits the ionic cross-linked sites to be accessed and broken down. Exelerate ZTF technology effectively reverses the polymerization reaction, leaving monomeric oil molecules that are then easily emulsified by the formulation.

FIG. 1. *Exelerate ZTF can be applied as a gel to provide more time for the chemistry to act on very heavy soils and on surfaces that are difficult to reach and clean, such as hood vents, walkways, and refrigeration coils.*

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FIG. 1. *The gene expression of FATB thioesterase and FAD2 desaturase were reduced via RNAi technology.*

Vistive® Gold and Soymega™: A one-two punch for trait-enhanced oils

Two scientists at Monsanto Co. describe the genetic modifications used to develop a low-saturated-fat frying oil and a land-based source of stearidonic acid, an omega-3 fatty acid that is an intermediate in the conversion of α-linolenic acid to eicosapentaenoic acid, and compare the composition and functionality of these pipeline products to commodity oils.

Toni Voelker and Richard S. Wilkes

Vistive® Gold—low-saturated-fat frying oil

The polyunsaturated fatty acid (PUFA) content of edible oil significantly influences shelf life and frying performance. Oils with low PUFA content offer longer product shelf lives and are required for commercial frying. Prior to the development of health concerns around the consumption of *trans* fats, hydrogenation was commonly used to reduce the PUFA content in oils and improve frying performance. With functionality and consumer health in mind, Monsanto has developed a low-saturate, high-oleic soybean, which will be marketed as Vistive Gold. In Table 1, the fatty acid composition of Vistive Gold is compared to conventional soybean oil. Oleic acid is increased, with a concomitant reduction of linoleic (LA) and α-linolenic (ALA) acids. In addition, palmitic acid has been reduced by more than 70%, resulting in fewer saturates than are found in canola oil.

How are these fatty acids made in the cells? As in all other oilseeds, common intermediate metabolites in the seeds are assembled by the fatty synthase enzymes to produce saturated fatty acids. At the palmitate stage, the chain elongation can either be terminated by FATB thioesterase, generating palmitate ready for deposition in triglycerides, or the elongation can continue to stearate (Fig. 1).

Stearate can be either directly incorporated into oil, or a sequence of three different desaturases can add a specific double bond each, leading to 18:1 (oleic acid), 18:2 (LA), or 18:3 (ALA). The relative strength of these enzymes in the cell determines the fatty acid composition of the resulting vegetable oils. To redirect soybean oil biosynthesis to Vistive Gold production, these key enzymes were rebalanced.

To achieve this goal, we needed to reduce the levels of three different enzymes in the fatty acid biosynthesis pathway of developing soybeans (symbol X in Fig. 1). The gene expression of FATB thioesterase and FAD2 (flavin adenine dinucleotide 2) desaturase were reduced via RNAi (RNA interference) technology. For RNAi, double-strand RNA specific for a target gene is used as the suppression agent. For Vistive Gold, a genetically modified (GM) transgene was assembled and inserted into the soy genome to produce a double-strand transcript containing short stretches of FATB and FAD2 sequences. This resulted in partial suppression of FATB and FAD2. As a result of these reductions, these RNAi GM beans produce high-oleic, low-saturated oil (Wagner, *et al.*, 2010). To reduce the level of ALA as well, the GM line was subsequently crossed with Vistive, a low-linolenic variety containing a conventional FAD3 desaturase mutation (Fig. 1, blue X).

After several years of agronomic tests, breeding, and extensive safety studies for global regulatory submissions, Vistive Gold soybeans have now advanced to Phase IV (preintroduction), the final

TABLE 1. Typical fatty acid compositions

Fatty acid (%)	16:0	18:0	18:1	18:2 LA[a]	18:3 ALA[a]	18:3 GLA[a]	18:4 SDA[a]
Soy commodity	11	4	20	56	8	—	—
Vistive® Gold	3	3	74	15	<3.5	—	—
Soymega™	12	4	19	27	12	5	20

[a]LA, linoleic acid; ALA, α-linolenic acid; GLA, γ-linolenic acid; SDA, stearidonic acid.

step within the Monsanto research and development (R&D) pipeline. To date, the US Food and Drug Administration (FDA) has issued a positive response letter to Monsanto's Generally Recognized as Safe notification for the use of Vistive Gold under its intended uses, which include fry oil, topical application, and use in shortening blends. Additionally, the FDA has issued a positive response to Monsanto's biotech notification. The USDA completed its plant pest risk assessment and the draft environmental assessment in June 2011, with a public comment period through August 2011.

Extensive application testing has been conducted to demonstrate the product benefits of Vistive Gold, including testing with French fries (chips), fried chicken, tortilla chips, and snack crackers. In each case, the amount of saturated fat in each product was reduced compared to frying with alternative oils (Fig. 2). Fry studies confirmed improved fry stability compared to first-generation *trans*-free alternatives, including Vistive low-linolenic soybean oil (Fig. 3).

Sensory studies demonstrated acceptable flavor, aroma, and texture of each food when Vistive Gold was used, either as a fry medium or as a topical application. With the improved heat and oxidative stability of the oil, polymerization of the oil during industrial frying can also be reduced.

Soymega™ for heart health

It is well established that long-chain omega-3 fatty acid intake is important to maintaining heart health, yet the majority of people are still not consuming omega-3s in the amounts recommended by many professional organizations. Soymega™ was developed to create a land-based source for long-chain omega-3 fatty acids that can be added to many processed foodstuffs. The polyunsaturates in soybean oil were enhanced by modifying the fatty acid biosynthesis to produce more omega-3 fatty acids, especially stearidonic acid (SDA; 18:4n-3). Once in the body, SDA is more efficiently converted to heart-healthy eicosapentaenoic acid (EPA; 20:5n-3) compared to ALA (James, *et al.*, 2003). Currently, SDA, a precursor of EPA, usually enters our diet through the consumption of cold-water fish. Other sources of SDA are black currant, echium, and borage oils, available as supplements.

The key step in the development of Soymega was identifying a Δ6 desaturase gene from primula, a plant that naturally produces SDA-containing oil in its seeds. This primula desaturase, when expressed in developing soybeans, places an extra double bond at ω-12 in LA and ALA lipid intermediates (Fig. 1). When LA is desaturated

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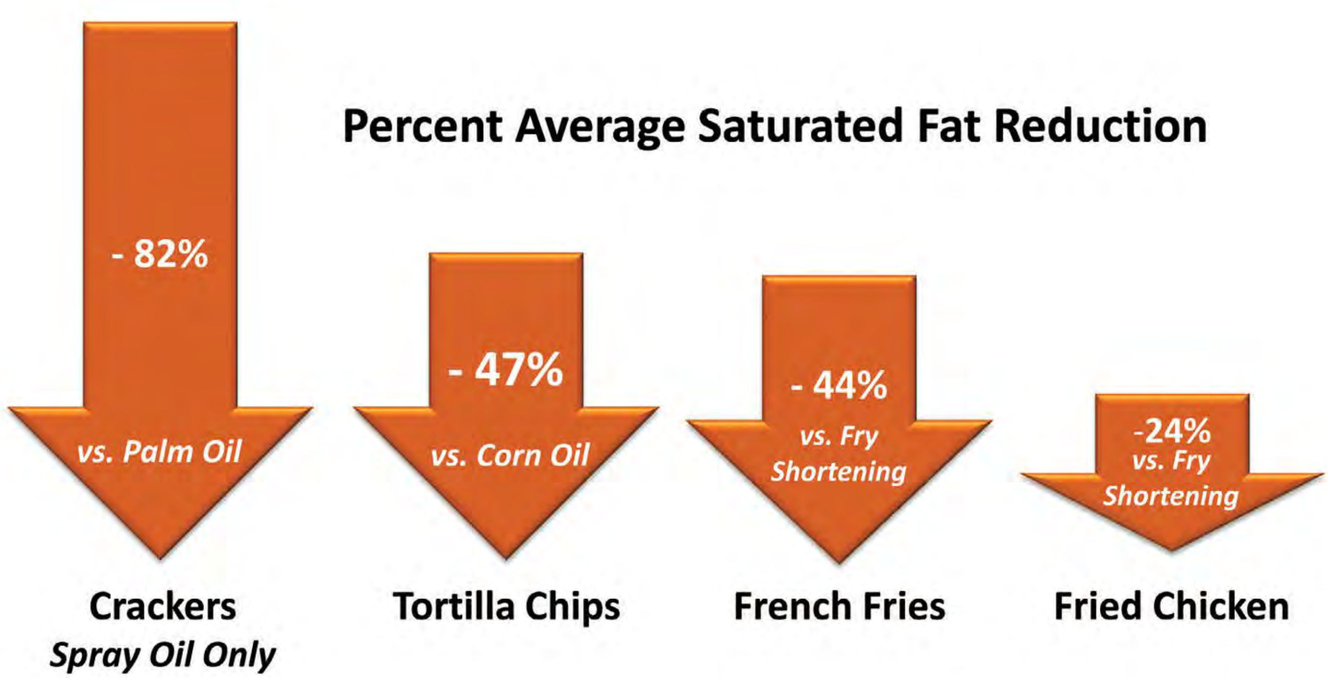

FIG. 2. *Saturated fat reduction from the use of Vistive Gold.*

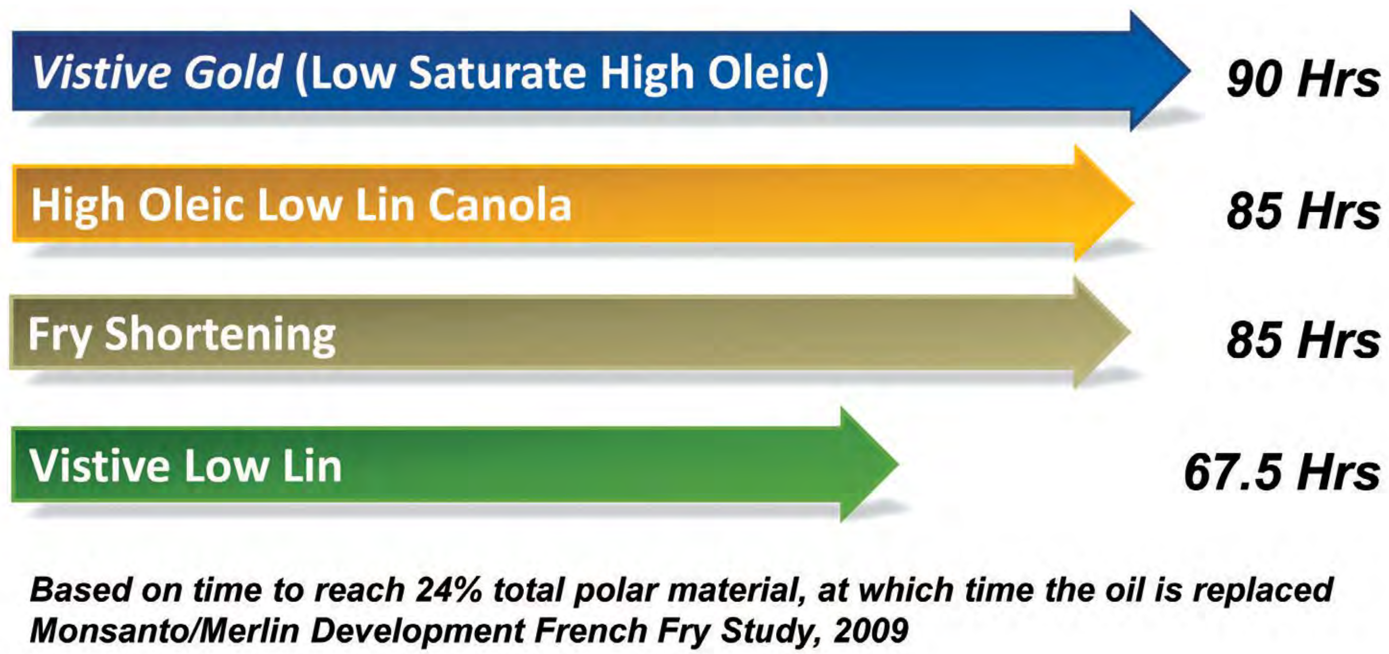

FIG. 3. *Fry life (all samples contained 180 ppm* tert-*butyl hydroquinone).*

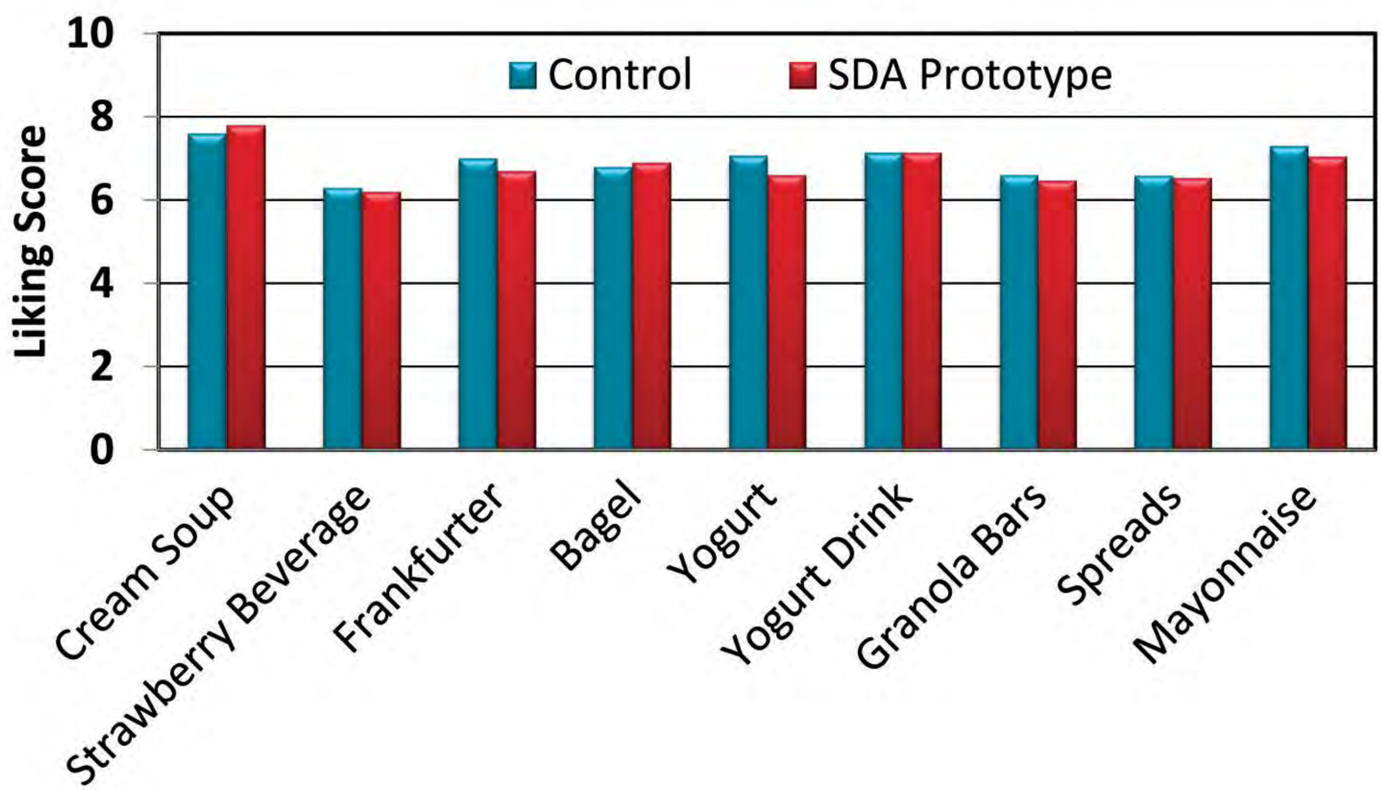

FIG. 4. *Overall liking scores of stearidonic acid (SDA)-containing food prototypes.*

information

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by the primula desaturase, γ-linolenic acid (18:3n-6; GLA) is produced; ALA leads to SDA. To boost SDA levels further, a Δ15 desaturase was overexpressed as well, increasing the unsaturation of LA lipids to ALA lipids. As a result of adding these two enzymes to the cells, a large portion of LA, the 56% omega-6 fraction of conventional soybean oil, is replaced in Soymega by 20% SDA, accompanied by increased ALA levels, and some GLA (see Table 1).

Randomized human intervention trials using Soymega demonstrated that this SDA-enriched oil in the diet will increase the omega-3 index [a measure of EPA and docosahexaenoic acid, or DHA (22:6n-3), content of red blood cell membranes] and lead to higher EPA levels in blood markers (Lemke, *et al.*, 2010).

With improved oxidative stability compared to alternative marine and algal sources of long-chain omega-3s, SDA soybean oil offers food companies the option to develop everyday foods that help increase consumers' intake of long-chain omega-3 fatty acids. After several years of agronomic tests, breeding, and extensive safety studies for global regulatory submissions, Soymega soybeans have advanced to Phase IV. To date, the US FDA has issued a positive response letter to Monsanto's Generally Recognized as Safe notification for the use of Soymega oil under its intended uses, which include dressings, sauces, margarine spreads, and baked goods.

Monsanto Co. and Solae, LLC, are collaborating to develop SDA soybean oil commercially. A range of food product prototypes has been prepared to evaluate the impact SDA soybean oil has on flavor, shelf life, and, more importantly, consumer acceptance. Based on past clinical study results, a target of 375 mg SDA per serving was used in each formulation. Prototypes include creamed soups, strawberry beverage, frankfurters, yogurt, yogurt drink, fruit and nut granola bars, 60% fat margarine-type spreads, and mayonnaise (Whittinghill and Welsby, 2010). Fig. 4 summarizes consumer acceptance data for a range of food prototypes.

In each case, consumers were presented with the prototype at an average age they would typically consume the product, and rated it on a hedonic scale from 1 (extremely dislike) to 9 (extremely like). In each case, the consumer liking was not significantly different from a control made with commodity soybean oil. The results demonstrate that everyday foods can be formulated with SDA soybean oil to provide consumers with a new means of increasing long-chain omega-3 consumption in their diets.

Toni Voelker is a senior scientist at Monsanto Co. in Davis, California, USA. His expertise is in the metabolic engineering of plant lipids. Through the last two decades he has led research and genetic engineering strategies of crops with the goal of modifying vegetable oil composition. He is named inventor on 20 patents and an author on more than 30 scientific publications. He can be reached at toni.voelker@monsanto.com. Richard S. Wilkes has since 2005 been director–food applications for Monsanto Co. in St. Louis, Missouri, USA. There, he supports an expanding portfolio of oils with food-quality traits with direct consumer benefits. Prior to this, Wilkes was director–research & development (R&D) for Bestfoods and Unilever Bestfoods, with responsibility in R&D and new business development for a variety of products. He can be reached at Richard.S.Wilkes@Monsanto.com.

The benefits of land-based omega-3s

Mary Lee Chin

The evidence that the long-chain polyunsaturated fatty acids DHA (docosahexaenoic acid) + EPA (eicosapentaenoic acid) have beneficial health effects is mounting. But what about EPA alone? And how much dietary stearidonic acid (SDA) is converted to EPA?

One of the largest studies suggesting that eicosapentaenoic acid (EPA) is associated with heart health is the Japan Eicosapentaenoic Acid (EPA) Lipid Intervention Study, which examined the effects of long-term supplementation of EPA in Japanese patients with hypercholesterolemia, or high serum cholesterol and triglycerides (*Lancet 369*:1090–1098, 2007). This was an open-label, endpoint-blinded trial of more than 18,000 study participants with and without a history of coronary artery disease. The subjects were placed on low-dose statin therapy and then randomized to either a group receiving 1,800 mg/day of highly purified EPA capsules or to the control group. The primary endpoint was any major cardiovascular event.

Over the 4.6 mean years of follow-up there was a statistically significant 19% reduction in major coronary events in subjects with EPA supplementation compared with the control group. Additionally, in the test group, the risk of unstable angina and nonfatal coronary events was reduced by 24% and 19%, respectively. In patients with a history of coronary artery disease in the EPA test group, major coronary events were reduced by 19%. It should be noted, however, that this study population was exclusively Japanese. This population has a high consumption of fish and an average intake of 600–1,000 mg/day of EPA + DHA from dietary sources.

In 2008, the Joint Food and Agriculture Organization/World Health Organization (FAO/WHO) Expert Consultation on Fats

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California Dreamin' for the next AOCS Annual Meeting & Expo

Emily Wickstrom

What's your California dream: a bustling city or a relaxing beach? You can experience both at the 103rd AOCS Annual Meeting & Expo (AM&E) in Long Beach, California, USA, April 29–May 2, 2012. And, it is all just a 27-minute drive from the Los Angeles International Airport.

The seventh-largest city in California, Long Beach offers the best of both worlds, combining the excitement of a big city with the allure of a beach town. A maritime center of the United States, the "Aquatic Capital of the Nation" is also home to the Long Beach Convention & Entertainment Center, a world-class facility located on the Pacific Ocean waterfront.

Attendees at the 103rd AM&E will find plenty to do when sessions are completed for the day, as shopping, nightlife, cultural entertainment, and more than 100 restaurants are all located within an eight-block radius of the convention center. Long Beach was recently rewarded for its accessibility when it was named as one of the Top 10 Most Walkable Neighborhoods in America by WalkScore.com.

If the beach is more your style, you are in luck. Long Beach features 5.5 miles (9 kilometers) of waterfront, accessible by foot, bicycle, or inline skates. Opportunities to rent boats, jet skis, paddle boards, fishing equipment, and more are available at numerous locations along the coast, or you can just choose to take a relaxing stroll and enjoy the ocean view. Following are some "can't-miss" attractions to check out during your free time.

The Queen Mary

Once the most luxurious ocean liner on the Atlantic Ocean, the Queen Mary moved to Long Beach in 1967. It is now a popular tourist attraction, with daily tours that detail the history, architecture, and mystique of the ship. The Queen Mary also features several forms

CONTINUED ON NEXT PAGE

of entertainment such as cabaret shows, interactive exhibits, and the Ghosts & Legends show.

Aquarium of the Pacific

The aquarium features more than 11,000 animals from 500 different species. Visitors can journey through the Pacific Ocean's three regions: Southern California/Baja, the Tropical Pacific, and the Northern Pacific. Interactive exhibits such as the Shark Lagoon and Lorikeet Forest allow visitors a unique chance to touch stingrays, to pet sharks, and to feed birds.

Museums

The Long Beach Museum of Art houses a permanent collection of approximately 3,000 works featuring 300 years of ceramics and Californian Modernist and contemporary Californian art. Overlooking the Pacific Ocean, the museum includes the historic Elizabeth Milbank Anderson house and carriage house, oceanfront gardens, and two floors of gallery space for changing exhibits. Art fans may also want to visit the Museum of Latin American Art, the only museum in the United States dedicated to modern and contemporary Latin American art.

Historical sites

The historic ranch and gardens of Rancho Los Alamitos feature five agricultural buildings, a working blacksmith shop, four acres (1.6 hectares) of gardens, and an adobe ranch house built around 1800. Rancho Los Cerritos is on the National Register of Historic Places and features a California history research library.

Gondola rides

Long Beach is one of only seven places in the United States with gondola rides. Relaxing (and romantic) tours through the canals of Naples Island are offered seven days a week.

Whale watching and ocean excursions

Daily harbor tours, whale watching tours, and fishing excursions are available from several organizations. The Long Beach Area Convention & Visitors Bureau recommends Harbor Breeze Cruises, Pierpoint Landing, Newport Beach Whale Watching, and Catalina Express.

Art Theatre of Long Beach

Billed as a "one-of-a-kind return to the Golden Age of Cinema," the Art Theatre was originally built in 1924. Voted the top independent theatre in Los Angeles, the Art Theatre currently screens independent, documentary, animated, and foreign language films.

Catalina Island

Just an hour's boat ride from Long Beach, charming Catalina Island is a unique and delightful tourist destination. From the luxury yachts floating in the bay to the tile-adorned fountain and walkways, the Mediterranean-like paradise has been the setting for many films and a getaway for Hollywood stars. The island features a historic casino and activities for everyone's taste, including golf, scuba diving, snorkeling, glass-bottom boat tours of local reefs and shipwrecks, shopping, hiking, a zip line, and several tours (by foot, trolley, or helicopter). There are also more than 30 restaurants and live music on most nights.

Parks

Long Beach is known for having one of the best park districts in the United States, with 92 parks covering more than 3,000 acres. The largest is El Dorado Regional Park, which features a nature center, fishing lakes, an archery range, and bike trails.

Amusement parks

Long Beach is a short drive from the most popular amusement parks in Southern California, including Disneyland, Disney California Adventure Park, Universal Studios, Knott's Berry Farm, Sea World, and Six Flags Magic Mountain.

As you can see, the 103rd AOCS AM&E is the perfect time to combine work with pleasure and enjoy California with family and friends. Visit annualmeeting.aocs.org for travel tips and helpful sightseeing links.

Emily Wickstrom is a marketing and public relations specialist at AOCS. She can be reached at emilyw@aocs.org.

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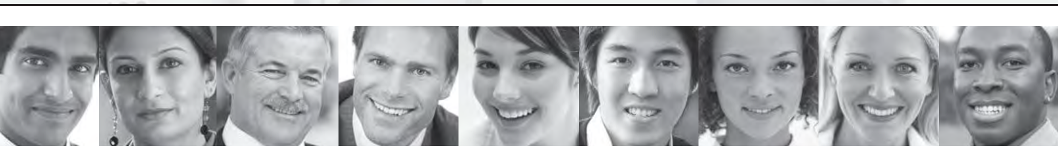

All members contribute to the success of the Society while furthering their professional goals.

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Innovations in the "post-*trans*" era of fats and oils

David Piller

Entire countries in Europe have essentially banned them; the most populous state and the most populous city in the United States have, too. "They" are *trans* fats, and, from the labels on food packages to reports in the worldwide media, it is nearly impossible not to hear about their negative health effects and the efforts of governments and agencies to regulate them.

With new regulations and labeling requirements having been enacted in the United States and around the world, oil-processing companies have been faced with the daunting task of developing alternatives that impart the same qualities to processed foods that partially hydrogenated oils do.

Partial hydrogenation in the 20th century

Well into the 1990s, partially hydrogenated vegetable oils, the main source of *trans* fats, were in widespread use and considered a viable and healthful alternative to saturated animal fats. After all, partially hydrogenated oil had been on the market since the early 20th century when The Procter & Gamble Co. (P&G; Cincinnati, Ohio, USA) obtained the rights to German chemist Wilhelm Normann's patented process for hydrogenating liquid oils. P&G began marketing the solid, all-vegetable oil shortening Crisco in 1911.

The following decades saw the use of hydrogenated vegetable oils increase exponentially as food manufacturers discovered that these oils offered considerable advantages over animal fats. Compared to butter or lard, these new oils offered a much longer shelf life for foods, while maintaining the texture consumers preferred. In addition, the process of hydrogenation could turn liquid oil solid, making a product like margarine a convenient and less expensive alternative to butter.

Health concerns emerge

During the 1980s and 1990s, a growing body of clinical research emerged that suggested that the advantages of partial hydrogenation could not outweigh the health risks associated with the *trans* fatty acids produced by the hydrogenation process. Clinical studies indicated that *trans* fatty acids increase levels of low-density lipoprotein (LDL) cholesterol, also known as "bad" cholesterol, and significantly increase the risk of cardiovascular disease (CVD). A 2006 study by Dariush Mozaffarian and co-workers in *The New England Journal of Medicine* even suggested that 10–19% of CVD events in the United States could be avoided by reducing *trans* fats consumption.

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information

Hayes, K.C., and A. Pronczuk, Replacing *trans* fat: the argument for palm oil with a cautionary note on interesterification, *Journal of the American College of Nutrition 29*:253S–284S (2010).

Mozaffarian, D.,M.B. Katan, A. Ascherio, M.J. Stampfer, and W.C. Willett, *trans* Fatty acids and cardiovascular disease, *The New England Journal of Medicine 354*:1601–1613 (2006).

As the scientific evidence mounted, governments around the world began considering legislation that would require food manufacturers either to indicate *trans* fat content on labels or to limit it in their products. In 2004, Denmark became the first country to effectively ban *trans* fats by mandating that all oils and fats contain less than 2% *trans* fatty acids. In 2008, Switzerland followed suit. In the United States, a new labeling rule, "*trans* Fatty Acids in Nutrition Labeling, Nutrient Content Claims, and Health Claims," became federal law in July 2003. The new regulation stated that, beginning in January of 2006, food labels must list the amount of *trans* fatty acids in a product if it contains more than 0.5 grams per serving.

Industry's major challenge

One widely recognized authority in the field of edible oils, *trans* fats, and the development of alternatives, Gary List, explains that many companies began researching *trans* fat replacements in the early 1990s in anticipation of new regulations. Dilip Nakhasi, team director of R&D Innovations for Bunge Oils, says that industry initially looked for a quick solution. For Bunge, that solution was palm oil. Using palm oil accomplished the goal of removing *trans* fats while still maintaining high stability. According to List, palm oil, along with soybean oil, now accounts for 60% of the world's edible oil production. "The palm approach works as a quick fix, but it still brings saturates," Nakhasi says.

List says that companies are also looking into trait-modified oils whose fatty acid compositions have been altered by plant breeding or biotechnology. These oils offer little or no *trans* fat and increased omega-3 fatty acid content. Some examples of trait-modified oils include low-linolenic acid and high-oleic acid canola oil, low-linolenic and mid-oleic soybean oil, and mid- and high-oleic sunflower oil. Several other trait-modified soybean oils are nearing commercialization, including high-stearic acid oils that will give added functionality in baking.

Companies respond

In a relatively short period of time, companies have responded to the worldwide push to limit or ban *trans* fats with an impressive array of alternatives. Research into new options is continuing at a feverish pace. Many of the world's leading producers of fats and oils have made significant strides in their product offerings and are publicly committed to doing more. In 1994, for example, Unilever began removing *trans* fats from margarine spreads in Europe and, in 2004, announced that it had removed *trans* fats from all of its margarine products in Canada. Since 2005, the company says it has eliminated more than 30,000 tons (27,000 metric tons) of *trans* fatty acids and 20,000 tons (18,000 metric tons) of saturated fats from its products worldwide. Unilever has also committed to removing any *trans* fats arising from partially hydrogenated vegetable oil by 2012.

"Unilever introduced mainly interesterified mixtures of palm stearin and palm kernel oil as alternatives to partial hydrogenated oils," says Gerrit van Duijn, oil supply technology director, Unilever R&D Vlaardingen (Netherlands) (Interesterification processes rearrange the attachments of fatty acids to glycerols by either chemical or enzymatic means.). "We are currently changing from chemical to enzymatic interesterified mixtures to move to more 'green' ingredients."

Archer Daniels Midland Co. (ADM; Decatur, Illinois, USA) was the first North American company to commercialize the enzymatic interesterification process. According to the company's website, "… interesterification is the most effective way to decrease the *trans* fat content in foods without sacrificing the functionality of partially hydrogenated vegetable oils."

Yet, while interesterified oils offer numerous functional advantages, a 2010 analysis by K.C. Hayes and Andrzej Pronczuk in the *Journal of the American College of Nutrition* suggests that further study is needed to determine what, if any, long-term effects these oils have on human nutrition.

Bunge Oils is another company using the interesterification process, as well as oil blending and other proprietary processes, to produce new products. Nakhasi says that the company is looking beyond simply eliminating *trans* fats and working to develop oils that can actually enhance good nutrition. Bunge says its Delta™ SL randomized triacylglycerol blend of high-oleic canola and medium-chain triglycerides with added phytosterols has been clinically proven to help consumers reduce LDL cholesterol levels and maintain a healthy weight.

The future of oils

The list of countries and cities around the world that either severely limit *trans* fats or require labels showing *trans* fat content continues to grow. Nevertheless, countries like Canada, the UK, and Australia, which do not currently require *trans* fats to be listed separately, are either considering such requirements or finding other ways to recommend significantly reducing or eliminating *trans* fats from the food supply. Companies have responded to these requirements with a wide range of oil-processing alternatives, many of which are industry firsts, to reduce or remove *trans* fats from their products. Even the very first partially hydrogenated vegetable shortening, Crisco, has been changed. The J. M. Smucker Co., which purchased Crisco from P&G, announced in 2007 that all Crisco shortening products in the United States contain less than one gram of *trans* fat per serving.

Bunge's Nakhasi says that the next phase of alternative oil development will be to find solutions that not only remove *trans* fats but also remove saturated fats and enhance nutrition. "We've come a long way in finding solutions to the *trans* fats problem," he says. "But for our next major hurdle, we need a solution to saturates." This will prove difficult, he says, because any alternative must satisfy the dual criteria of stability and functionality. "It's a struggle," he says, "because we've come up with some great developments for stability, but we haven't done as well with functionality." Addressing that challenge is what will put companies on the cutting edge.

David Piller is a freelance science and health writer based in Cincinnati, Ohio, USA. A professional writer for more than 20 years, he has produced feature articles, web content, marketing communications, and technical documentation for both public and private healthcare organizations.

Brookhaven biochemists John Shanklin (left) and Ed Whittle helped solve the 40-year mystery of how desaturases exert such location-specific control of the double bond positions in hydrocarbon chains. Photo courtesy of Brookhaven National Laboratory.

Scientists solve mystery of double bond placement in plant fatty acids

Karen McNulty Walsh

Scientists at the US Department of Energy's (DOE) Brookhaven National Laboratory in Upton, New York, and collaborators at the Karolinska Institute in Sweden have discovered how an enzyme "knows" where to insert a double bond when desaturating plant fatty acids. Understanding the mechanism—which relies on a single amino acid far from the enzyme's active site—solves a 40-year mystery of how these enzymes exert such location-specific control.

The work, published in the *Proceedings of the National Academy of Sciences* the week of September 19, 2011 (Remote control of regioselectivity in acyl-acyl carrier protein-desaturases, *PNAS* 2011, doi:10.1073/pnas.1110221108), may lead to new ways to engineer plant oils as a renewable replacement for petrochemicals.

"Plant fatty acids are an approximately $150-billion-dollar-a-year market," said Brookhaven biochemist John Shanklin, lead author on the paper. "Their properties, and therefore their potential uses and values, are determined by the position of double bonds in the hydrocarbon chains that make up their backbones. Thus the ability to control double bond positions would enable us to make new designer fatty acids that would be useful as industrial raw materials."

The enzymes responsible for double-bond placement, called desaturases, remove hydrogen atoms and insert double bonds between adjacent carbon atoms at specific locations on the hydrocarbon chains. But how one enzyme knows to insert the double bond

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at one location while a different but closely related enzyme inserts a double bond at a different site has been a mystery.

"Most enzymes recognize features in the molecules they act on that are very close to the site where the enzyme's action takes place. But all the carbon–hydrogen groups that make up fatty-acid backbones are very similar with no distinguishing features—it's like a greasy rope with nothing to hold onto," said Shanklin.

In describing his group's long-standing quest to solve the desaturation puzzle, Shanklin quotes Nobel laureate Konrad Bloch, who observed more than 40 years ago that such site-specific removal of hydrogen "would seem to approach the limits of the discriminatory power of enzymes."

Shanklin and his collaborators approached the problem by studying two genetically similar desaturases that act at different locations: a castor desaturase that inserts a double bond between carbon atoms 9 and 10 in the chain (a Δ-9 desaturase); and an ivy desaturase that inserts a double bond between carbon atoms 4 and 5 (Δ-4). They reasoned that any differences would be easy to spot in such extreme examples.

But early attempts to find a telltale explanation—which included detailed analyses of the two enzymes' atomic-level crystal structures—turned up few clues. "The crystal structures are almost identical," Shanklin said.

The next step was to look at how the two enzymes bind to their substrates—fatty acid chains attached to a small carrier protein. First, the scientists analyzed the crystal structure of the castor desaturase bound to the substrate. Then they used computer modeling to further explore how the carrier protein "docked" with the enzyme.

"Results of the computational docking model exactly matched that of the real crystal structure, which allows carbon atoms 9 and 10 to be positioned right at the enzyme's active site," Shanklin said.

Next the scientists modeled how the carrier protein docked with the ivy desaturase. This time it docked in a different orientation that positioned carbon atoms 4 and 5 at the desaturation active site. "So the docking model predicted a different orientation that exactly accounted for the specificity," Shanklin said.

To identify exactly what was responsible for the difference in binding, the scientists then looked at the amino acid sequence—the series of 360 building blocks that makes up each enzyme. They identified amino acid locations that differ between Δ-9 and Δ-4 desaturases, and focused on those locations that would be able to interact with the substrate, based on their positions in the structural models.

The scientists identified one position, far from the active site, where the computer model indicated that switching a single amino acid would change the orientation of the bound fatty acid with respect to the active site. Could this distant amino-acid location remotely control the site of double bond placement?

To test this hypothesis, the scientists engineered a new desaturase, swapping out the aspartic acid normally found at that location in the Δ-9 castor desaturase for the lysine found in the Δ-4 ivy desaturase. The result: an enzyme that was castor-like in every way, except that it now seemed able to desaturate the fatty acid at the Δ-4 carbon location. "It's quite remarkable to see that changing just one amino acid could have such a striking effect," Shanklin said.

The computational modeling helped explain why: It showed that the negatively charged aspartic acid in the castor desaturase ordinarily repels a negatively charged region on the carrier protein, which leads to a binding orientation that favors Δ-9 desaturation; substitution with positively charged lysine results in attraction between the desaturase and carrier protein, leading to an orientation that favors Δ-4 desaturation.

Understanding this mechanism led Ed Whittle, a research associate in Shanklin's lab, to add a second positive charge to the castor desaturase in an attempt to further strengthen the attraction. The result was a nearly complete switch in the castor enzyme from Δ-9 to Δ-4 desaturation, adding compelling support for the remote control hypothesis.

"I really admire Ed's persistence and insight in taking what was already a striking result and pushing it even further to completely change the way this enzyme functions," Shanklin said.

"It's very rewarding to have finally solved this mystery, which would not have been possible without a team effort drawing on our diverse expertise in biochemistry, genetics, computational modeling, and X-ray crystallography.

"Using what we've now learned, I am optimistic we can redesign enzymes to achieve new desirable specificities to produce novel fatty acids in plants. These novel fatty acids would be a renewable resource to replace raw materials now derived from petroleum for making industrial products like plastics," Shanklin said.

Karen McNulty Walsh is a writer/editor for Media & Communications and Production Services at Brookhaven National Laboratory.

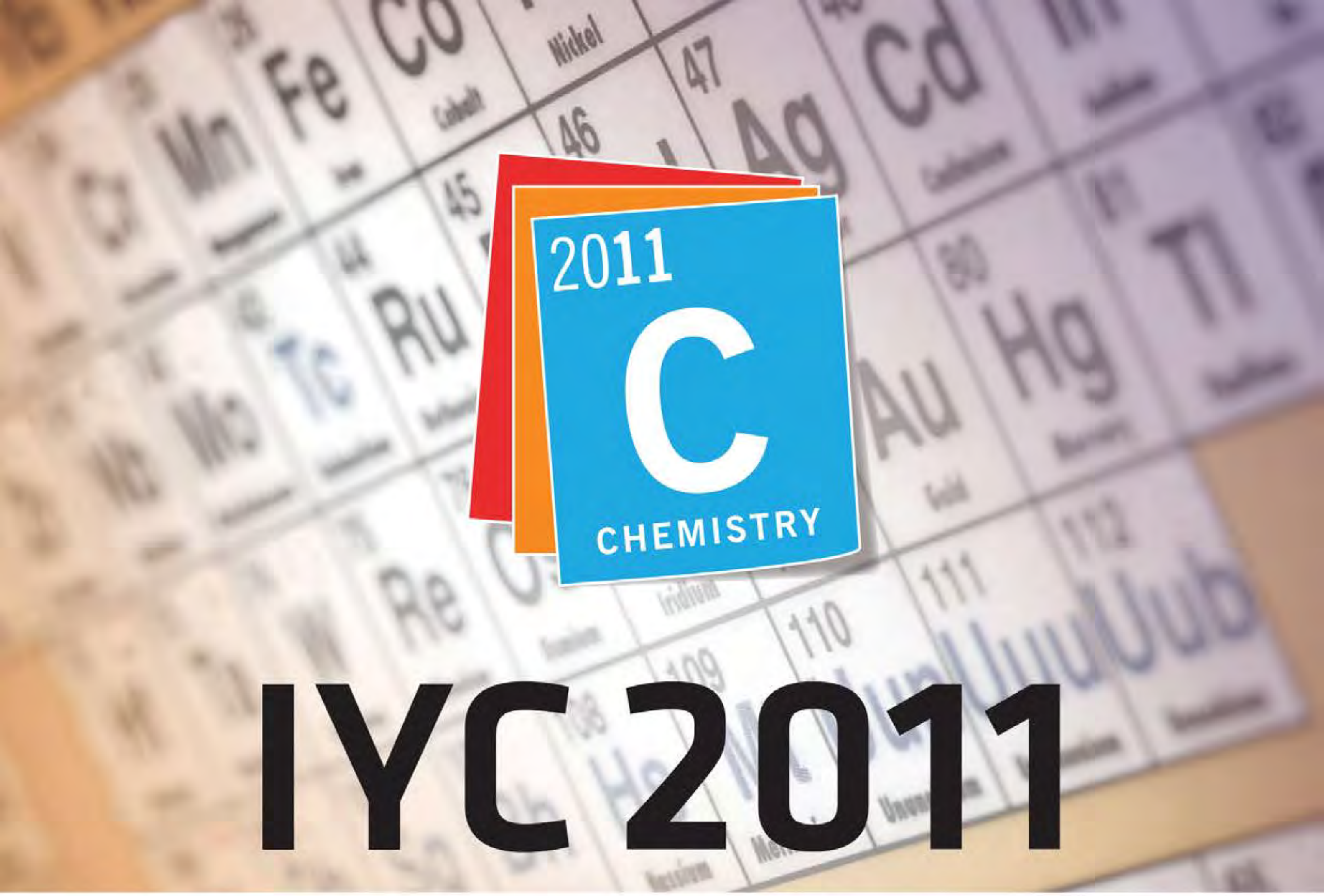
CLEANING CHALLENGE (CONTINUED FROM PAGE 636)

The innovative technology works at room temperature, which is very important for food manufacturers, as many processing surfaces cannot be heated for extended periods. In addition, it can be applied as a gel to provide more time for the chemistry to act on very heavy soils and on surfaces that are difficult to reach and clean, such as hood vents and perforated cat walks.

Before initiating the use of Exelerate ZTF to remove zero *trans*-fat residues, one major US food processing facility spent nearly 40 hours per week cleaning five mixers used in the production of filling for its snack products, which caused production delays. The plant was able to reduce its cleaning time per mixer from eight hours to one hour per mixer using the Exelerate ZTF technology, saving the manufacturer 35 hours per week that was previously spent cleaning.

Exelerate ZTF technology is a good example of how Ecolab partners with its customers to solve their practical cleaning challenges and the company's scientific approach to innovation. The technology not only effectively cleans the polymerized soils created by the use of zero *trans*-fat oils in food products but also offers time and labor savings for customers. For these reasons, the technology received a 2011 Institute of Food Technologists Food Expo Innovation Award.

Robert J. Ryther is a corporate scientist at Ecolab in St. Paul, Minnesota, USA. He can be reached at Robert.ryther@ecolab.com.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People News/ Inside AOCS

Avanti Award in Lipids to Carman

AOCS member **George M. Carman**, professor and director of the Center for Lipid Research at Rutgers University (New Brunswick, New Jersey, USA), won the Avanti Award in Lipids. Carman has made many contributions to the understanding of the enzymology and metabolism of phospholipids, and, most recently, his laboratory discovered the molecular function of the fat-regulating protein lipin as a phosphatidic acid phosphatase enzyme.

Carman

The award will be presented on April 22, 2012, at the annual meeting of the American Society of Biochemistry and Molecular Biology, to be held in San Diego, California, USA. In conjunction with the award, Carman will present a lecture entitled "Lipin/Phosphatidic Acid Phosphatase in Lipid Metabolism and Cell Physiology."

New president for Desmet Ballestra

As of September 1, 2011, **James Willits** was promoted to the position of president and chief executive officer of Desmet Ballestra North America Inc. (Marietta, Georgia, USA). He had served as vice president of sales and marketing since joining the company seven years ago. Desmet Ballestra is involved in processing equipment and process engineering for the fats and oils industry.

Willits

Willits is currently the chair of the AOCS Processing Division.

Alfa Laval on TV

How 2 Media, the producers of the television show "World's Greatest!..." that appears in the United States on the ION network, selected Alfa Laval to be a part of its television series. "World's Greatest!..." is a 30-minute show that focuses on companies, products, places, and people of high repute.

Alva Laval was selected, according to Gordon Freeman, executive producer of the show, because "They are an innovative, worldwide company with separation, heat transfer and fluid handling products and solutions that are used in areas of vital importance for humanity, such as food and water supply, energy production, process optimization, environmental sustainability, and more. They have a valuable story to tell." The show featured interviews with key customers and footage filmed on-site.

The program aired twice in September and once in October. It is now available online at http://www.alfalaval.us.

AOCS member elected president of KFRI

Suk Hoo Yoon was elected as president of the Korea Food Research Institute (KFRI) in September for a three-year term. He is a charter member of the KFRI, having joined in 1988. He is also president-elect of the Korean Society of Food Science and Technology for 2012.

yoon

His research has involved lipid chemistry and biotechnology, lipid oxidation and prevention, refining and processing of fats and oils, single cell oil, and structured lipids using lipase and phospholipase.

Yoon has been a member of AOCS since 1979, and is currently secretary/treasurer of

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IN MEMORIAM

Lois Swart Crauer

Lois Swart Crauer, the first woman to serve on the AOCS Governing Board and the first to be elected AOCS secretary, died on September 1, 2011, at her birthplace in Hoffmans, New York. The AOCS emeritus member was 93.

Crauer

Crauer, born Lois Swart, grew up wanting to follow in the tracks of a great-grandfather who had been a surgeon in the Mohawk Valley in upstate New York. As a youngster, she enjoyed thumbing through his old medical books, which dated back to Revolutionary War days.

In college, Crauer majored in physiology and nutrition and minored in chemistry at the University of Rochester (New York, USA), from which she received her undergraduate degree in 1939.

In 1944, she accepted a position as a chemist with DeLaval Separator Co. (now Alfa Laval) in Poughkeepsie, New York, where she became a process chemist in the company's new Process Engineering Division during a time when the food industry was moving from batch operations into continuous processing. In those days, the few women who worked in the fats and oils area primarily worked in industry laboratories or for the government. It was quite rare to find a woman professional working in a plant facility.

In 1952, Crauer joined AOCS, where she continued to break new ground. In 1967, she was the first woman to be elected to the Governing Board, as a member-at-large. She was re-elected in 1968, and became the first woman elected secretary in 1969.

During her active years in the Society, Crauer co-chaired the 1966 short course on "Processing and Quality Control of Fats and Oils" and served on such committees as Communications, Scopes, Merit Award, Education, Meeting Logistics, Society Improvement, Oil Retention and Moisture, Volatile Matter in Filter Cake, Long-Range Planning and the *Journal of the*

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American Oil Chemists' Society (*JAOCS*). She wrote a number of papers on continuous processing, received the society's Award of Merit in 1975, and was profiled in *JAOCS* (*61*:64–68, 1984).

In 1975, Crauer retired from DeLaval to her rural roots in the Mohawk Valley, living at the family homestead where she had grown up.

Her husband of 37 years, Gordon Robert Crauer, preceded her in death. She is survived by two children, five grandchildren, and four great-grandchildren.

Giles Burdette Colbert, Sr.

Emeritus AOCS member Giles Colbert, late of Southaven, Mississippi, USA, died on August 2, 2011, at the age of 83. He had been an AOCS member since 1956.

Colbert was born in Pascola, Missouri, and graduated from high school in Mississippi at the age of 16. He served in the US Army during World War II and graduated from Arkansas State University (Jonesboro, USA) in 1953 with degrees in chemistry and mathematics.

He spent his career in the edible oils industry with AC Humko in Memphis, Tennessee, and Champaign, Illinois; and Riceland Foods in Stuttgart, Arkansas.

Colbert is survived by Bette B. Colbert, his wife of 56 years, and his son Galen. His son Giles Jr. preceded him in death.

Robert Martin Uschan

AOCS has been notified that Robert "Bob" Uschan died on March 30, 2011, at the age of 87.

Uschan served in the US military during World War II and earned his B.S. in chemical engineering from the University of Wisconsin-Madison in 1949.

When Uschan joined AOCS in 1958 he had already been employed by Orthmann Laboratories, Inc., of Milwaukee, Wisconsin, USA, for six years, in charge of the chemical laboratory of a meat packing plant manufacturing a full line of shortening products. During his career, he also worked for Ambrosia Chocolate (now part of ADM Cocoa) in Milwaukee and Donahue & Associates, and he also worked as a private consultant.

As well as being a 58-year member of AOCS, Uschan was a 58-year member of American Chemical Society.

Uschan is survived by his wife of 31 years, Jean; four stepchildren, and eight grandchildren.

the Biotechnology Division and secretary of the Asian Section.

Hammond moves to Champion Technologies

Charles Hammond, research associate with Sasol North America Inc. for 22 years, has moved to Champion Technologies Inc. (Fresno, Texas, USA). In his new position, his title is research fellow. Hammond first joined AOCS in 1991 and has been active as an associate editor, a board member and chair of the Surfactants and Detergents Division, and a member at large on the Governing Board of AOCS. He is currently on the Editorial Advisory Committee for the *Journal of Surfactants and Detergents*. He may be contacted at Charles.Hammond@Champ-Tech.com.


Hammond

Renmatix announces Advisory Board

Renmatix, the Kennesaw, Georgia (USA), producer of cellulosic sugars for the renewable chemical and fuels markets, announced at the end of August the addition of Ian Purtle to the company's Scientific Advisory Board.


Purtle

According to Manuk Colakyan, Renmatix's chief technology officer, "[Purtle] brings to the board rare experience with substantial technical and commercial insight in the biorenewable space. He is a respected bioindustry leader who knows exactly what Renmatix customers need on a deep technical level."

Purtle, who retired in June 2011 from his post as Cargill's chief scientist and director of Sustainable Energy, served as president of AOCS in 2009–2010. ■

AOCS Meeting Watch

April 29–May 2, 2012. 103rd AOCS Annual Meeting & Expo, Long Beach Convention and Entertainment Center, Long Beach, California, USA. Information: phone: +1 217-693-4821; fax: +1 217-693-4865; email: meetings@aocs.org; http://AnnualMeeting.aocs.org.

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September 30–October 4, 2012. World Congress on Oleo Science & 29th ISF Conference (JOCS/AOCS/KOCS/ISF Joint Conference), Arkas Sasebo, Nagasaki Prefecture, Japan. Information: http://www2.convention.co.jp/wcos2011/index.html.

■■■

October 29–31, 2012. Singapore 2012: World Conference on Fabric and Home Care, Shangri-La Hotel, Singapore. Information: email: meetings@aocs.org; phone: +1 217-693-4821; fax: +1 217-693-4865; email: meetings@aocs.org; http://singapore.aocs.org.

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April 28–May 1, 2013. 104th AOCS Annual Meeting & Expo, Palais des congrès de Montréal, Montréal, Québec, Canada. Information: phone: +1 217-693-4821; fax: +1 217-693-4865; email: meetings@aocs.org; http://AnnualMeeting.aocs.org.

For in-depth details on these and other upcoming meetings, visit www.aocs.org/meetings.

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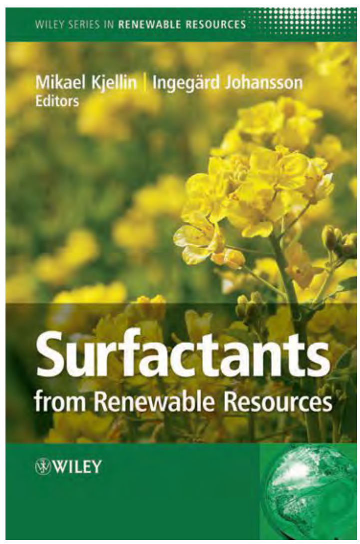
Book Review

Surfactants from Renewable Resources
Mikael Kjellin and Ingegard Johansson (eds.)
John Wiley & Sons, Ltd., 2010, 319 pages
ISBN 978-0-470-76041-3, $150.00

Charles Hammond

Surfactants from Renewable Resources presents a good overview of the development of biobased surfactants. It provides a starting point for those who want to understand the types of molecules that are working their way into the surfactant market. It also has information that positions the compounds into various market segments. Each chapter has a considerable number of references and ends with a conclusion on the status of the technology.



The book does a good job of outlining the synthesis routes for a large number of surfactants, as well as providing the appropriate molecular structures. The compounds covered include multifunctional fatty acids, nitrogen-containing molecules, forest product derivatives, carbohydrates, small organic acids, green ethylene, fermentation products, enzymes, biomass-based products, lecithin, lipids, saponin derivatives, polymers from cellulose, lignosulfates, and inulin.

The subject is timely, given the rapidly growing demand for oilfield surfactants and the fact that the use of surfactants in the chemically enhanced oil recovery market is projected to grow to twice the demand of the household detergent market—currently at 6 million metric tons per year— as reported in *inform* (*20*:682–685, 2009).

From an industrial chemist's perspective, the book does not present the hurdles one would need to overcome to get the products to market. That is, do the new surfactants have CAS numbers, do they need to be listed on inventories, are there ample starting materials available, are there side products or processing issues? In addition, it would have been helpful to see how the molecular structure relates to the phase diagram and/or the hydrophilic–lipophilic deviation equation. The authors did, however, focus on where the new surfactants function. In the end, I am glad I reviewed the book and have a copy on my shelf.

Charles Hammond is a research fellow with Champion Technologies in Fresno, Texas, USA, and has been an AOCS member since 1991. He can be reached at charles.hammond@champ-tech.com.

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Extracts & Distillates

MALDI imaging MS of phospholipids in the mouse lung

Zemski Berry, K.A., *et al.*, *J. Lipid Res.* *52*:1551–1560, 2011.

Lipid mediators are important in lung biochemistry and are derived from the enzymatic oxidation of arachidonic and docosahexaenoic acids, which are polyunsaturated fatty acids (PUFA) that are present in phospholipids in cell membranes. In this study, MALDI [matrix-assisted laser desorption ionization] imaging MS [mass spectroscopy] was used to determine the localization of arachidonate- and docosahexaenoate-containing phospholipids in mouse lung. These PUFA-containing phospholipids were determined to be uniquely abundant at the lining of small and large airways, which were unequivocally identified by immunohistochemistry. In addition, it was found that the blood vessels present in the lung were characterized by sphingomyelin molecular species, and lung surfactant phospholipids appeared evenly distributed throughout the lung parenchyma, indicating alveolar localization. This technique revealed unexpected high concentrations of arachidonate- and docosahexaenoate-containing phospholipids lining the airways in pulmonary tissue, which could serve as precursors of lipid mediators affecting airways biology.

Advances and perspectives in using microalgae to produce biodiesel

Amaro, H.M., *et al.*, *Appl. Energy* 88:3402–3410, 2011.

Carbon-neutral renewable liquid biofuels are needed to displace petroleum-derived transport fuels in the near future—which contribute to global warming and are of a limited availability. A promising alternative is conveyed by microalgae, the oil content of which may exceed 80% (w/w_{DW})—as compared with 5% of the best agricultural oil crops. However, current implementation of microalga-based systems has been economically constrained by their still poor

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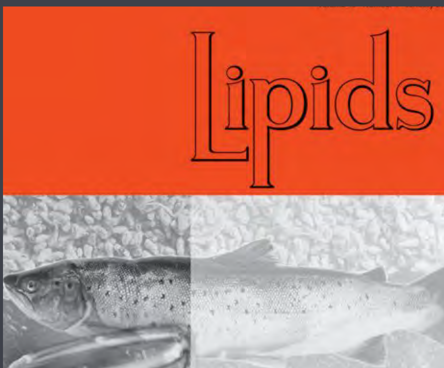
AOCS Journals

Journal of the American Oil Chemists' Society (October)

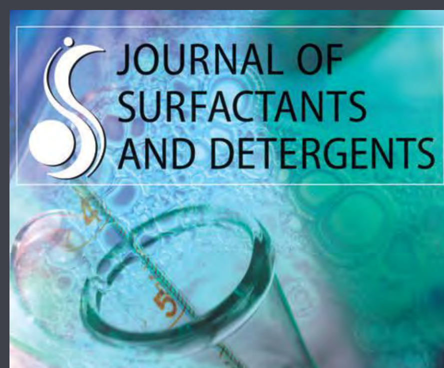
- Multivariate analysis of ^{1}H-NMR spectra of genetically characterized extra virgin olive oils and growth soil correlations, Papadia, P., L. Del Coco, I. Muzzalupo, M. Rizzi, E. Perri, G. Sesari, V. Simeone, D. Mondelli, F.P. Schena, and F.P. Fanizzi
- Application of a portable handheld infrared spectrometer for quantitation of *trans* fat in edible oils, Birkel, E., and L. Rodriguez-Saona
- Fatty acid profile including *trans* fatty acid content of margarines marketed in Mexico, Hernández-Martínez, M., T. Gallardo-Velázquez, and G. Osorio-Revilla
- Separation and determination of wax content using 100-Å Phenogel column, Aryusuk, K., S. Chumsantea, P. Sombatsuwan, S. Lilitchan, and K. Krisnangkura
- Influence of polydimethylsiloxane on the formation of 4-hydroxynonenal in soybean oil at frying temperature, Gerde, J.A., E.G. Hammond, and P.J. White
- Dry fractionation and crystallization kinetics of high-oleic high-stearic sunflower oil, Bootello, M.A., R. Garcés, E. Martínez-Force, and J.J. Salas
- Simultaneous quantification of oil and protein in cottonseed by low-field time-domain nuclear magnetic resonance, Horn, P.J., P. Neogi, X. Tombokan, S. Ghosh, B.T. Campbell, and K.D. Chapman
- Characterization of terebinth fruit oil and optimization of acidolysis reaction with caprylic and stearic acids, Koçak, D., H. Keskin, S. Fadıloğlu, B. Kowalski, and F. Göğüş
- Compositional and structural studies of the major and minor components in three Cameroonian seed oils by GC–MS, ESI-FTICR-MS and HPLC, Yeboah, S.O., Y.C. Mitei, J. Catherine Ngila, L. Wessjohann, and J. Schmidt
- Study on free lipase-catalyzed ethanolysis for biodiesel preparation in an oil/water biphasic system, Ren, H., W. Du, L. Lv, and D. Liu
- Preparation of diacylglycerol-enriched oil from free fatty acids using lecitase ultra-catalyzed esterification, Wang, L., Y. Wang, C. Hu, Q. Cao, X. Yang, and M. Zhao
- Enzymatic epoxidation of corn oil by perstearic acid, Sun, S., G. Yang, Y. Bi, and H. Liang
- Influence of polydimethylsiloxane on the degradation of soybean oil at frying temperature, Gerde, J.A., E.G. Hammond, and P.J. White
- Quantity and quality of free oil recovered from enzymatically disrupted soybean oleosomes, Towa, L.T., V.N. Kapchie, G. Wang, C. Hauck, T. Wang, and P.A. Murphy
- Adsorption of soy protein isolate in oil-in-water emulsions: difference between native and spray dried isolate, Keerati-u-rai, M., Z. Wang, and M. Corredig
- Characterization of fenugreek (*Trigonella foenum-graecum*) seed lipids, Ciftci, O.N., R. Przybylski, M. Rudzinska, and S. Acharya
- Highly stable nonionic fatliquors based on ethoxylated overused vegetable oils, Nashy, E.H.A., and G.A. Abo-ELwafa
- Comparison of flavor volatiles and some functional properties of different soy protein products, Wu, N., L. Wang, X. Yang, S. Yin, Z. Teng, and E. Zheng
- Effect of dehulling treatment on the oxidative stability of cold-pressed low erucic acid rapeseed oil, Yang, M., C. Liu, F. Huang, C. Zheng, and Q. Zhou
- Effects of oil extraction methods on physical and chemical properties of red salmon oils (*Oncorhynchus nerka*), Yin, H., K.M. Solval, J. Huang, P.J. Bechtel, and S. Sathivel
- Pilot-plant proof-of-concept for integrated, countercurrent, two-stage, enzyme-assisted aqueous extraction of soybeans, de Moura, J.M.L.N., D. Maurer, S. Jung, and L.A. Johnson

Publications



Lipids (October)

- JNK inhibition by SP600125 attenuates *trans*-10, *cis*-12 conjugated linoleic acid-mediated regulation of inflammatory and lipogenic gene expression, Martinez, K., A. Kennedy, and M.K. McIntosh
- 2-Polyunsaturated acyl lysophosphatidylethanolamine attenuates inflammatory response in zymosan A-induced peritonitis in mice, Hung, N.D., M.R. Kim, and D.-E. Sok
- Pleiotropic effects of a schweinfurthin on isoprenoid homeostasis, Holstein, S.A., C.H. Kuder, H. Tong, and R.J. Hohl
- Modified-policosanol does not reduce plasma lipoproteins in hyperlipidemic patients when used alone or in combination with statin therapy, Backes, J.M., C.A. Gibson, J.F. Ruisinger, and P.M. Moriarty
- Dyslipidemic diabetic serum increases lipid accumulation and expression of stearoyl-CoA desaturase in human macrophages, Wong, B.X.W., R.A. Kyle, P.C. Myhill, K.D. Croft, C.M. Quinn, W. Jessup, and B.B. Yeap
- Amadori-glycated phosphatidylethanolamine, a potential marker for hyperglycemia, in streptozotocin-induced diabetic rats, Sookwong, P., K. Nakagawa, I. Fujita, N. Shoji, and T. Miyazawa
- Leptospirosis is associated with markedly increased triglycerides and small dense low-density lipoprotein and decreased high-density lipoprotein, Gazi, I.F., F.A. Apostolou, E.N. Liberopoulos, T.D. Filippatos, C.C. Tellis, M.S. Elisaf, and A.D. Tselepsis
- *trans–trans* Conjugated linoleic acid enriched soybean oil reduces fatty liver and lowers serum cholesterol in obese Zucker rats, Gilbert, W., V. Gadang, A. Proctor, V. Jain, and L. Devareddy
- Regulation of phosphatidic acid levels in *Trypanosoma cruzi*, Gimenez, A.M., V.S. Santander, A.L. Villasuso, S.J. Pasquaré, N.M. Giusto, and E.E. Machado
- Fatty acid status determination by cheek cell sampling combined with methanol-based ultrasound extraction of glycerophospholipids (Methods), Klingler, M., H. Demmelmair, B. Koletzko, and C. Glaser



Journal of Surfactants and Detergents (Issue 4)

- Performance and microstructural study on soap using different fatty acids and cations, Nadarajan, R., and R. Ismail
- Physico-chemical studies on microemulsion: effect of cosurfactant chain length on the phase behavior, formation dynamics, structural parameters and viscosity of water/(polysorbate20 + *n*-alkanol)/*n*-heptane water-in-oil microemulsion, Paul, S., and A.K. Panda
- Surfactants based on bis-galactobenzimidazolones: synthesis, self-assembly and ion sensing properties, Lakhrissi, L., N. Hassan, B. Lakhrissi, M. Massoui, E.M. Essassi, J.M. Ruso, C. Solans, and C. Rodriguez-Abreu
- A novel zwitterionic imidazolium-based ionic liquid surfactant: 1-carboxymethyl-3-dodecylimidazolium inner salt, Liu, X., L. Dong, and Y. Fang
- New Schiff base cationic surfactants: surface and thermodynamic properties and applicability in bacterial growth and metal corrosion prevention, Negm, N.A., A.F. El Farargy, A.M. Al Sabagh, and N.R. Abdelrahman
- Synthesis and characterization of glycoside-based trisiloxane surfactant, Han, F., Y. Chen, Y. Zhou, and B. Xu
- Synthesis and properties of novel double-tail trisiloxane surfactants with high spreading ability, Peng, Z., S. Huang, and M. Cao
- Synthesis, characterization and surface-activity of hydroxyethyl group-containing quaternary ammonium surfactants, Yunling, L., L. Qiuxiao, Z. Lifei, and Z. Minghui
- Green production of anionic surfactant obtained from pea protein, Rondel, C., B. Portet, I. Alric, Z. Mouloungui, J.F. Blanco, and F. Silvestre
- Effect of inorganic additives on a conventional anionic–nonionic mixed surfactants system in aqueous solution, Khimani, M., and S. Vora
- Micellization behavior of cationic gemini surfactants in aqueous-ethylene glycol solution, Tikariha, D., B. Kumar, N. Singh, K.K. Ghosh, and P. Quagliotto
- Physicochemical studies on the interfacial and micellization behavior of CTAB in aqueous polyethylene glycol media, Manna, K., and A.K. Panda
- Precipitation and micellar properties of novel mixed anionic extended surfactants and a cationic surfactant, Panswad, D., D.A. Sabatini, and S. Khaodhiar
- Stabilization of gas bubbles released from water-soluble carbohydrates using amphiphilic compounds: preparation of formulations and acoustic monitoring of bubble lifetime, Hoff, L., P.A. Foss, K. Dyrstad, J. Klaveness, and P. Rongved
- Thermal characterization and flammability of polyester fiber coated with nonionic and cationic softeners, Rahimi, M.H., M. Parvinzadeh, M.Y. Navid, and S. Ahmadi
- Comparison of a cationic gemini surfactant and the corresponding monomeric surfactant for corrosion protection of mild steel in hydrochloric acid, Mahdavian, M., A.R. Tehrani-Bagha, and K. Holmberg
- Calculation of the interfacial rigidity term found in the HLD-NAC equation of state for microemulsions (Letter to the Editor), Hammond, C.E., and S. Congiundi
- Neumann, A.W., R. David, and Y. Zuo (eds.), *Applied Surface Thermodynamics*, 2nd edn. CRC Press, Taylor & Francis Group, Boca Raton, London, 2011 (Book Review), Salager J. L.

volumetric efficiencies—which lead to excessively high costs, as compared with petrofuel prices. Technological improvements of such processes are thus critical—and this will require a multiple approach, both on the biocatalyst and bioreactor levels. Several bottlenecks indeed exist at present that preclude the full industrial exploitation of microalgal cells: The number of species that have been subjected to successful genetic transformation is scarce, which hampers a global understanding (and thus a rational design) of novel blue-biotechnological processes; the mechanisms that control regulation of gene expression are not fully elucidated, as required before effective bioprocesses based on microalgae can be scaled up; and new molecular biology tools are needed to standardize genetic modifications in microalgae—including efficient nuclear transformation, availability of promoter or selectable marker genes, and stable expression of transgenes. On the other hand, a number of pending technological issues are also present: the relatively low microalga intrinsic lipid productivity, the maximum cell concentration attainable, the efficiency of harvest and sequential recovery of bulk lipids, and the possibility of by-product upgrade. This review briefly covers the state of the art regarding microalgae toward production of biofuels from the point of view, both of the microalgal cell itself and of the supporting bioreactor, and discusses, in a critical manner, current limitations and promising perspectives in this field.

Triglycerides and heart disease: still a hypothesis?

Goldberg, I.J., *et al.*, *Arterioscler. Thromb. Vasc. Biol. 31*:1716–1725, 2011.

The purpose of this article is to review the basic and clinical science relating plasma triglycerides and cardiovascular disease. Although many aspects of the basic physiology of triglyceride production, its plasma transport, and its tissue uptake have been known for several decades, the relationship of plasma triglyceride levels to vascular disease is uncertain. Are triglyceride-rich lipoproteins, their influence on high-density lipoprotein and low-density lipoprotein, or the underlying diseases that lead to defects in triglyceride metabolism the culprit? Animal models have failed to confirm that anything other than early fatty lesions can be produced by triglyceride-rich lipoproteins. Metabolic products of triglyceride metabolism can be toxic to arterial cells; however, these studies are primarily *in vitro*. Correlative studies of fasting and postprandial triglycerides and genetic diseases implicate very-low-density lipoprotein and their remnants and chylomicron remnants in atherosclerosis development, but the concomitant alterations in other lipoproteins and other risk factors obscure any conclusions about direct relationships between disease and triglycerides. Genes that regulate triglyceride levels also correlate with vascular disease. Human intervention trials, however, have lacked an appropriately defined population and have produced outcomes without definitive conclusions. The time is more than ripe for new and creative approaches to understanding the relationship of triglycerides and heart disease.

Essential fatty acids and psychiatric disorders

Perica, M.M., and I. Delaš, *Nutr. Clin. Pract. 26*:409–425, 2011.

Psychiatric disorders are a significant source of disability worldwide. Increasing evidence indicates that disturbances of fatty acids and phospholipid metabolism can play a part in a wide range of psychiatric, neurological, and developmental disorders in adults. Essential fatty acids, omega-3 and omega-6 polyunsaturated fatty acids, play a central role in the normal development and functioning of the brain and central nervous system. The aim of this article is to discuss the overall insight into roles of essential fatty acids in the development of mental disorders (depression, schizophrenia, bipolar disorder) and, in light of the fact that disturbances of fatty acid metabolism can play a part in the above-mentioned disorders, to investigate the current knowledge of lipid abnormalities in posttraumatic stress disorder. The information in this review was obtained after extensive MEDLINE searching of each topic area through relevant published studies from the past 20 years. References from the obtained studies were also used. This review summarizes the knowledge in terms of essential fatty acids intake and metabolism, as well as evidence pointing to potential mechanisms of essential fatty acids in normal brain functioning and development of neuropsychiatric disorders. The literature shows that omega-3 fatty acids provide numerous health benefits and that changes in their concentration in organisms are connected to a variety of psychiatric symptoms and disorders, including stress, anxiety, cognitive impairment, mood disorders, and schizophrenia. Further studies are necessary to confirm omega-3 fatty acids' supplementation as a potential rational treatment in psychiatric disorders.

LC-PUFA from photosynthetic microalgae: occurrence, biosynthesis, and prospects in biotechnology

Khozin-Goldberg, I., *et al.*, *Appl. Microbiol. Biotechnol. 91*:905–915, 2011.

Microalgae offer potential for numerous commercial applications, among them the production of long-chain polyunsaturated

CONTINUED ON PAGE 664

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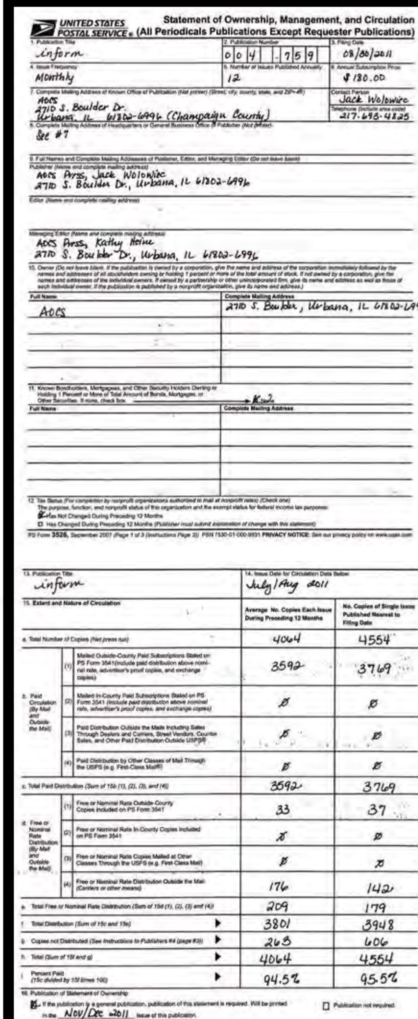

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Fat-soluble drug composition

Kikuchi, E., and S. Kawada, Riken Vitamin Co., US7947305, May 24, 2011

The present invention aims at providing a fat-soluble drug composition having improved absorbability of the fat-soluble component in the living body and being stable as a formulation specifically a fat-soluble drug composition for capsules. The present invention relates to a fat-soluble drug composition comprising a fat-soluble component and an emulsifier wherein the emulsifier contains diacetyltartaric and unsaturated fatty acid esters of glycerol and a glycerol ester of unsaturated fatty acid.

Modifications of solid 3-*sn*-phosphoglycerides

Yesair, D.W., *et al.*, Biomolecular Products, Inc., US7947306, May 24, 2011

Methods for hydrolyzing solid ungranulated lysophosphatidylcholine with phospholipase A_2 are provided. Also disclosed are methods for making a lipid matrix of lysophosphatidylcholine monoglyceride and fatty acid and lipid matrices of particular structure.

Low-*trans* fats for confectionery and bakery fat composition

Cleenewerck, B., *et al.*, Fuji Oil Co. Ltd., US7947323, May 24, 2011

The present invention relates to a process for the production of a fat composition for confectionery or baking applications. According to this process a starting fat composition containing palm oil or a palm oil fraction and having the following composition: (i) a glyceride composition with a S_2U content between 47 and 75 weight percent, a SU_2+U_3 content <40 weight percent, a S_3 content between 1 and 15 weight percent, a diglyceride content of 3 to 12 weight percent, the glyceride contents being expressed as weight percent with respect to the total amount of di- and triglycerides in which S means a saturated fatty acid with a hydrocarbon chain length of 14–24 carbon atoms and U means an unsaturated fatty acid with a hydrocarbon chain length of 14–24 carbon atoms, and (ii) a total content of unsaturated fatty acids of less than 55 weight percent, preferably less than 50 weight percent, more preferably less than 48 weight percent is subjected to a catalytic hydrogenation so as to obtain a first fat with a *trans* fatty acid content <weight percent, preferably <10 weight percent, most preferably <5 weight percent and an increase of C18-0 of less than 1 weight percent, preferably less than 0.7 weight percent, more preferably less than 0.4 weight percent. This first fat is incorporated in the fat composition.

Method of treating hypertension and reducing serum lipase activity

Wadstein, J., and J. Remmereit, Aker Biomarine ASA, US7947737, May 24, 2011

This invention relates to a method of treating hypertension and reducing serum lipase activity by dietary supplementation with conjugated linoleic acid. The method comprises administering a safe and effective amount of conjugated linoleic acid to a human. The conjugated linoleic acid may be provided in the form of a free fatty acid or chemical derivatives thereof in a pill or as a component of a prepared food product.

Agent for treating oil-polluted ground and for cleaning oil-contaminated surfaces and containers

Kroh, W., Swisstech Holding AG, US7947641, May 24, 2011

The invention relates to a concentrate for the effective environmentally friendly treatment of oil-polluted stretches of ground and the cleaning of oil-contaminated surfaces, said concentrate containing an emulsifier, a vegetable oil, and ethanol. The emulsifier is preferably a nonionic surfactant with an HLB [hydrophilic-lipophilic balance] value between 7 and 8. The vegetable oil is preferably selected so that it is liquid at temperatures above 5°C. Oils containing unsaturated fatty acids, in particular germ oils, are especially suitable. For its application as a treatment for stretches of ground, the inventive concentrate is diluted with water to form a cleaning solution and is applied to the oil-contaminated surface that is to be treated. The oil is emulsified in the inventive cleaning solution and is detached from the particles of the ground. The oil degrades in a significantly easier manner in the emulsified state. To clean oil-contaminated surfaces, the cleaning solution is sprayed onto the latter. In an advantageous embodiment of the inventive cleaning method, a powder-like adsorption agent is added to the oil emulsion that is formed during the cleaning of oil-tank interiors, said agent adsorbing the emulsified oil and forming a sediment with the latter.

Stabilized vegetable oils and methods of making same

Higgins, N.W., and J.F. Stults, Bunge Oils, Inc., US7947847, May 24, 2011

A method for modifying ethylenic unsaturation in a triglyceride. One or more unsaturated fatty acyl moieties present in the triglyceride are substituted with a lactone or ketone moiety via an electron acceptor-mediated reaction. The resulting reaction products are useful, for example, as formulations for lubricants, hydraulic fluids, dielectric fluids, and intermediates for polymer synthesis.

Method for preparing fatty acid esters of natural origin functionalized by oxidation for use as fluxing oils for bitumen

Deneuvillers, C., and L.C. Hoang, Colas SA; Valagro Centre de Valorisation Industrielles des Agroressources, US7951238, May 31, 2011

A method for preparing a fluxing oil having an iodine number ranging from 50 to 200 based on fatty substances of natural origin having been chemically functionalized by oxidation, includes the steps of: (i) providing a fatty substance or a mixture of fatty substances of natural origin, (ii) subjecting the fatty substance or the mixture of fatty substances of natural origin to at least one transesterification or esterification reaction by at least one alkanol or mono-alcohol, (iii) subjecting the compound or mixture of compounds obtained at step

(ii) to at least one chemical functionalization reaction by oxidation introducing at least one functional group selected from carboxylic acid, epoxy, peroxide, aldehydes, ether, ester, alcohol, and ketone groups, and (iv) collecting the fluxing oil.

Enzymatic hydrolysis of a polymer comprising vinyl acetate monomer

Borch, K., *et al.*, US7951267, May 31, 2011

The invention relates to the use of certain lipolytic enzymes such as cutinases and lipases in the manufacture of paper and paper products from recycled paper. Examples of such enzymes are derived from strains of *Humicola*, *Candida*, *Fusarium*, and *Pseudomonas*. By use of these enzymes, the problems relating to the so-called "stickies" derived from waste paper are reduced.

Methods for extending the shelf-life of food compositions containing polyunsaturated fatty acids

Lin, H.C., *et al.*, Hills Pet Nutrition, Inc., US7951493, May 31, 2011

A process for preparing a food composition by mixing a nutritive base with at least one long-chain polyunsaturated fatty acid; cooking the resulting mixture at a temperature not less than about 50°C; adding to the food composition at least one oxidatively protected long-chain polyunsaturated fatty acid; and packaging the resulting composition in an oxygen-depleted environment within a sealed container to provide the food product that exhibits (i) acceptable palatability to an animal and (ii) a shelf-life of at least about 6 months when stored at ambient temperature without opening the container.

Production of peracids using an enzyme having perhydrolysis activity

Gavagan, J.E., *et al.*, E.I. Du Pont de Nemours and Co., US7951566, May 31, 2011

A process is provided for producing peroxycarboxylic acids from carboxylic acid esters. More specifically, carboxylic acid esters are reacted with an inorganic peroxide such as hydrogen peroxide in the presence of an enzyme catalyst having perhydrolysis activity. The present perhydrolase catalysts are classified as members of the carbohydrate esterase family 7 (CE-7) based on the conserved structural features. Further disinfectant formulations comprising the peracids produced by the processes described herein are provided.

Method and apparatus for preparing fatty acid alkyl ester using fatty acid

Chun, S., *et al.*, SK Chemicals Co. Ltd., US7951967, May 31, 2011.

A method and an apparatus for preparing fatty acid alkyl ester for bio-diesels are disclosed, wherein fatty acid, specifically fatty acid distillate reacts with alcohol, without a catalyst. The method does not require the purification process of the catalyst and glycerin, and has the superior conversion ratio of fatty acid. The method for preparing fatty acid alkyl ester for bio-diesel fuels comprises the step of esterifying fatty acid raw material with alcohol under a temperature of 200–350°C and a pressure of atmospheric pressure to 10 bar. The apparatus for preparing fatty acid alkyl ester for bio-diesel fuels comprises: the first reactor for esterifying fatty acid raw material with alcohol under a temperature of 200–350°C and a pressure of atmospheric pressure to 10 bar and for converting 80–90% of total fatty acid into fatty acid alkyl ester; and the second reactor for converting remaining fatty acid unconverted at the first reactor into fatty acid alkyl ester.

Production of peracids using an enzyme having perhydrolysis activity

DiCosimo, R., *et al.*, E.I. du Pont de Nemours and Co., US7951567, May 31, 2011

A method is provided for producing peroxycarboxylic acids from carboxylic acid esters. More specifically, carboxylic acid esters are reacted with an inorganic peroxide such as hydrogen peroxide in the presence of an enzyme catalyst having perhydrolysis activity derived from *Bacillus* sp. to produce peroxycarboxylic acids.

Hydrogenated and partially hydrogenated heat-bodied oils and uses thereof

Bloom, P.D., and D.P. Holzgraefe, Archer Daniels Midland Co., US7951862, May 31, 2011

The present disclosure presents materials comprising hydrogenated and/or partially hydrogenated polymerized vegetable oils. Non-limiting applications of the polymerized oils, including coatings, binders, blends, and greases are presented. Methods for forming these materials are also disclosed.

Method for recycling and exploitation of the glycerin obtained in the production of biodiesel

Rabello, C.R.K., *et al.*, Petroleo Brasileiro SA–Petrobras, US7955402, June 7, 2011

A method to exploit the glycerin obtained as a by-product of the industrial process to produce biodiesel inside or out of the industrial production unit, providing a reduction in the environmental liability that may be caused by an excess in the production of glycerin that cannot be exploited for industrial use. The referenced method uses recycling of the glycerin obtained through industrial process to produce biodiesel, using a process basically consisting of four stages: (i) extracting glycerin produced as a by-product of the industrial process for producing biodiesel; (ii) hydrogenation of said *n*-propanol glycerin, (iii) recycling of the *n*-propanol thus obtained to be added to a mixture of alcohols; and (iv) transesterification of the *n*-propanol mixture added to the alcohol mixture, together with raw material triglycerides from renewable sources in order to obtain biodiesel. The referenced recycling of the *n*-propanol stream provides a reduction in the amount of the alcohol mixture necessary for the industrial process to produce biodiesel, consequently reducing operational costs.

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.

LAND-BASED OMEGA-3s (CONTINUED FROM PAGE 641)

recommended intake level of 0.25 g/day of EPA + DHA for adult males and nonpregnant, nonlactating adult females. (The US Institute of Medicine has not set Dietary Reference Intakes for either EPA or DHA.)

Canned (in water and drained) or fresh (bluefin cooked in dry heat) tuna contain anywhere from 0.23 to 1.27 grams of EPA + DHA per three-ounce serving, according to the US Department of Agriculture's Nutrient Composition Database. Thus, an intake range of 2.5 to 12 ounces is required to consume 1 gram of DHA + EPA. (These values are approximate, as variables such as species, diet, season, and cooking methods can alter levels.)

Fish oil supplements contain approximately 0.30 g of EPA + DHA per capsule, whereas a concentrate will contain 0.50 g per capsule (*Circulation 106*: 2747–2757, 2002). However, in 2003, the FAO/WHO cautioned that increasing dietary intake of fish needs to be weighed against the potential depletion of world marine food sources, underscoring the need for land-based sources of omega-3s.

Conventional soybean oil contains approximately 7% α-linolenic acid (ALA). Conversion of ALA to serum EPA is inefficient; studies suggest that intake of ALA results in a rise of serum EPA of only 0.2% to 7%, according to the Soymega website (www.soymega.com). Soymega soybean oil contains between 15 and 30% SDA, an omega-3 fatty acid that is an intermediate product in the conversion of ALA to EPA. Conversion of SDA to EPA in humans is more efficient than that of ALA to EPA; research indicates that intake of SDA results in an increase in serum EPA of between 16.7% and 26%, again according to the Soymega website. Foods made with the Monsanto/Solae Soymega soybean oil could deliver up to 375 mg of SDA oil per serving. Given the conversion factor, persons would need to consume between 4 and 6 g of SDA daily to convert it to 1 g of EPA.

A number of international research groups are working on the synthesis and accumulation of long-chain polyunsaturated fatty acids in transgenic plants such as linseed and Arabidopsis, according to QUALISOY, a third-party group formed by the United Soybean Board that provides marketing and research support for trait-enhanced soybean oils. QUALISOY helps bring enhanced soy oil traits to the market by collaborating with such groups, evaluating existing and emerging technologies, and determining which traits, products, and processes are the most beneficial for the industry and for end users.

Meanwhile, the market for omega-3 fatty acids is booming, according to market research firm, Packaged Facts, with nearly 1,300 introductions of new foods containing EPA or DHA in Europe and North America since 2007. Retail sales are expected to reach $8 billion by 2012.

Mary Lee Chin is a registered dietitian specializing in health communications. She is regularly consulted by local and national media on nutrition trends. She can be contacted at maryleechin@msn.com.

EXTRACTS & DISTILLATES (CONTINUED FROM PAGE 660)

fatty acids (LC-PUFA). These valuable fatty acids are important for a variety of nutraceutical and pharmaceutical purposes, and the market for these products is continually growing. An appropriate ratio of LC-PUFA of the omega-3 and omega-6 groups is vital for "healthy" nutrition, and adequate dietary intake has strong health benefits in humans. Microalgae of diverse classes are primary natural producers of LC-PUFA. This minireview presents an introductory overview of LC-PUFA-related health benefits in humans, describes LC-PUFA occurrence in diverse microalgal classes, depicts the major pathways of their biosynthesis in microalgae, and discusses the prospects for microalgal LC-PUFA production.

Replacing fossil oil with fresh oil—with what and for what?

Carlsson, A.S., *et al.*, *Eur. J. Lipid Sci. Technol. 113*:812–831, 2011.

Industrial chemicals and materials are currently derived mainly from fossil-based raw materials, which are declining in availability, are increasing in price, and are a major source of undesirable greenhouse gas emissions. Plant oils have the potential to provide functionally equivalent, renewable and environmentally friendly replacements for these finite fossil-based raw materials, provided that their composition can be matched to end-use requirements and that they can be produced on sufficient scale to meet current and growing industrial demands. Replacement of 40% of the fossil oil used in the chemical industry with renewable plant oils, whilst ensuring that growing demand for food oils is also met, will require a trebling of global plant oil production from current levels of around 139 million metric tons (MMT) to over 400 MMT annually. Realization of this potential will rely on application of plant biotechnology to (i) tailor plant oils to have high purity (preferably >90%) of single desirable fatty acids, (ii) introduce unusual fatty acids that have specialty end-use functionalities, and (iii) increase plant oil production capacity by increased oil content in current oil crops, and conversion of other high biomass crops into oil-accumulating crops. This review outlines recent progress and future challenges in each of these areas. Practical applications: The research reviewed in this paper aims to develop metabolic engineering technologies to radically increase the yield and alter the fatty acid composition of plant oils and enable the development of new and more productive oil crops that can serve as renewable sources of industrial feedstocks currently provided by nonrenewable and polluting fossil-based resources. As a result of recent and anticipated research developments, we can expect to see significant enhancements in quality and productivity of oil crops over the coming decades. This should generate the technologies needed to support increasing plant oil production into the future, hopefully of sufficient magnitude to provide a major supply of renewable plant oils for the industrial economy without encroaching on the higher priority demand for food oils. Achievement of this goal will make a significant contribution to moving to a sustainable carbon-neutral industrial society with lower emissions of carbon dioxide to the atmosphere and reduced environmental impact as a result. ■