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International News on Fats, Oils, and Related Materials

Nutricosmetics

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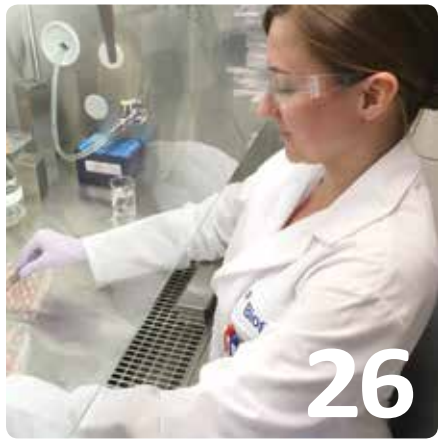

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Beauty FROM within

Laura Cassiday

Since ancient times, beauty and youthfulness have been inexorably linked. Yet the world's population is aging: According to predictions from the United Nations, by 2050 21% of the global population will be aged 60 years or older, compared with 10% in 2000 and 8% in 1950 (https://tinyurl.com/UN-aging, 2001). Along with the more serious health concerns that often accompany older age, many people over 40 worry about changes in their appearance such as greying or thinning hair, wrinkles, and sagging skin. They may even resort to expensive and invasive procedures such as cosmetic surgery or the injection of botulinum toxin (BOTOX) or dermal fillers. But what if youthfulness could be restored simply by taking a daily dietary supplement or sipping a "beauty beverage"?

- **"Beauty from within" refers to the growing nutricosmetics market, which seeks to restore skin youthfulness through supplements and functional foods and beverages.**
- **Popular nutricosmetic ingredients include collagen peptides, astaxanthin, tomato and rosemary extracts, and resveratrol.**
- **Although some ingredients show promising results in preclinical and clinical studies, larger, better-designed clinical trials are needed to establish effectiveness.**

Such is the promise of the booming nutricosmetics industry, which seeks to restore "beauty from within" through a variety of ingestible skin-, hair-, and nail-boosting supplements. The global market for nutricosmetics reached US $5.13 billion in 2016 and is expected to grow at a compound annual growth rate (CAGR) of 5% between 2017 and 2025 (Transparency Market Research, 2017). In addition to capsule and tablet forms, nutricosmetics are commonly available as powders that can be added to water, juice, or smoothies, and as confectionery items such as chocolates, bars, or gummies. Although conclusive scientific evidence for the efficacy of most nutricosmetics is lacking, promising *in vitro*, animal, and human data highlight the potential of beauty from within.

BEAUTY FOOD

Beauty from within is not a novel concept for the Asian market, where the movement has its origins. In Asia, and particularly in Japan, nutricosmetics such as collagen are commonly found in foods and beverages including tea, cookies, chocolate, coffee, and water. The acceptance of nutricosmetics is generally higher in Asia than in Europe or the United States because many nutricosmetic ingredients, such as green tea and bone broth, are linked to traditional Asian medicine (Gunn, L., and Creasy, P., https://tinyurl.com/nutrition-beauty, 2017a). In general, EU and US consumers tend to be more skeptical of the idea of "beauty foods" and are more likely to demand scientific backing for such claims (Gunn, L., and Creasy, P., https://tinyurl.com/nutrition-collagen, 2017b).

Similar to Asia, the Latin American market is highly receptive to the concept of beauty from within. From 2012 to 2016, Latin America showed the fastest growth in new collagen product launches at 33% CAGR, followed by Asia at 23% (Innova Market Insights, 2017). In contrast, North America and Europe had much slower rates of growth in product launches containing collagen, with CAGRs of 16% and 11%, respectively.

Different markets have different priorities for beauty from within products. In Asia, the focus is often skin whitening, whereas in the United States and Europe, consumers desire UV protection and wrinkle-smoothing products (Gunn, L., and Creasy, P., https://tinyurl.com/nutrition-regional, 2017c). Although beauty beverages predominate in Asia, nutricosmetics in the form of tablets, soft-gels, or capsules are more popular in the United States and Europe.

AGING SKIN

Skin aging results from both intrinsic and extrinsic factors (Spiro, A., and Lockyer, S., http://dx.doi.org/10.1111/nbu.12304, 2018). Intrinsic skin aging is genetically determined and is influenced by individual skin properties and changing hormone levels as a person ages. Extrinsic aging is caused by environmental factors such as sun exposure, pollution, smoking, and nutrition. Most aging-related changes in the skin can be traced to a lifetime of exposure to the sun. UV rays penetrate the skin and trigger the production of reactive oxygen species and matrix metalloproteinases that degrade collagen, the main structural protein in the extracellular matrix of connective tissues such as skin, cartilage, and bone. After age 30, collagen degrades at a rate of 1–2% per year (Shuster, S., *et al.*, https://doi.org/10.1111/j.1365-2133.1975.tb05113.x, 1975).

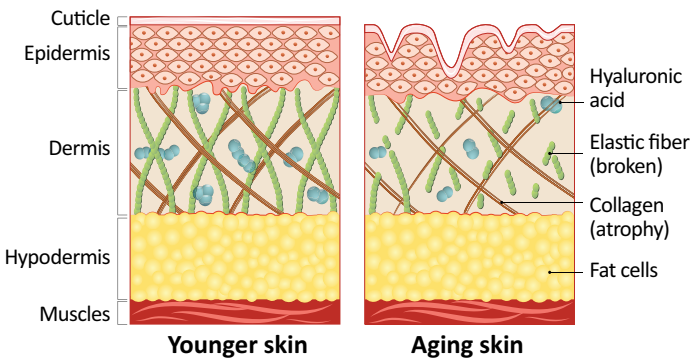

FIG. 1. The structure of younger skin (left) versus aging skin (right). In the dermis, fragmentation of collagen and elastin fibers and reduced hyaluronic acid with aging cause skin thinning, wrinkling, and dryness. Credit: Shutterstock

The breakdown of collagen and elastic fibers in the dermis contributes to thinning, sagging, wrinkling, and loss of elasticity in the skin (Fig. 1). In addition, UV radiation damages DNA in skin cells and accelerates the degradation of hyaluronic acid, a glycosaminoglycan important for retaining moisture in the skin.

Most topical cosmetic products cannot penetrate past the epidermis, the outermost layer of the skin. In contrast, if nutricosmetics are sufficiently bioavailable, they can circu-

late throughout the body, allowing them to reach the dermis where they can have more profound effects on skin structure. "Topical applications affect only the epidermis, and those results are generally more superficial and temporary," says Lara Niemann, Marketing Director for the Americas at GELITA USA, a manufacturer of collagen peptides with US headquarters in Sergeant Bluff, Iowa. "When ingested orally, collagen peptides affect the dermal layer of the skin, so it really is beauty from within."

TRENDING INGREDIENTS

For decades, physicians have recognized the value of micronutrients such as vitamin C, vitamin A, zinc, and biotin for skin health because dietary deficiencies can cause skin conditions, among other problems. In addition, antioxidants, such as vitamins E and C, have long been recommended to mitigate oxidative damage in skin, although consistent evidence for their efficacy is lacking. The current crop of popular nutricosmetics includes more complex ingredients harvested from natural sources, such as collagen peptides, astaxanthin, tomato and rosemary extracts, and resveratrol.

Collagen peptides

Collagen is the most abundant protein in humans, comprising about 30% of the protein in the body and 75% of the protein in skin. However, consuming bone broth or other products containing whole collagen is likely ineffective for boosting collagen in the skin. The digestive process breaks whole collagen into fragments of various sizes that are not specifically targeted to skin cells. Therefore, some companies have developed specific collagen peptides that they claim survive digestion and localize to the skin.

GELITA is a producer of gelatin, collagen, and collagen peptides, with worldwide headquarters in Eberbach, Germany (www.gelita.com). The company extracts collagen from bovine and porcine bone and skin, which are byproducts of the meat industry. The collagen is partially hydrolyzed to produce gelatin, a gelling agent used in marshmallows, gummies, and other foods. By treating the hydrolyzed collagen with proprietary enzymes, GELITA scientists produce specific collagen peptides with unique functions. They can then isolate particular peptides or mixtures of peptides. "GELITA has a comprehensive portfolio of bioactive collagen peptides, all of which have been optimized to target different cells of the body," says Niemann, "Our product VERISOL targets cells in the dermis for skin health. Other products target osteoblasts for bone health, or chondrocytes and the extracellular matrix of joint cartilage for joint health."

According to Niemann, the collagen peptides bind to specific receptors on the surfaces of cells. For example, the collagen peptides in VERISOL bind to receptors found only on dermal fibroblasts, targeting the peptides to the skin. The receptors recognize the collagen peptides as collagen degradation products. The binding of the collagen peptides to the receptors stimulates the cells to produce more collagen, as well as other extracellular matrix components, to counteract the perceived collagen degradation. The collagen peptides also provide cells with amino acid building blocks to produce more collagen.

Critics have argued that collagen peptides are degraded into individual amino acids upon digestion and therefore could not exert specific effects on skin cell receptors. An upcoming article in the June 2018 issue of *Inform* will describe how researchers demonstrated that the ingestion of collagen hydrolysate increased blood plasma levels of bioactive collagen peptides, such as prolyl-hydroxyproline, in humans (original research in Iwai, K., *et al.,* https://doi.org/10.1021/jf050206p, 2005).

Animal studies suggest that collagen peptides have beneficial biological effects on skin (reviewed in Proksch, E., *et al.*, https://doi.org/10.1159/000351376, 2014). In one study, ingested collagen peptides increased the size and density of dermal fibroblasts and increased the density of collagen fibers in pig skin. In rats, collagen peptides significantly increased collagen production and reduced the expression of matrix metalloproteinase-2, an enzyme that degrades collagen.

Several clinical trials of collagen peptides have been conducted in humans. In a double-blind, placebo-controlled trial

FIG. 2. Eye wrinkle appearance before (A) and after (B) 8 weeks of supplementation with GELITA VERISOL collagen bioactive peptides
Credit: GELITA AG

of GELITA VERISOL, 69 women aged 35–55 years were randomized to receive 2.5 g VERISOL, 5 g of VERISOL, or a placebo once daily for 8 weeks (Proksch, E., *et al.*, https://doi.org/10.1159/000351376, 2014a). The women consumed VERISOL as a powder dissolved in water or another cold liquid. Relative to the placebo, both doses of VERISOL showed significant improvements in skin elasticity, which was measured by the extension of skin in response to a suction vacuum. After 8 weeks, the mean increase in skin elasticity was 7% for both of the VERISOL groups, with some women experiencing as much as 30% increased elasticity. There were no statistically significant changes from placebo in skin hydration, transepidermal water loss, or skin roughness. However, this study was conducted on skin of the inner forearm, which makes it difficult to extrapolate the results to facial skin.

The same researchers conducted another double-blind, placebo-controlled study of VERISOL in 114 women aged 45–65 years, this time examining wrinkles in the eye area ("crow's feet") (Proksch, E., *et al.*, https://doi.org/10.1159/000355523, 2014b). The women were randomized to receive either 2.5 g VERISOL or a placebo once daily for 8 weeks. After 8 weeks, the VERISOL group had a mean 20.1% reduced eye wrinkle volume compared with placebo (Fig. 2). The maximum reduction in eye wrinkle volume was 49.9%. Four weeks after the last dose, the VERISOL group still showed a mean 11.5% reduction in eye wrinkle volume, suggesting that the effects were relatively long-lasting.

The researchers also examined the amounts of collagen, elastin, and fibrillin in the skin of a subset of the participants by inducing a blister on the forearm with suction and then collecting the fluid with a syringe. They found that the amount of procollagen type 1 (one of two types of collagen proteins that combine to make a collagen fibril) increased by 65% after 8 weeks in the VERISOL group compared with the placebo group. Elastin content increased 18% compared with placebo, whereas there was no significant difference between groups in the amount of fibrillin (another extracellular matrix protein found in skin).

A recent double-blind, placebo-controlled study examined the effects of collagen peptides from a different supplier, Nitta Gelatin Inc. (Osaka, Japan), on facial skin (Inoue, N., *et al.*, https://doi.org/10.1002/jsfa.7606, 2016). Nitta's Wellnex collagen peptides are enriched in two key dipeptides, prolyl-hydroxyproline (Pro-Hyp) and hydroxyprolyl-glycine (Hyp-Gly). *In vitro* studies have shown that these dipeptides enhance the proliferation of dermal fibroblasts. Pro-Hyp also chemically attracts dermal fibroblasts and increases their production of hyaluronic acid. The study included 85 Chinese women who consumed 5 g daily of Wellnex collagen peptides, which were ingested orally in hot milk, coffee, or other beverages, for 8 weeks. A mixture of collagen peptides containing a high ratio of Pro-Hyp and Hyp-Gly significantly improved facial skin moisture, elasticity, wrinkles, and roughness compared with the placebo.

In addition to possible benefits for facial skin, collagen peptides may help improve the appearance of cellulite—the skin dimpling of the thighs and buttocks that affects 85% of the global female adult population (Schunck, M., *et al.*, https://doi.org/10.1089/jmf.2015.0022, 2015). A double-blind, placebo-controlled study examined the effects of VERISOL collagen peptides on 105 normal and overweight women aged 24–50 years with moderate cellulite. The researchers found that a 2.5 g daily dose of VERISOL collagen peptides administered for 6 months significantly improved the cellulite score, reduced skin waviness on thighs, and increased dermal density compared with the placebo. The effects were more pronounced for normal-weight women: These women showed a mean reduction of 9% in cellulite score compared with placebo, versus a mean 4% reduction in cellulite score for overweight women. The researchers proposed that the improvements in cellulite appearance could result from increased synthesis of dermal connective tissue, which improved skin strength and elasticity.

A recent open-label clinical trial suggested that collagen peptides also improve the health and appearance of fingernails (Hexsel, D., *et al.*, https://doi.org/10.1111/jocd.12393, 2017). Twenty-five participants took 2.5 g of VERISOL once daily for 24 weeks. At the end of the treatment period, nail growth rate had increased by 12%, and the frequency of broken nails had decreased by 42%. Nail brittleness improved in 64% of participants, and 80% of participants said the treatment improved the appearance of their nails. However, this study must be repeated with larger numbers, blinding, and a placebo group before definitive conclusions can be made.

Collagen peptides have properties that make them highly functional as ingredients for food and beverage formulations, says Niemann. "They are neutral in taste, neutral in color, highly dissolvable, and dispersible, so that lends them very well to any number of different applications," she says. These "functional food" applications include beverages, dairy products such as yogurts and smoothies, bars, and gummies.

Astaxanthin

Another popular ingredient in the beauty from within category is astaxanthin, a carotenoid antioxidant. Astaxanthin (3,3'-dihydroxy-β-carotene-4,4'-dione; Fig. 3) is the red-orange pigment that gives shrimp, lobster, and salmon their brilliant color. The richest natural source of astaxanthin is the microalga *Haemotococcus pluvialis*.

"Microalgae have been on the planet for billions of years and have managed to survive all kinds of climactic changes and disasters using very unique survival mechanisms," says Efrat Kat, Vice President of Marketing and Sales at Algatechnologies Ltd., in Ketura, Israel (www.algatech.com). One of these survival mechanisms, which involves astaxanthin, allows microalgae to survive during bouts of intense sunlight. Under these conditions, *H. pluvialis* forms cysts, during which the cells produce high levels of astaxanthin to help cope with environmental stress (Fig. 4). "The role of the astaxanthin is to protect the photosynthetic apparatus of the algae from sun radiation and other environmental stress," says Kat. "Exactly the same as astaxanthin protects the algae, it can protect our skin."

The chemical structure of astaxanthin allows the molecule to span cellular membranes. Hydrophilic head groups project into the cytoplasm and extracellular environment, whereas the nonpolar carbon chain resides amidst the fatty acid tails in the phospholipid bilayer. This structure facilitates electron transfer from free radicals along the conjugated double bonds of the molecule to an acceptor molecule, such as vitamin C. In human dermal fibroblasts, astaxanthin attenuates the UVA-induced increase in expression of two enzymes that break down the collagen and elastin networks in the dermis—matrix metalloproteinase-1 and skin fibroblast elastase (Suganuma, K., *et al.*, https://doi.org/10.1016/j.jdermsci.2010.02.009, 2010).

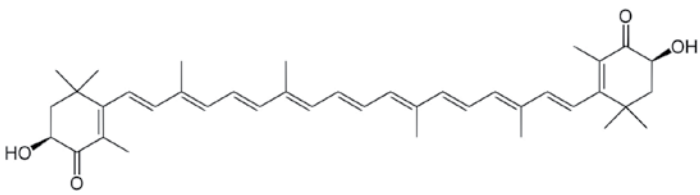

FIG. 3. Structure of astaxanthin Credit: Wikimedia Commons

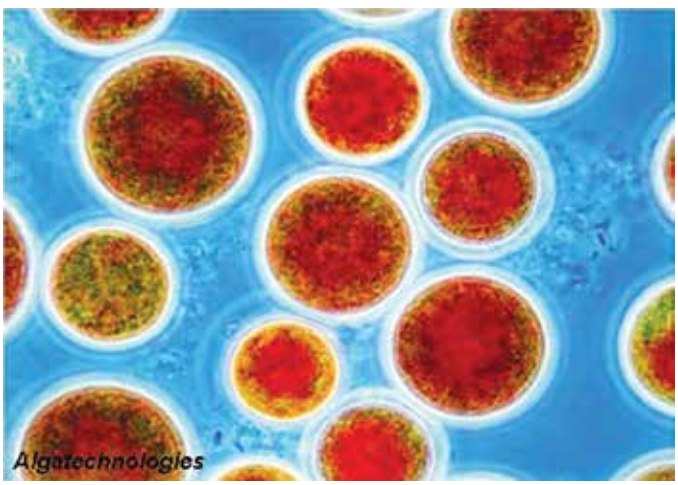

FIG. 4. *H. pluvialis* cysts, which naturally produce high amounts of astaxanthin (red pigment) under conditions of intense sunlight Credit: Algatechnologies Ltd.

Algatechnologies produces astaxanthin from *H. pluvialis* cultivated in about 600 km (373 miles) of closed tubular photobioreactors exposed to natural sunlight. The Algatechnologies production facility is located in the Arava Desert of southern Israel. "It's one of the most arid places on earth, and we have very high sun radiation year round," says Kat. She notes that Algatechnologies has identified a species of *H. pluvialis*, named the "Arava species," that produces particularly high amounts of astaxanthin under these conditions. "If you take the same species and grow it in a different location or use a different technology, you will not get the same results," she says. "It's a combination of the species, the technology, and the location that gives us the best results." Algatechnologies scientists extract astaxanthin from the cells using supercritical carbon dioxide technology to ensure a highly pure, solvent-free product known as AstaPure.

Few high-quality clinical trials on the skin benefits of astaxanthin have been reported. In a randomized, double-blind, placebo-controlled study of 36 healthy males aged 20–60 years, supplementation with 6 mg AstaREAL astaxanthin (Tokyo, Japan) for 6 weeks improved the area and volume of crow's feet wrinkles by about 16% and 15%, respectively, compared with the placebo (Tominaga, K., *et al.*, *Acta Biochim. Pol 59*, 43–47, 2012). In addition, skin elasticity improved by 5%, and transepidermal water loss decreased by almost 20% in the AstaREAL group compared with placebo.

In another study, researchers examined changes in systemic oxidative stress and residual skin surface components upon astaxanthin supplementation in 31 volunteers aged 40–80 years (Chalyk, N. E., *et al.*, https://doi.org/10.1016/j.nutres.2017.10.006, 2017). The volunteers consumed 4 mg per day of astaxanthin (Lycotec Ltd., Cambridge, UK) for 4 weeks. Then researchers took blood samples and measured levels of plasma malondialdehyde (MDA), which is a biomarker of systemic oxidative stress. They found that the mean MDA concentration in blood plasma decreased from baseline by 11.2% on day 15 and by 21.7% on day 29 of astaxanthin supplementation.

Residual skin surface components (RSSC) consist of a mixture of lipids produced by sebaceous glands and epidermal cells, desquamated corneocytes, and sweat. The researchers found that at the end of the study, participants had decreased levels of corneocyte desquamation and microbial stress—two characteristics that are associated with younger skin. These differences from baseline were more pronounced in obese subjects, possibly because a higher body mass index (BMI) has been associated with increased oxidative stress. Therefore, obese people may show a stronger response to the antioxidant effect of astaxanthin. This study was limited by a small sample size and no placebo group.

According to Kat, Algatechnologies offers a variety of different delivery forms of astaxanthin. "We can supply astaxanthin as a carotene oil form, powder, tablets, water-dispersible powder, or emulsion," she says. "We try to offer all of the possible solutions so our customers can develop almost any type of product." Kat notes that because astaxanthin is a dark red pigment, it is difficult to incorporate the high dosages found in oral supplements into topical creams. "To keep the cream at the desired color, you must use a very low dosage of astaxanthin," she says.

Cambridge Chocolate Technologies (Cambridge, UK) has produced a dark chocolate bar that is enriched with astaxanthin. One bar contains about 11.4 mg astaxanthin—roughly the same amount as 300 g salmon. In addition to astaxanthin, the cocoa flavanols in the chocolate act as antioxidants, the developers say.

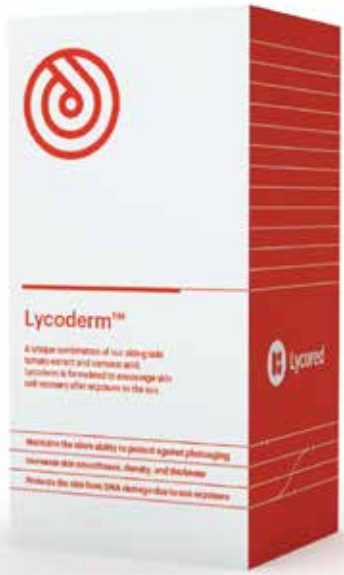

FIG. 5. Lycoderm, a combination of standardized tomato and rosemary extracts formulated to help protect skin from UV damage and other environmental stress Credit: Lycored

Tomato/rosemary extracts

A synergistic effect between lycopene from tomatoes and carnosic acid from rosemary underlies Lycoderm, Lycored's proprietary carotenoid blend for skin health (Fig. 5). Lycored, with headquarters in Be'er Sheva, Israel, was established in 1995 "with a vision to bring the health benefits of the tomato to people around the world," says Golan Raz, head of the Global Health Division at Lycored. "The company developed proprietary tomato breeds together with unique extraction and validation methods." In addition to Lycoderm, Lycored offers supplements for heart health (Cardiomato), menopause (Lycofem), eye health (Lycoinvision), and prostate health (Lycopro).

Lycoderm's tomato extract contains the carotenoids lycopene, phytoene, and phytofluene, which function as antioxidants. Carnosic acid from rosemary is also a potent antioxidant. In May 2017, Lycored was awarded the NutraIngredients Award for Best University Research for a study published in the *British Journal of Dermatology*. The placebo-controlled, double-blind, randomized, cross-over study examined the ability of Lycoderm, lutein, or a placebo to dampen the expression of three genes that are induced by UV radiation: *HO1* (an indicator of oxidative stress), *ICAM1* (involved in skin inflammation), and *MMP1* (involved in collagen breakdown) (Grether-Beck, S., *et al.*, https://doi.org/10.1111/bjd.15080, 2017).

In this study, 65 healthy volunteers aged 18–60 years were allocated to four treatment groups. Each group either started with the active treatment (Lycoderm or lutein) for 12 weeks and then switched to the placebo for 12 weeks, or vice versa. At the beginning and end of each treatment phase, the participants' skin was mildly irradiated with UV light, and 24 hours later, skin samples were taken for gene expression analysis by reverse transcriptase–polymerase chain reaction (RT-PCR).

Lycoderm inhibited the UV-induced upregulation of *HO1*, *ICAM1*, and *MMP1*, in either crossover sequence (before or after placebo). In contrast, lutein inhibited UV-induced gene expression if it was taken in the first sequence (before placebo), but worked less well in the second sequence (after placebo). The researchers do not currently know the mechanism behind this observation, but consistent with previous studies, the combined effects of tomato phytonutrients appear to be stronger than any one phytonutrient for protection from UV skin damage. UVA1 radiation is known to generate singlet oxygen, which initiates radiation-induced gene expression. Carotenoids, especially lycopene, can quench singlet oxygen.

Resveratrol

Resveratrol, a phenol found in grapes, berries, peanuts, and Japanese knotweed, has antioxidant and anti-inflammatory properties (Fig. 6). In pre-clinical studies, resveratrol was shown to inhibit the UV-induced activation of pro-inflammatory transcription factors and activate enzymes and transcription factors that combat reactive oxygen species (Farris, P., *et al., J. Drugs Derm. 12*, 1389–1394, 2013). Resveratrol may also play a role in mitochondrial biogenesis. Some have proposed that resveratrol, famously found in red wine, underlies the so-called French paradox: the observation that despite eating a diet rich in saturated fats, French people have a low incidence of heart disease. "Although resveratrol is naturally found in red wine, it's only in very small amounts," says Clare Panchoo, sales director for Evolva (Reinach, Switzerland) in Europe, the Middle East, and Africa. "You'd have to drink around 75 glasses of wine in one day to get an effective dose of resveratrol."

Although resveratrol is unlikely to explain the French paradox, the molecule has been studied widely for possible effects on heart disease, cancer, and life extension. Recently, researchers have begun to explore the use of resveratrol for skin health. Some small-scale studies have hinted at effects of topical resver-

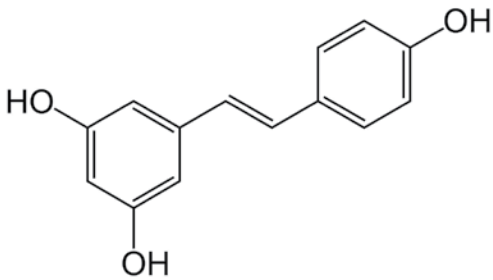

FIG. 6. Structure of resveratrol Credit: Wikimedia Commons

atrol in anti-aging, skin whitening, acne, and psoriasis. Thus far, no studies have reported effects of ingested resveratrol by itself on skin health, although one study examined a dietary supplement containing both resveratrol and the polyphenol procyanidin (Buonocore, D., *et al.*, https://doi.org/10.2147/CCID.S36102, 2012). The researchers found that the combined supplement decreased systemic oxidative stress, improved skin moisturization and elasticity, diminished skin roughness and depth of wrinkles, and decreased the intensity of age spots.

Evolva produces a food-grade form of resveratrol, called Veri-te, through a yeast fermentation process. The product is off-white, odorless, and colorless. "Today, resveratrol is mainly available in supplement form, but Evolva's Veri-te brand is focused on helping expand the application possibilities," says Panchoo. "Currently, it is challenging to incorporate resveratrol into functional beverages because it is not soluble. This spring, the Veri-te brand will launch an ingredient innovation that will enable cold-water dispersion of resveratrol."

Thus far, the biggest challenge facing ingested resveratrol has been its poor *in vivo* bioavailability (Ndiaye, M., *et al.*, https://doi.org/10.1016/j.abb.2010.12.030, 2011). In mammals, resveratrol is quickly metabolized in the liver, often within 30–60 minutes of ingestion. "More than 10,000 studies on resveratrol have been published, including 200 clinical trials, and many have identified the beneficial effects of oral resveratrol for indications ranging from cognitive and bone health to cardiovascular and skin health," says Panchoo. "Therefore, resveratrol might have low bioavailability, but it has high bioactivity."

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THE FUTURE OF BEAUTY?

Although beauty foods, drinks, and supplements require more research to firmly establish their benefits, mechanisms, and possible risks, beauty from within is likely to be an attractive and intuitive concept for many consumers. An open question is whether people will be satisfied with or even notice the relatively modest improvements (usually on the order of 10–20%) demonstrated thus far for skin characteristics such as moisture, elasticity, and wrinkle depth. In any case, consumers should not expect miraculous or instantaneous transformations. "We know it takes a while for the skin's metabolism to slow and wrinkles to form, so it's only natural that supplementation to improve these things is going to take time, as well," says Niemann. "It's not that you take VERISOL collagen peptides today, and your skin looks better tomorrow."

Other ingredients not discussed in this article have shown promise as skin-boosting supplements in some studies, such as probiotics, prebiotics, coenzyme Q10, and hyaluronic acid. It is likely that a combination of ingredients, rather than any one, in both topical and supplement forms will provide the greatest benefits to skin health. "A nice trend we see developing is the combination of nutritional and topical products into one holistic approach," says Raz. "This trend is well supported by a growing awareness among consumers of the importance of a multi-factorial approach when it comes to skin's health, longevity, and beauty. One aspect, no matter how sophisticated it is, will not provide the long-term foundation for lasting health and beauty."

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AOCS MEETING WATCH

May 6–9, 2018. AOCS Annual Meeting & Expo, Minneapolis Convention Center, Minneapolis, Minnesota, USA.

September 6, 2018. JOCS AOCS Joint Symposium, Kobe Gakuin University, Arise Campus, Kobe, Japan.

September 9–11, 2018. Canadian Section of the AOCS (CAOCS) to host 26th CAOCS Canadian Lipid & Bioresource Conference, Saskatoon, Saskatchewan, Canada.

October 28–31, 2018. Fabric and Home Care World Conference, Boca Raton Resort & Club, Boca Raton, Florida, USA.

May 5–8, 2019. AOCS Annual Meeting & Expo, America's Center Convention Complex, St. Louis, Missouri, USA.

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Plant-based proteins: an alternative to synthetic emulsifiers

Cansu Ekin Gumus

- **Food companies are trying to find natural alternatives to synthetic emulsifiers, and plant-based proteins are promising options.**
- **Legume proteins were shown to have emulsion formation and stability characteristics and lipid oxidation rates similar to those of emulsions stabilized by dairy proteins.**
- **Digestibility is not an issue when plant-based proteins are used as emulsifiers.**

As consumers become more aware of how their diets affect their health and the environment, they are changing their dietary habits and trying to make healthier and more sustainable choices. A few of the statements they look for on food labels include "all natural", "clean-label", "earth-friendly", "pure", and plant-based." Consequently, food companies feel the need to make a shift and replace synthetic or animal-based ingredients with natural and sustainable alternatives. Meanwhile, media propaganda advising consumers "not to eat it if you cannot pronounce it," makes consumers even more skeptical of ingredients with complex names they do not recognize. Hence, to stay strong in the food market, food producers are trying to use simpler, easier-to-understand ingredients. Some companies even woo consumers by giving their ingredients unique names that sound more natural, such as "evaporated sugar cane juice" instead of "sugar."

Meanwhile, the functional food market is growing due to the higher expectations consumers have for food products. When a millennial eats a snack, she/he expects not only to satisfy hunger, but also to receive a beneficial health effect. Unfortunately, most of the ingredients that give health benefits are not very stable or compatible with food matrixes. Therefore, food emulsions are becoming more popular in the food industry, because they can overcome solubility and degradation issues and increase the bioavailability of nutrients.

To highlight the high protein content, sustainable production, high availability, and low-cost of legumes, the United Nations named 2016 "the year of pulses." Recent interest in finding natural alternatives to animal-based or synthetic emulsifiers has since led researchers to focus on plant-based emulsifiers. Among these, pulse proteins are of specific interest due to the above-mentioned advantages.

EMULSION FORMATION AND STABILITY

Emulsions consist of a liquid phase dispersed in another liquid. Many foods come in emulsion form, such as mayonnaise, soups, salad dressings, milk, sauces, and ice cream.

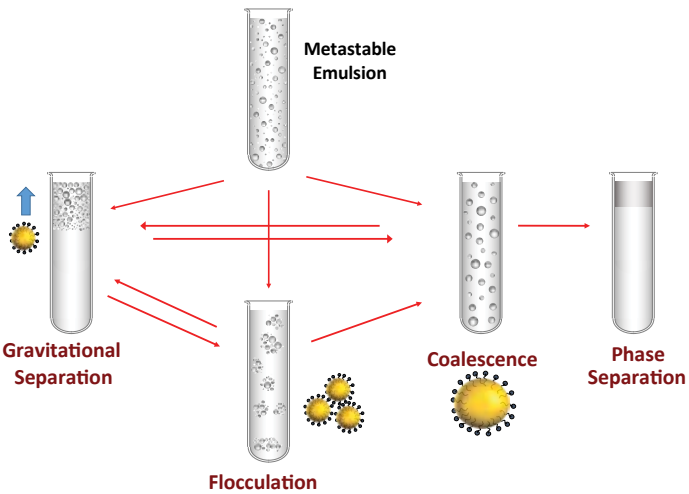

FIG. 1. Emulsions may become physically unstable through various physicochemical processes. (McClements and Gumus, 2016: https://doi.org/10.1016/j.cis.2016.03.002)

Emulsifiers, compounds that have both hydrophilic and hydrophobic parts, have two main functions: to facilitate emulsification and to keep emulsions stable over their shelf life. Some common emulsifiers used in the food industry can be proteins (e.g., whey protein), polysaccharides (e.g., gum arabic), phospholipids (e.g., lecithin), and synthetic emulsifiers (e.g., Tweens).

Synthetic emulsifiers can be tailored for specific needs and can be more efficient than natural alternatives in forming an emulsion and keeping it stable. However, as consumers seek natural alternatives, plant-based emulsifiers (pea, lentil, and faba bean proteins) were investigated and shown to have similar emulsion formation and stability characteristics as those stabilized by dairy-proteins. In general, protein-coated droplets tend to become unstable with pH fluctuations and therefore must be mixed with other emulsifiers, such as polysaccharides to ensure stability.

DIGESTION AND BIOAVAILABILITY

It is important for the protective layer encapsulating a bioactive to be digested in the human gastrointestinal tract so the functional ingredients can be released in the small intestine and adsorbed by the body. The type of emulsifier affects the digestibility of the oil droplets and the bioavailability of the bioactive compounds that are encapsulated. Small oil droplets, which can be formed with more efficient emulsifiers, can be digested faster and enhance bioavailability. In addition, the state of the droplets prior to entering the small intestine (i.e., in the stomach) affects the free-fatty-acid (FFA) release rate. The thickness of the protective layer around the droplet core also affects digestibility and can sterically prevent lipase from acting on the

droplet and cause slower digestion rates. For these reasons, protein-coated droplets were shown to aggregate and hence result in slower digestion in the small intestine, whereas synthetic-emulsifier-coated droplets were more stable against droplet aggregation in the stomach and resulted in faster FFA release in the small intestine.

Although plant-based proteins were reported to have lower digestibility, when used as emulsifiers they were digested at the same rate as commonly used animal-based emulsifiers such as whey protein. Therefore, digestibility is not an issue when plant-based proteins are used as emulsifiers.

LIPID OXIDATION

Lipid oxidation can impair product quality, decrease nutritional value, and lead to the formation of potentially toxic products. The emulsifier type is a factor that affects lipid oxidation. In cases where an emulsifier is susceptible to oxidation itself (e.g., phospholipid), the rate of lipid oxidation was found to be slower than for synthetic emulsifier-stabilized emulsions.

Metal-catalyzed decomposition of lipid hydroperoxides is the leading pathway of lipid oxidation in emulsions. Emulsifiers can inhibit lipid oxidation by forming a steric barrier between the oil droplets and reactive species, such as metal ions. On the other hand, some emulsifiers, such as several proteins, can bind metals and cause a close proximation between the oil droplets and metal ions and promote lipid oxidation. However, when there is excess protein in the aqueous phase, the additional protein will protect the oil droplets from lipid oxidation by binding the metal ions in the aqueous phase and preventing their contact with the oil droplets. The pH of an emulsion changes the protein's ability to inhibit or promote lipid oxidation. Below their isoelectric points, proteins are positively charged, which would repel the positively charged metal ions from the droplet surface when they are used as emulsifiers and prevent lipid oxidation. Therefore, the concentration of unadsorbed and adsorbed protein and matrix pH are two factors impacting lipid oxidation. Pulse-protein-stabilized emulsions showed lipid oxidation rates similar to those of whey protein-stabilized emulsions. This suggests that they could be used to replace such animal-based emulsifiers.

In summary, the emulsifying capabilities and digestibility of plant-based emulsifiers make them good alternatives to synthetic emulsifiers. However, more research is needed to understand how other aspects, such as sensory characteristics, could affect commercialization. Pulse proteins, for instance, gave the emulsion samples a highly beany smell, and this might need to be masked.

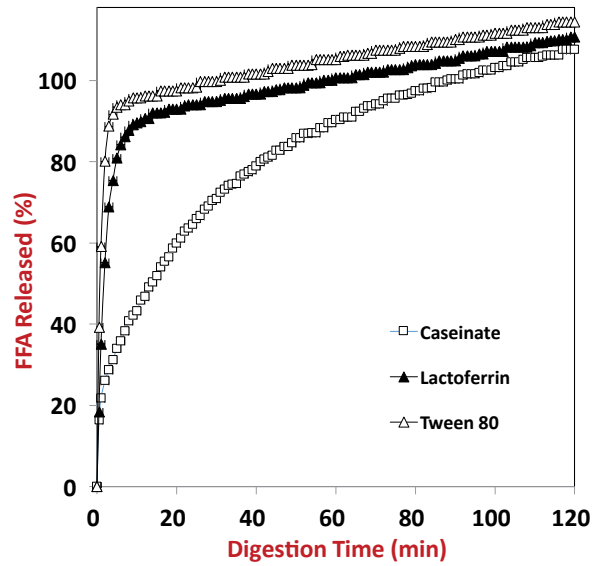

FIG. 2. The type of emulsifier affects free-fatty-acid release in the small intestine. (Zhang, et al., 2015: http://pubs.acs.org/doi/10.1021/acs.jafc.5b04691)

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Gumus Cansu received her PhD degree in Food Science from the University of Massachusetts Amherst in May 2017. Part of her doctoral research at the Food Colloids and Biopolymers Laboratory under the advising of David Julius McClements compared the utilization of pulse proteins to form emulsions with commonly used whey protein. She now works as a laboratory expert at the Scientific and Technical Application and Research Center at Hitit University in Çorum Turkey. She can be contacted at cansu.e.gumus@gmail.com.

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FIG. 1. Eastern red cedar growing along a fencerow

Eastern red cedar: cedarwood oil extraction and bioactivity

Fred J. Eller, III

Eastern red cedar (ERC), *Juniperus virginana* L. (Cupressaceae) is a common coniferous evergreen tree and a very abundant natural resource in the United States. The species covers vast areas, and its geographical range is currently increasing. It has been reported that there are more Eastern red cedars now than when Christopher Columbus arrived in North America. One report stated that the state of Oklahoma alone is losing an estimated 700 acres per day to ERC. It is very common along fencerows, highways, and edges of pastures (Fig. 1).

- **Eastern red cedar is an abundant natural resource in United States.**
- **Cedarwood oil is a valuable product derived from Eastern Red Cedar.**
- **Cedarwood oil has great potential as a natural pest control agent.**

In the past, periodic wildfires controlled ERC. However, current practices that suppress wildfires have allowed ERC to thrive. Birds also consume juniper berries and help spread ERC. Juniper berries that have been consumed by birds and passed through their digestive systems have three times the germination rate as seeds not eaten by birds (Fig. 2). Juniper berries also happen to be the flavoring agent for gin.

In addition, because ERC is a C3 plant, it has a photosynthetic advantage over C4 plants, including many grasses it competes against, and would benefit under higher atmospheric CO_2 concentrations. Because of its encroachment onto pastures and rangeland, ERC is considered an invasive/pest species. Junipers are also an alternate host for cedar-apple rust, and some management strategies recommend removal of ERC near apple orchards. Therefore, there is considerable interest in efforts to control this species.

USES AND VALUE

Eastern red cedar, on the other hand, is highly prized for its aromatic wood, especially the reddish heartwood, which is used to make cedar chests, closet liners, and fence posts. Baton Rouge (French for "red stick"), Louisiana, gets its name from the reddish color of ERC poles. Besides valuable lumber, cedarwood oil (CWO) (CAS 8000-27-9) can be obtained from the heartwood (Fig. 3). Cedarwood oil is a valuable commodity; a recent internet search indicated CWO is valued at between $12.75 and $14.48 per pound at drum quantities.

CEDARWOOD OIL PRODUCTION AND COMPOSITION

Cedarwood oil is most often obtained by steam distillation of sawmill wastes; however, this process has several disadvantages, including relatively low yields and altered oil characteristics. Steam-distilled CWO smells very different from the unextracted cedarwood. In addition, steam-distilled CWO has relatively low amounts of cedrol and higher amounts of α-cedrene than CWO obtained by other solvent extraction methods.

Cedarwood oil is a complex mixture with over 37 identified compounds, virtually all sesquiterpenes. Although steam-distilled CWO contains even more than these 37 compounds, the most abundant five compounds account for ca. 85% of steam-distilled CWO. These five and their relative percentages are: thujopsene (470-40-6) (28%), α-cedrene (CAS 469-61-4) (27%), cedrol (CAS 77-53-2) (16%), β-cedrene (CAS 546-28-1) (8%) and cuparene (16982-00-6) (6%).

Depending on the production method used, the composition of CWO can vary widely. My laboratory has been investigating alternative methods to steam distillation for obtaining CWO from ERC, including liquid carbon dioxide (L-CO_2) extraction, supercritical carbon dioxide (SC-CO_2) extraction, pressurized solvent extraction, and soxhlet extraction. The carbon dioxide extractions gave the highest yields of CWO ever reported (i.e., 4.6% compared to previous reports of less than 1 to 3.5% using steam distillation). In addition, the CO_2-derived CWO is more similar in odor to unextracted wood than CWO obtained by steam distillation.

The CO_2-derived CWO also had much higher levels of cedrol (ca. 3 times as much) and correspondingly lower levels of α-cedrene (ca. ½) than that of steam distilled CWO. The hot

FIG. 3. Reddish heartwood of Eastern red cedar

FIG. 2. Hillside enchroached by Eastern red cedars

acidic conditions that occur during steam distillation of ERC catalyze the dehydration of the tertiary alcohol, cedrol, to its hydrocarbon analog, α-cedrene. This is why steam-distilled CWO has relatively low levels of cedrol and high levels of α-cedrene. The cedrol/α-cedrene ratio is indicative of the quality of the CWO, particularly as an estimate of the dehydration of cedrol to α-cedrene. Because cedrol has been reported to be one the most bioactive components of CWO, it is prudent to preserve (i.e., prevent its degradation to α-cedrene) it in the CWO.

The steam-distilled CWO described above has a cedrol/α-cedrene of 0.59. Two commercially available CWOs have stated cedrol concentrations of 22.5% and 20–26%. Both of these CWOs have relatively low cedrol concentrations compared to CWOs obtained by solvent extraction. One of these sources provided the α-cedrene content at 27% to give a cedrol/α-cedrene of less than 1.0, also quite low and suggesting cedrol degradation to α-cedrene.

In contrast, when a solvent (e.g., L-CO_2, SC-CO_2, or pressurized hexane) was used, the ratio of cedrol/α-cedrene was significantly higher than 1 (e.g., 2.6, 3.4, 3.8, 4.4, 10.1, 11, 13.3, and 26.2,). Clearly, the solvent extraction of ERC leads to higher cedrol concentrations and this would undoubtedly result in a CWO with higher bioactivity because of this higher cedrol/α-cedrene ratio.

Recently, SC-CO_2 extraction and soxhlet (*n*-hexane and isohexane) extractions were compared for CWO yield and composition from ERC sawdust. Although there were some minor differences in yield and compositions of the CWOs obtained, all three extraction methods gave very similar results (Table 1). Solvent extractions, whether using a standard solvent such as isohexane or a less-standard solvent like CO_2, have significant advantages over steam distillations for obtaining high yields and high-quality CWO. Although CO_2 extractions have significant benefits (e.g., no solvent residue, non-toxic, non-flammable, widely available, and relatively inexpensive), CO_2 extractions require higher capital investments. Alternatively, standard solvent extraction is a commonly employed technology, and CWO could economically be extracted from ERC using a solvent such as isohexane.

TABLE 1. Comparison of methods for extracting cedarwood oil (CWO) from Eastern Red Cedar heartwood sawdust

	Extraction method [a]		
	Supercritical CO_2	Soxhlet *n*-Hexane	Soxhlet Isohexane
Solvent:Feed Ratio (g/g)	18.3	24.2	23.5
Mean [b] Percentage CWO Yield [c]	1.85 a	2.55 b	2.85 b
Mean [b] Percentage α-Cedrene	14.6 a	15.6 b	15.7 b
Mean [b] Percentage Thujopsene	14.4 a	15.8 b	16.4 c
Mean [b] Percentage Cedrol	55.7 b	53.2 a	54.0 a
Mean [b] Cedrol/ α-Cedrene Ratio	3.82 b	3.41 a	3.44 a

[a] Supercritical CO_2 extractions were performed at 70°C and 27.6 MPa. Soxhlet extractions used 10 cycles of refluxing solvent.
[b] There were 3 replications per mean. Means within a row without letters in common differ significantly using Least Significant Difference (P=0.05) after one-way ANOVA.
[c] Cedarwood oil yield based on post-extraction oven-dried wood mass (overnight at 90°C and 0.088 MPa). %CWO=100*(CWO mass/(CWO mass + dried wood mass)).

CEDARWOOD OIL USES

Cedarwood oil has been designated "Generally Recognized as Safe" (GRAS) by the US Food & Drug Administration (Code of Federal Regulations, Title 21, Chapter I, Subchapter B, Part 172, Subpart F, Section 172.515). Cedarwood oil is used in perfumes, insecticides, repellents, and as an immersion oil in microscopy. Because of cedarwood oil's aromatic properties, it is often used in aromatherapy as well. Interestingly, an ancient Egyptian embalming practice also employed the use of cedarwood oil for preservation.

The bioactivity of CO_2-derived CWO has been demonstrated in a variety of ways. Cedarwood oil is toxic and/or repellent to a diverse group of insects, including termites. It has long been recognized that fence posts made from junipers last a very long time (e.g., over a hundred years!) because they are resistant to wood-decay fungi and termites. It was hypothesized that CWO extracts from ERC could be used to impart resistance to otherwise susceptible woods, such as pine, and protect them from attack. Carbon dioxide-derived CWO did, in fact, confer resistance against both wood-decay fungi and termites when it was vacuum-impregnated into pine sapwood. Therefore, CWO could serve as a natural wood preservative to pressure treat wood in place of materials currently used today.

Carbon dioxide-derived CWO has also been shown to be repellent to several species of ants, including economically important red imported fire ants (*Solenopsis invicta* Buren) and little fire ants (*Wasmannia auropunctata* Roger). In laboratory and field tests, CWO repelled ants from an otherwise attractive food source. In one instance, ants were inhibited from travelling up a pole to a hummingbird feeder filled with sugar water. In another, ants were deterred from reaching peanut butter baits on sticks. The repellency of CWO against ants could be a very useful pest management tool for managing these serious pests.

Cedarwood oil is toxic to many economically important arthropods, including many dangerous disease vectors. Research has shown that CWO has significant toxicity against black-legged ticks, brown dog ticks, and lone star ticks. These tick species are responsible for transmitting diseases such as

Lyme disease, babesiosis, and rocky mountain spotted fever. Cedarwood oil also kills adults of mosquitoes, which vector diseases such as zika, yellow fever, and dengue fever. In addition, CWO kills houseflies, which are mechanical vectors for over a hundred pathogens, such as those causing typhoid, cholera, salmonellosis, bacillary dysentery, tuberculosis, and anthrax.

FUTURE NEEDS AND PROSPECTS

Cedarwood oil is a valuable commodity from an abundant, renewable, and underutilized natural resource. It is very safe and holds great potential as an environmentally friendly natural pest management tool for a wide range of economically important pests. However, the value of CWO from ERC may not be enough in and of itself to make it economic to harvest ERC merely for the CWO alone. Therefore, other products from ERC will be required to make higher ERC utilization profitable. Gustavus Franklin Swift of Swift & Company meat packing famously bragged that his slaughterhouses had become so sophisticated that they used "Everything but the squeal." For ERC, we should strive to find uses for everything but its shadow. Some proposed potential additional revenue sources from ERC include fuel pellets, biochar, biofuels such as butanol, or ethanol fermented from the wood. Any of these uses or others could be integrated and lead to an increase in the speed at which ERC is harvested. In addition, there are several related junipers, specifically Western Juniper (*Juniperus occidentalis* Hook.) and Ashe Juniper (*Juniperus ashei* J. Buchholz) which are quite similar to ERC in their ecology and chemistry. Together, all of these junipers offer many opportunities for expanded uses.

Fred Eller is a native of Saint Paul, Minnesota and received his BSc and MSc degrees from the University of Minnesota and his PhD from the University of Florida. He is currently a research chemist in the Functional Foods Research Unit at the National Center for Agriculture Utilization Research, US Department of Agriculture Research Service, in Peoria, Illinois. His research interests include supercritical and liquid carbon dioxide extractions, counter-current critical fluid fractionations, lipid analyses, and the isolation and identification of bioactive natural products. He has authored or co-authored over 80 publications, is first inventor on two USPatents, has made over 40 presentations at international and national meetings, and is an active member of the American Oil Chemists' Society. He has been married to Denise Devereaux Eller for over 36 years and is the father of three grown daughters, Melissa, Jessica, and Rebecca. In his spare time, he enjoys fishing, jogging, and other outdoor activities. He can be contacted at Fred.Eller@ARS.USDA.gov or +1 (309) 681-6232.

Mention of trade names or commercial products in this article is solely for the purpose of providing scientific information and does not imply recommendation or endorsement by the US Department of Agriculture (USDA). USDA is an equal opportunity provider and employer.

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Vibrational spectroscopy and chemometric procedures for the rapid assessment of olive oil authenticity

- **Vibrational spectroscopy and chemometric procedures developed by researchers at the US Food and Drug Administration's Center for Food Safety and Nutrition in College Park, Maryland, USA, have been used to assess the authenticity of retail products labeled extra virgin olive oil (EVOO).**
- **In a recent assessment, the overall percentage of predicted authentic EVOO was 27%, a result that is fairly consistent with recently published literature reports for EVOO products purchased in the United States.**
- **Following is a brief summary written by researchers Magdi Mossoba, Sanjeewa Karunathilaka, Kyungeun Lee, Lea Brückner, and Betsy Jean Yakes**

Prompted by persistent media reports that have presumed the prevalence of olive oil adulteration and due to the paucity of analytical methods suitable for rapid screening and regulatory surveillance, we have been developing and optimizing, complementary untargeted procedures based on vibrational spectroscopy (FT-NIR, ATR-FTIR, and Raman) in conjunction with chemometrics. Proposed FT-NIR and partial least squares regression (PLSR) procedures have been used to rapidly (<5 min) *predict* whether 88 and 74 retail products labeled extra virgin olive oil (EVOO) purchased primarily in College Park, Maryland, and Atlanta, Georgia, respectively, belonged to the class of authentic EVOO or were flagged as atypical. The latter class consisted of EVOO products that may have been mixed with extraneous refined oils including seed oils that could potentially adversely impact the health of consumers who are allergic to seed oils.

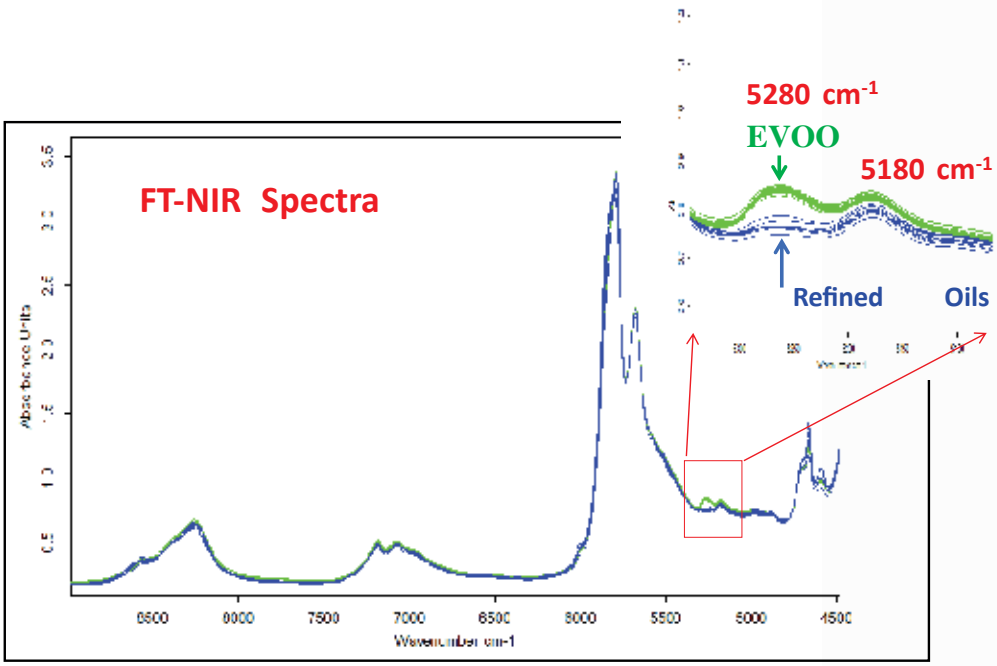


FIG. 1. FT-NIR spectra

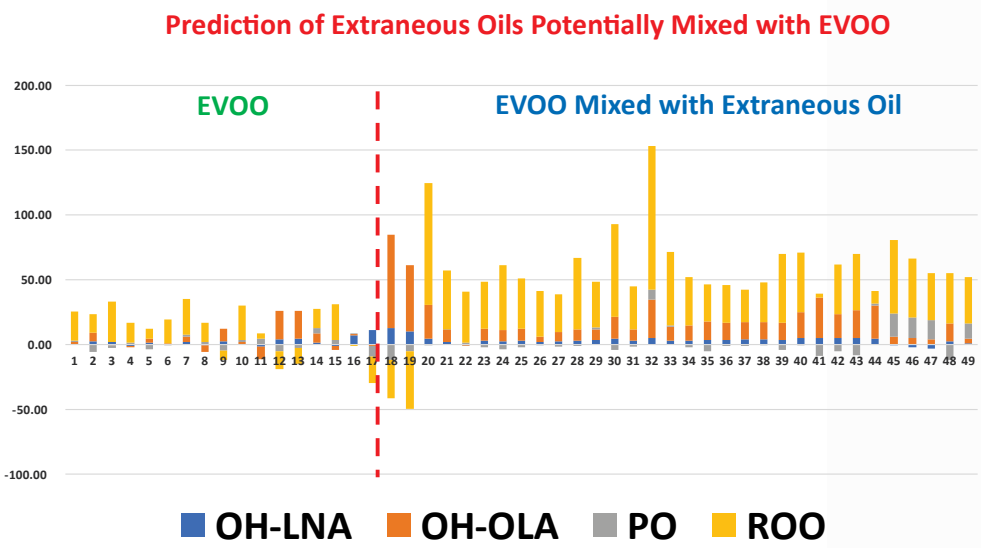


FIG. 2. Prediction of extraneous oils potentially mixed with EVOO

In the present study, 49 EVOO commercial products were purchased locally from retail outlets in Brussels, Belgium in 2017 and evaluated. Displayed are spectra for EVOO and refined edible oils (Fig. 1) as well as a plot about the *prediction* of an extraneous oil (oil high in linoleic acid (OH-LNA), oil high in oleic acid (OH-OLA), palm olein (PO), and/or refined olive oil (ROO)) potentially mixed with EVOO (Fig. 2).

In addition, FT-NIR Index values estimated to be lower than approximately 75 (on a scale of 100) indicated either quality or purity issues. This index is based on estimating the intensity (relative to the feature at 5180 cm^{-1}) of the weak, yet highly characteristic band observed at 5280 cm^{-1}. A relatively intense band is attributed to the presence of volatile carbonyl constituents, as we have observed for authentic EVOO, while a weak one may indicate loss of volatiles due to aging, mishandling by exposure to heat during storage or shipping, or mixing with refined edible oils. Based on the *predicted* outputs of these two complementary procedures and the concentrations of select fatty acid markers, 13 out of 49 products met all three assessment criteria; therefore, the overall percentage of predicted authentic EVOO in this set of commercial products was 27%, a result that is fairly consistent with recently published literature reports for EVOO products purchased in the United States (Mossoba, *et al. Lipids 52*: 443–455, 2017, https://doi.org/10.1007/s11745-017-4250-5).

Portable Raman spectroscopy and chemometric methods for the analysis of marine oil dietary supplements

- **Questions about the validity of label claims have pointed out the need for rapid and accurate screening of marine oil dietary supplements.**
- **Established analytical methods for analyzing such supplements can be costly and time-consuming.**
- **Researchers at the US Food and Drug Administration's Center for Food Safety and Applied Nutrition (CFSAN) in College Park, Maryland, USA, recently evaluated the accuracy and feasibility of using three types of handheld Raman spectrometers. Here is a brief summary by Betsy Jean Yakes, Sanjeewa R. Karunathilaka, Sung Hwan Choi, Kyungeun Lee, Lea Brückner, Cynthia Srigley, and Magdi Mossoba that describes the results.**

With recent increased use of marine oil supplements in the United States due to their potential health benefits, questions have arisen on the validity of label claims on the content of long-chain omega-3 polyunsaturated fatty acids (PUFAs). Established analytical methods, including gas chromatography with flame ionization detection (GC-FID), excel at analyzing these dietary supplements for fatty acid content, but the cost of instrumentation and amount of time for analysis limit rapid, accurate screening. As such, we have been exploring portable spectroscopic devices combined with chemometrics for analysis of fatty acids and fatty acid classes (FA/FA classes), with a focus on eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) concentration prediction to ensure both quality and accuracy in label declarations.

Three handheld Raman spectrometers were evaluated with a set of 104 marine oil products to determine feasibility of measurement and accuracy of results. The first device features a unique laser setup and data processing algorithm to decrease fluorescence interference, the second spectrometer incorporates onboard chemometrics for immediate pass/fail triaging of complex samples, and the third instrument uses an infrared (1064 nm) laser to limit potential fluorescence from the sample matrices. After the neat (underivatized) oil spectra

were obtained on each instrument, broad-based calibration models were developed for each instrument using partial least-squares regression (PLSR) to predict fatty acid composition.

In general, the Raman spectrometers performed well with the yellow, liquid marine oil supplements while performance was less satisfactory with red-colored samples and those that were emulsions or solids. Models were validated by applying cross-validation and by using an independent test set protocol with 2/3 of samples used for calibration and 1/3 of samples used for the test set. As displayed in the three prediction plots, the predicted omega-3 PUFA values for each of the handheld Raman spectrometers were in good agreement with the GC-determined concentrations. It is interesting to note, the two fluorescence reducing instruments (Device 1 and Device 3, depicted in Figure 1) were successfully used to accurately predict seven additional test samples. When comparing the accuracy of the devices (Fig. 2), similar performance was found with the models developed for the major classes of fatty acids, with Device 2 appearing to have the best accuracy, as indicated by lower prediction errors (shorter bars on graph in Fig. 2). These initial studies illustrate the potential for portable Raman spectroscopy combined with PLSR to be successfully employed for rapid quantification of six major FA/FA classes in marine oil supplements.

SRK is supported by the Research Participation Program at CFSAN, administered by ORISE through an interagency agreement between the US DOE and US FDA.

FIG. 1. PLSR model performance for each Raman spectrometer for predicting omega-3 PUFA concentration

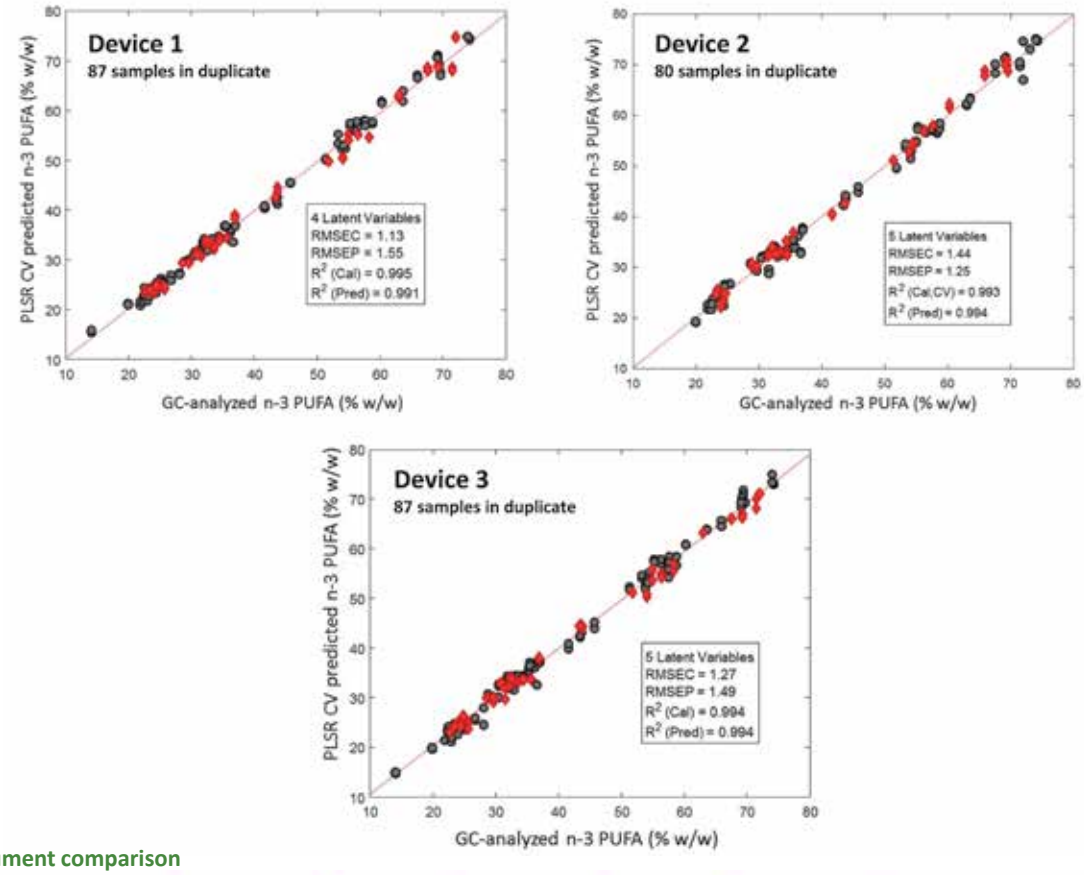
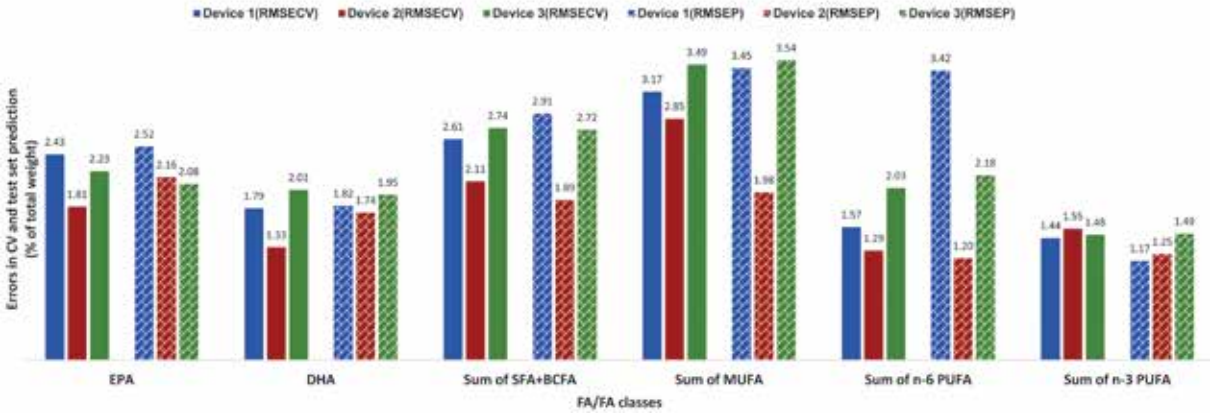


FIG. 2. Instrument comparison



Abbreviations: EPA (eicosapentaenoic acid), DHA (docosahexaenoic acid), SFA (saturated fatty acids), BCFA (branch chain fatty acids), MUFA (monounsaturated fatty acids), n-6 PUFA (omega-6 polyunsaturated fatty acids), n-3 PUFA (omega-3 polyunsaturated fatty acids) RMSECV (Root mean square error of cross-validation; a measure of the accuracy in cross-validation) RMSEP (Root mean square error of prediction; a measure of the accuracy in prediction)

Not just for universities: How US organizations in the private sector can use the J-1 visa program to host visiting foreign research scientists

Louisa Manzeske

- **Under the US Department of State's multifaceted J-1 Exchange Visitor Program, (https://j1visa.state.gov/programs), foreign research scientists can be sponsored as "J-1 Scholars" to visit the United States to conduct research, observe, or consult on collaborative research or other academic projects.**

- **The J-1 Research Scholar visa permits a research engagement of up to 5 years, whereas the J-1 Short-Term Scholar visa limits activities to 6 months. Both J-1 Scholar visas aim to promote the exchange of ideas and cultural perspectives between scientists in the United States and abroad and to stimulate international research efforts and collaboration. In today's globalized world—and in science—opportunities to build and strengthen ties around the world cannot be underestimated.**

- **This article aspires to expand awareness and use of J-1 Scholar visa programs beyond traditional academia. Other organizations engaged in scientific research can also consider hosting J-1 Scholars with the help of an authorized J-1 visa sponsor.**

Visiting research scientists under the J-1 Scholar program are traditionally based at the universities that sponsor their J-1 visas. In this scenario, the university fulfills a dual role: it is both the J-1 Scholar's visa sponsor and host organization.

Private organizations may also apply to become sponsors, though this requires a government application and fees, infrastructure, and the ability to host at least five scholars per year. Many organizations do not wish to deal with the administrative requirements of being a sponsor and/or they do not bring in a high enough volume of J-1 Scholars to justify the costs. This article presents an alternative option for such organizations to consider, where they can still participate in J-1 programs as *hosting* organizations of J-1 Scholars, while the *sponsoring* role is managed by another organization.

In this scenario, the visa *sponsor*, an organization or institution certified by the US Department of State to sponsor J-1 visas, shoulders responsibility for immigration compliance. The sponsor will vet the research and prospective scientist's qualifications opportunity against Department of State requirements, issue Form DS-2019 for eligible candidates (this is the "Certificate of Eligibility" necessary for the J-1 visa application), provide ongoing immigration advising to foreign national scientists under their program, and perform compliance reporting to the Department of

Birgit Obermeier, from Germany, participated in a J-1 Scholar research program at Biogen in Cambridge, Massachusetts, USA. She studied how immune cells migrate across the blood-brain barrier, a key pathological event in multiple sclerosis.

State. Meanwhile, the *host organization* is a research organization that—with the sponsor's authorization—may physically host J-1 Scholars on site and plan and supervise their research.

This arrangement allows research organizations to benefit from hosting J-1 Scholar exchanges, but they can do so at an appropriate scale for their need, and simultaneously are relieved of the main administrative burdens of J-1 sponsoring, which are managed by the visa sponsor.

IREX SCHOLARSHIP SPONSORSHIP SERVICES

IREX, established in 1968, is one such US Department of State-designated J-1 Scholar visa sponsor with a long history of administering academic and research exchange programs that occur at third-party host sites. A glance at the organization's website (https://www.irex.org/) shows that IREX is principally an international development organization with a mission to strengthen institutions and extend access to quality education and information around the world. Yet while many of its programs support international collaboration between the United States and developing countries, IREX's J-1 visa sponsorship services (https://www.irex.org/project/services-j-1-visa-sponsorship) extend to facilitate international collaboration between the United States and industrialized countries as well. Generally, foreign research scientists from any country are eligible to be J-1 Scholars under IREX's program.

Today, IREX's J-1 Scholar sponsorship services help a growing number of Fortune 500 corporations, research organizations, and colleges to host foreign research scientists. These J-1 Scholars are contributing to some of the most cutting-edge fields, from artificial intelligence to bioengineering to recycling. In general, partnering host organizations have at least 25 full-time employees and/or an annual revenue of at least $3 million to be eligible, although some smaller organizations may also host J-1 Scholars following added screening. IREX fees for visa sponsorship services also make a positive difference around the world, directly supporting IREX's broader international development mission. Fees, timelines, and other logistics can be seen in Table 1.

SCIENTIFIC EXCHANGES PLANT SEEDS FOR A VARIETY OF LONG-TERM BENEFITS

Research productivity and innovation

According to IREX program reports, research scientists who participate in the J-1 Scholar visa program advance scientific initiatives during their sojourn in the US which mutually benefit them and their host organizations.

Professional development

The value of meeting and learning from experts in their field is a recurring theme communicated by research scientists who participate in J-1 Scholar programs. For example, Zhiqi Song of China writes, "I am impressed very much by the pathologists' deep knowledge and rich experience…My learning from all of them in the past 6 months will lay a critical foundation for my future professional career."

Broader cultural perspectives

J-1 Scholar alumni also speak of the personal growth and perspective they accrued from conducting research in a new cultural environment, which in turn better equips them to conduct research in a global environment. "I found the experience of going to the US as an exchange researcher extremely useful and fun! This invaluable experience taught me fast adaptivity,

TABLE 1. Fees, timelines, and other logistics for obtaining J-1 visas

Typical time frame to get a visa	**1-2 months**
Cost	$3,000 visa sponsorship fee* $180 US government fee $500 optional expedite fee
Parties involved	• Host organizations interact with IREX and the foreign research scientist • IREX and the foreign research scientist also interact with the US Department of State
Work permit available for spouse?	Yes

*IREX fees vary based on duration of visa sponsorship. The cost scenario above is IREX's fee for a two-year stay in the US.

J-1 Scholar visas for visiting research scientists offer opportunities for US organizations to:

- internationalize postdoctoral research programs;
- bring in expert talent from abroad to consult/collaborate on short- or long-term research projects;
- build ties and share resources with institutions or labs abroad;
- foster international industry-academic partnerships; and
- host doctoral students for dissertation research or professors on sabbatical.

André Lin Ouedraogo, from burkina Faso, was a J-1 Scholar at the Institute for Disease Modeling, Intellectual Ventures' Global Good initiative, in Bellevue, Washington, USA, where he refined and applied mathematical models in order to design, test and improve interventions for malaria control and eradication in endemic countries.

tolerance, and how different ways of thinking can enormously benefit a project," said Helena Rannikmae of Sweden, who conducted oncology research at AstraZeneca.

Relationship building for future collaboration

Perhaps the most powerful benefits to the J-1 program are the relationships that are fostered and the scientific engagement that continues long after the J-1 Scholar returns home. Leila Giron, from Brazil, said, "Since I went back, me and my [J-1 Scholar program] advisor in US continue our collaborations and scientific exchange." Leila is currently preparing two manuscripts for publication with her US advisor at the Blood Systems Research Institute, and plans are in motion to work together on a project in Brazil. Likewise, Helena's doctoral research continues to involve an ongoing academia-industry collaboration between her home institution and AstraZeneca, her US host organization during the J-1 program.

INTERESTED IN LEARNING MORE?

IREX staff are experts in visa regulations and will be happy to discuss an organization's research initiatives and explain options to host eligible foreign research scientists under the J-1 Scholar visa program.

For more information, contact the J visa sponsorship team at:

IREX J Visa Exchange Program
1275 K St. NW, Suite 600, Washington, DC 20005
E: jvisaexchange@irex.org T: 202-628-8188 (extension 179)
Program overview: www.irex.org/j-visa
Application process: https://www.irex.org/how-apply-j-1-visa

Louisa Manzeske is a senior program officer for IREX's J Visa Exchange Visitor Program, where she manages IREX's J visa sponsorship services for Research Scholars and Short-Term Scholars and administers an international fellowship program for research managers in Africa and Eurasia. She also guides host organizations, immigration attorneys, and foreign exchange visitors throughout the application and J visa processes; provides ongoing support and immigration advising during the research period; and manages immigration compliance. She can be contacted at lmanzeske@irex.org.

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Sarah A. Echols, Head of Innovation of Sweet Ingredients, North America, at CSM Bakery Solutions and member of the Edible Applications Technology Division

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- Secretary-Treasurer of the Edible Applications Technology Division, 2017–present

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30 • INFORM May 2018, Vol. 29 (5)

Grass-fed milk: health or hype?

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

Laura Cassiday

Throughout much of human history, the dietary ratio of omega-6 to omega-3 fatty acids has been about 1:1. Today, with greatly increased consumption of vegetable oils and processed foods high in omega-6 fatty acids, the average ratio in most Western diets ranges from 10:1 to 25:1. The health consequences of this dramatic shift are uncertain, but some studies have linked elevated omega-6/omega-3 ratios to chronic inflammation, obesity, cardiovascular disease, and other ailments. Now, a paper in *Food Science & Nutrition* claims that grass-fed milk can help restore the historical balance of fatty acids in humans, by virtue of a six-fold lower omega-6/omega 3 ratio than conventional milk (Benbrook, C.M., *et al.*, http://dx.doi.org/10.1002/fsn3.610, 2018). However, organic industry involvement and other issues may cast doubt on some of the study's conclusions.

The study compared the fatty acid compositions of conventional, organic, and grass-fed milk. In the United States, most cows in conventional dairies consume about 6% of their daily dry matter intake (DMI) from pasture during grazing season. On an annual basis, the cows consume abou 53% of their DMI from forage, which includes both grazing and stored forage such as dried alfalfa, and 47% from corn and concentrate feeds. Organic milk must conform with the organic standard set by the United States Department of Agriculture, which specifies that lactating cows must consume at least 30% of their daily DMI from pasture during a grazing season of at least 120 days. Over the entire year, most cows fed an organic diet consume about 80% of their DMI from pasture and stored forage and about 20% from grains and concentrates.

The grass-fed milk in this study came from the Wisconsin-based cooperative CROPP, which markets the Organic Valley Grassmilk brand. CROPP has even more stringent forage requirements than the USDA organic program: Lactating cows must consume over 60% of their DMI from pasture during grazing season, with a grazing season of at least 150 days. In addition, cows in the Grassmilk program must consume 100% of their yearly DMI from pasture and stored forage, with no grains or concentrates allowed.

In a previous study, Benbrook and colleagues found that organic milk contained higher levels of omega-3 fatty acids than conventional milk (Benbrook, C.M., *et al.*, http://dx.doi.org/10.1371/journal.pone.0082429, 2013). However, the total amount of omega-3 fatty acids in milk—organic or conventional—was minuscule compared with good sources of omega-3s, such as oily fish. In their new study, Benbrook and colleagues added Grassmilk to their analysis to determine if a completely grain-free diet would increase omega-3 levels above those seen in organic milk. The 1,163 full-fat Grassmilk samples were collected over a three-year period (2014–2016) throughout the United States.

The researchers found that Grassmilk contained 0.0489 g total omega-3 fatty acids per 100 g of whole milk, compared with 0.0198 g/100 g conventional whole milk and 0.0321 g/100 g organic whole milk. Grassmilk contained about 1.4-fold more eicosapentaenoic acid (EPA; 0.00357 g/100g versus 0.0025 g/100 g) and 1.3-fold more docosapentaenoic acid (DPA; 0.0047 g/100 g versus 0.0037 g/100 g) than conventional milk. The level of docosahexaenoic acid (DHA) in all milk samples was much lower: unquantifiable in conventional and organic milk, and only 0.00092g/100 g of Grassmilk. Most of the observed increase in omega-3 fatty acids in Grassmilk came

from a 2.4-fold increase in alpha-linolenic acid (ALA) compared with conventional milk (0.0382 g/100 g versus 0.0159 g/10 g).

With regard to omega-6 fatty acids, Grassmilk contained 0.0454 g/100 g milk, compared with 0.0948 g/100 g conventional milk and 0.0711 g/100 g organic milk. The major omega-6 fatty acid in all milk samples was linoleic acid (LA), with 0.0387 g/100 g Grassmilk, 0.0639 g/100 g organic milk, and 0.0856 g/100 g conventional milk.

Grassmilk contained more conjugated linoleic acid (CLA; 0.0431 g/100 g) than conventional milk (0.0192 g/100 g) or organic milk (0.0227 g/100 g). CLA, a *trans* fatty acid produced naturally by ruminant animals, was recently linked with a reduced risk of heart failure in 3,806 older British men (Wannamethee, S.G., *et al.*, http://dx.doi.org/10.1161/JAHA.117.006653, 2018). The increased omega-3 fatty acids combined with the decreased omega-6 fatty acids led to a reduction in the omega-6/omega-3 ratio in Grassmilk (0.954) compared with conventional milk (5.774) and organic milk (2.276).

To explore whether these changes in fatty acid composition could have a meaninful impact on the human diet, Benbrook and colleagues modeled total LA and ALA intakes in the daily diet of a moderately active, 19–30 year old woman across 36 diet scenarios. Eighteen scenarios considered three levels of fat intake (20%, 33%, and 45% of total energy), two levels of dairy product consumption (3 and 4.5 servings per day), and the three types of milk (conventional, organic, and Grassmilk). The remaining 18 scenarios tested the same variables, in combination with a reduced non-dairy LA intake resutling from dietary substitutions (e.g., pita chips instead of corn chips, margarine made from canola oil instead of soy oil). The researchers focused on the LA/ALA ratio in these models because they claim that the USDA does not publish sufficient, reliable data on the total omega-6 and omega-3 contents of many common foods. In addition, the authors say that the LA/ALA ratio is a reliable proxy for the omega-6/omega-3 ratio because LA and ALA are the major dietary fatty acis in nearly all foods.

For a moderate fat intake (33% of total energy) and a moderate dairy intake (3 servings per day), the total dietary LA/ALA ratio was 8.64 for Grassmilk, 11.33 for conventional milk, and about 10 (exact value not shown) for organic milk. Switching from moderate to high consumption of dairy reduced the ratios further, down to 5.95 for Grassmilk, about 10 for conventional milk, and about 7.8 for organic milk. Lowering the amount of LA non-dairy fat in the diet reduced the LA/ALA ratio for all types of milk and made the differences between the milk types less pronounced. For example, for a moderate fat intake, moderate dairy intake, and reduced-LA diet, the LA/ALA ratio was about 4 for Grassmilk, 4.5 for organic milk, and 5 for conventional milk (estimated from a graph; exact values not given). The lowest LA/ALA ratio (3.14) could be obtained with a high intake of Grassmilk (4.5 daily servings), a low intake of dietary fat (20%), and a low intake of non-dairy LA.

The researchers also compared the fatty acid content of Grassmilk with the mean fatty acid content of seven common fish species (canned tuna, tilapia, halibut, sockeye slamon, catfish, trout, and Atlantic salmon). When scaled to the US per capita daily intake of dairy products, Grasmilk provided 171.7 mg per day of ALA and 174 mg of LA, with an LA/ALA ratio of 0.954. In addition, Grassmilk provided 23.2 mg per day of EPA + DPA + DHA. When scaled to the US per capita daily consumption of finfish, the 7 fish species provided an average of 5.5 mg ALA per day and 38.8 mg of LA, with an LA/ALA ratio of 6.5. The fish provided an average of 79.3 daily mg of EPA + DPA + DHA.

Although this paper provides evidence that grass-fed cows produce milk with a slightly improved fatty acid composition, many questions remain. For example, experts have not yet agreed on an optimal omega-6/omega-3 ratio, and some question whether the 1:1 ratio presumably attained in hunter-gatherer diets is ideal for today's conditions. The cardioprotective benefits of omega-3 fatty acids, particularly long-chain omega-3's such as DHA and EPA from fish, have been well established, but the omega-6/omega-3 ratio is a far less reliable predictor of cardiovascular health (Harris, W.S., https://doi.org/10.1007/s11883-006-0019-7, 2006). Therefore, it is uncertain whether lowering the omega-6/omega-3 ratio in the diet will actually translate to health benefits.

The researchers used LA/ALA as a proxy for omega-6/omega-3 for all foods, even fish, where this is clearly not accurate for many oily fish high in long-chain omega-3 fatty acids. The seven fish averaged in the study, which include four oily fish, have a reported LA/ALA ratio of 6.5, which the authors point out as being much higher than that of Grassmilk (0.954). However, if one calculates the average omega-3 level (ALA + EPA + DPA + DHA) of the seven fish species from information provided by the researchers (Table 9 in the paper), then the omega-6/omega-3 ratio would be about 0.457. In this light, the authors' statement, "Although oily fish have superior concentrations of long-chain omega-3 fatty acids, most fish have low levels of ALA (the major omega-3), and an omega-6/omega-3 ratio near 7," seems misleading.

The researchers do not provide many details about their nutritional modeling, so it is difficult to assess whether their model accurately reflects the average diet of a 19–30-year-old woman. But in any case, the data show that reducing LA levels is likely to have a more profound effect on the LA/ALA ratio than switching from conventional whole milk to whole Grassmilk. Also, many people avoid whole milk because of worries over added fat and calories, and reduced-fat Grassmilk would be less effective in lowering LA/ALA ratios because it would contribute less to the total dietary fat. It does not appear that the researchers included fish in their dietary model, noting that about 70% of the US population does not consumer fish regularly or at all. However, it is likely that a single 3-oz serving of salmon per week, with between 1.1 and 1.9 g of omega-3s, could have much greater effects on the omega-6/omega-3 ratio than Grassmilk. Thus, although Grassmilk may be an alternative for people who do not like fish to help improve their ALA levels, Grassmilk cannot be considered a good source of omega-3 fatty acids.

Another aspect that likely makes Grassmilk inferior to fish is the type of omega-3 it provides. ALA is a plant source

of omega-3 found in seeds, nuts, vegetable oils, and grass. Upon ingestion, the human body can convert ALA to the more beneficial, longer-chain omega-3 fatty acids EPA and DHA. The conversion rate of ALA to EPA and DHA is very low, typically on the order of a few percent or less, although the conversion can be improved by reducing the intake of LA (reviewed in Cassiday, L., *Inform 28*, 6–13, 2017). Therefore, it seems unlikely that much of the ALA in Grassmilk would be converted to long-chain omega-3s, which have proven health benefits. Reducing the amount of LA in the diet, as modeled by the researchers, would improve the ALA conversion rate, but it would still be less efficient than consuming EPA and DHA directly through fish.

In addition to these issues, a possible conflict of interest exists for this study, as it was funded and conducted by various organic interest groups, in particular the Organic Valley/CROPP Cooperative that sells Grassmilk. This column has discussed the issue of industry-funded research in the past (Cassiday, L., *Inform 26*, 36–37, 2016). Although such research is not by definition suspect, certain safeguards should be taken to avoid bias or the appearance of bias. Benbrook and colleagues fully disclosed their conflicts of interest in this study. However, the study has been given a free pass by most of the media touting the benefits of grass-fed milk, with little or no mention of conflicts of interest, whereas a study funded by a large agricultural company such as Monsanto would undoubtedly receive more scrutiny and accusations of bias.

The first author of the study, Charles Benbrook, is no stranger to controversy. Benbrook, an agricultural economist, has long been an outspoken activist and critic of conventional agriculture and crop biotechnology. Benbrook's 2013 paper on the fatty acid composition of organic milk, which was funded almost exclusively by Organic Valley, received criticism for equating organic production with pasture feeding (Entine, J., and Summers, J., https://tinyurl.com/GLP-milk, 2013). In a 2012 study, again funded almost exclusively by the organic industry, Benbrook and his coworkers claimed that cultivation of genetically modified crops leads to increased pesticide use, which is contrary to data from other researchers (e.g., Klümper, W., and Qaim, M., https://doi.org/10.1371/journal.pone.0111629, 2014). Although lauded and quoted by many anti-GMO groups, the paper was widely criticized by scientists.

In May 2015, Benbrook left his position as a professor at Washington State University after his contract was not extended. Also in 2015, two separate Freedom of Information Act requests—one by *The New York Times*—forced the release of dozens of emails between Benbrook and members of the organic and anti-GMO movements. The emails revealed that Benbrook, Organic Valley, and other allies crafted a coordinated media campaign to promote their 2013 study prior to its online publication, enlisting the help of well-known GMO critics, organic aficionados, celebrity doctors, and television personalities such as Michael Pollan, Marion Nestle, Dr. Oz, and Dr. Mercola to "help assure that the release and outreach effort is broad and on-message." Other email correspondence indicates that an organic group offered Benbrook payment for certain "deliverables" from his research.

Benbrook's history, as well as some methodological problems, may cast doubt on his most recent paper. Even if the study's conclusions are valid, the data do not address whether Grassmilk is more healthful than conventional milk. In addition to perceived healthfulness, many consumers of grass-fed or organic milk believe that the production systems are better for animal welfare and the environment. However, the validity of these beliefs often varies from farm to farm. A well-managed conventional dairy can be better for animals and the environment than a poorly managed grass-fed dairy. Studies of grass-fed versus grain-fed beef cattle have produced variable results as to which system has the lowest carbon footprint. Organic and grass-fed production systems are generally much less efficient than conventional dairies. With a growing world population and dwindling land available for grazing, it may not be practical or desirable for everybody to increase their intake of grass-fed milk to levels recommended by the researchers.

Information

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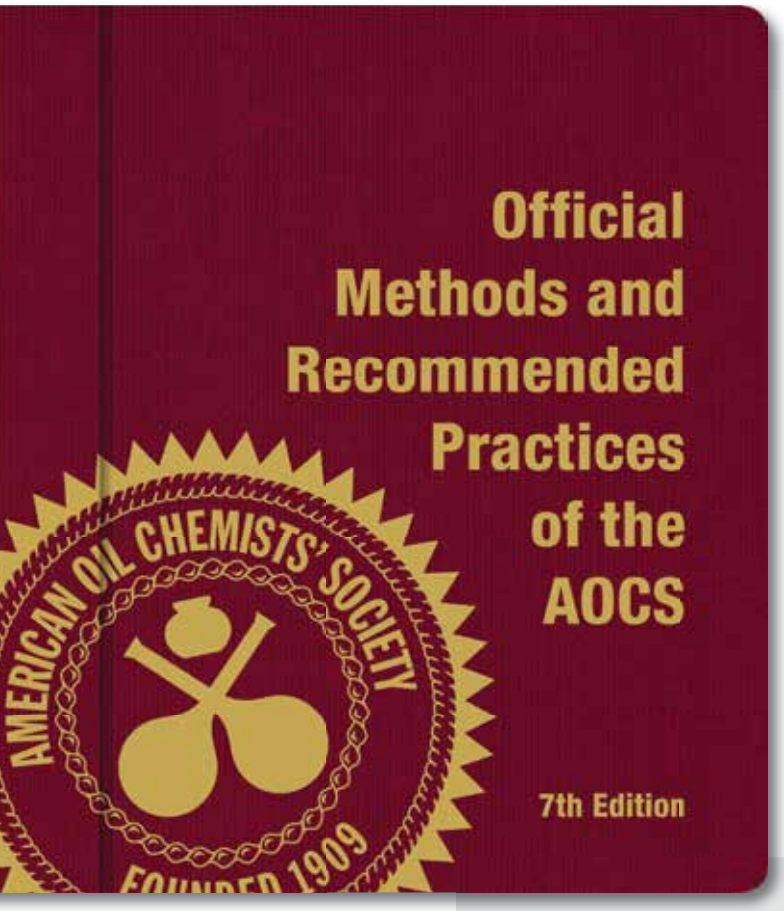
Olio is produced by Inform*'s associate editor, Laura Cassiday. She can be contacted at laura.cassiday@aocs.org.*



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Drought in Argentina expected to highly impact soy and corn production

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

Leslie Kleiner

The Argentinian newspaper *LA NACION*, has been diligently following the incidence of droughts in the Argentinean Pampas region; these are estimated to highly impact soy and corn production as the most fertile lands of the region are affected.

Q: Which areas are most affected, and what does it mean in terms of estimated soy crops production?

Members of "Agricultores Federados Argentinos, (AFA)," an agricultural cooperative in Argentina with about 36,000 Associate Producers [3]), report that due to drought, the region comprised of the south of Santa Fé and Córdoba provinces, as well as the north of the province of Buenos Aires were estimated (as of 2/27/18) to have average yield losses of approximately 46% in terms of soy production. These are the most fertile lands of the Pampas regions, and although the first soy crop was planted in October 2017 and was being harvested in February, it is estimated that grain weight and overall yield will be diminished by 27%, while further crops may be more severely affected. In specific regions, such as Sanford, Villa Maria, and Coronel Arnold, the yield losses achieve 38%, 42%, and 44%, respectively. Furthermore, soy crops which traditionally follow those of wheat are in worst shape than the first soy harvest, with some crops already being reported as losses [1].

Q: Has this type of drought been previously reported in the area?

According to *LA NACION*, from the end of 2017 to the beginning of 2018 there was a decline in rain ranging between 100 and 400 mm. This represents the worst drought for the region since 1973 (44 years) [1].

Q: What is the situation for corn crops?

AFA, which is one of the largest agricultural cooperatives in Argentina, reports that losses are also expected for corn. The

yield loss for early harvests (September–October 2017) was expected to be about 26%. Strong losses were also expected for later harvests [1].

Q: What would be the estimated monetary loss be?

According to "Consorcios Regionales de Experimentación Agrícola" (Regional Consortiums of Agricultural Experimentation), which comprises top producers, the estimated direct loss due to drought will be US$ 2.15 billion. This estimate is based on a report where 92% of the producing regions expect below average soy and corn yields for the summer harvest (notice that summer season corresponds to winter in the northern hemisphere) [2]. Furthermore, indirect segments that will also be affected are meat and milk production.

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

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PATENTS

Immediate-release, phospholipid-coated therapeutic agent nanoparticles and related methods

Trieu, V., *et al.*, Autotelic LLC, US9763892, September 19, 2017

Phospholipid-coated nanoparticles containing a therapeutic agent, compositions that include the nanoparticles, and methods for making and using the nanoparticles and compositions.

Therapeutic astaxanthin and phospholipid composition and associated method

Minatelli, J.A., *et al.*, US Nutraceuticals, LLC, US9763897, September 19, 2017

A dietary supplement includes comprising a therapeutic amount of astaxanthin derived from a synthetic or natural ester or diol, and at least one of a phospholipid, glycolipid, and sphingolipid, and formulated into an oral dosage form, wherein the astaxanthin is 0.1 to 15% by weight of the at least one phospholipid, glycolipid, and sphingolipid. The composition includes 0.5 to 12 mg of astaxanthin and may be used to treat low density lipoprotein (LDL) oxidation in humans and other diseases, disorders and impairments.

Separation processes for soy protein

Lihme, A.O.F., *et al.*, Upfront Chromatography A/S, US9765111, September 19, 2017

The invention provides a process for the separation of soy protein. The process begins with an aqueous extract or solution of soy protein, which is passed through at least one expanded bed absorption (EBA) process. The EBA process comprises contacting the aqueous extract or solution of soy protein with at least one adsorbent resin, said adsorbent resin comprising at least one ligand (L1 or L2), having particular chemical structures. Proteins of interest (e.g,. trypsin inhibitor (TI) protein or beta-conglycinin) are isolated by eluting them from said adsorbent resin. The invention also provides various novel protein compositions obtainable via the method of the invention.

Elastomer derived from epoxidized vegetable oil

Liu, Z., US Secretary of Agriculture, US9765182, September 19, 2017

Disclosed is an elastomer synthesized by a reacting epoxidized vegetable oil with carboxylic acid to form the elastomer compound. More specifically, disclosed herein is an elastomer compound having a polyester component. The method for making the elastomer comprises mixing a polybasic acid with an alcohol solvent to form a solution, reacting said solution having carboxylic groups with epoxidized vegetable oil, and heating the solution at a range of approximately 50°C to 80°C, wherein an amorphous polyester elastomer is formed. Also disclosed is an elastomer foam product formed by a reacting epoxidized vegetable oil with carboxylic acid.

Removal of unwanted propanol components

Bruse, F., Cargill, Inc., US9765281, September 19, 2017

The present invention relates to the use of short-path evaporation for reducing from deodorized triglyceride oils the content of propanol components selected from chloropropanols, chloropropanol fatty acid esters, epoxypropanols, epoxypropanol fatty acid esters, and combinations of two or more thereof. It further relates to the use of short-path evaporation wherein further the content of acyl glycerol components is reduced and these acyl glycerol components are selected from diacyl-glycerols, triglycerides with molecular weight in the range below 730 and mixtures of two or more thereof.

Ultrasound contact fluid

Selbekk, T., *et al.*, Sinvent AS, US9770521, September 26, 2017

An aqueous ultrasound contact fluid includes a pharmaceutical grade triglyceride and a pharmaceutically acceptable emulsifier and the use of the ultrasound contact fluid in an intraoperative or interventional ultrasound imaging procedure. A method for intraoperative ultrasound imaging includes filling an aqueous ultrasound contact fluid into a body cavity. The aqueous ultrasound contact fluid is a composition comprising a pharmaceutical grade triglyceride and a pharmaceutically acceptable emulsifier and optionally a pharmaceutically acceptable humectant, and the triglyceride content is in the range of 8–240 g/1000 ml composition contact fluid and the amount of emulsifier is 0.4–18 g/1000 ml composition contact fluid, and optionally a humectant in the amount of 1.2–30 g/1000 ml. The method further includes obtaining an ultrasound image of a body region that comprises at least part of the body cavity filled with the aqueous ultrasound contact fluid. The aqueous ultrasound contact fluid reduces image artifacts associated with the body cavity.

Tire with tread for combination of low-temperature performance and for wet traction

Sandstrom, P.H., *et al.*, The Goodyear Tire & Rubber Co., US9771469, September 26, 2017

This invention relates to a tire with tread for promoting a combination of wet traction and service at low temperatures of a rubber composition containing a styrene/butadiene elastomer, *cis* 1,4-polybutadiene rubber, liquid high Tg styrene/butadiene polymer, resin, and vegetable triglyceride oil.

Gasoline efficacy promoter (GEP) and method of making the same

Zhao, J.R.H., *et al.*, US9771535, September 26, 2017

The present invention discloses a gasoline efficacy promoter (GEP) boosting combustion efficiency of gasoline in internal combustion engines by a mechanism of micro-dissociation comprising a microemulsion of modified bio-carbon, a surfactant, water, a modified vegetable oil, and a dispersant, and a method of making it. The gasoline efficacy promoter, environmentally friendly and stable for longer than six months, can increase the combustion efficiency by more than 10%, and reduce 80% of NOx formation in exhaust emission when an appropriate dosage is added to a fuel tank in a vehicle.

Bio-based lubricants

Tanner, J.T., Ethon Chemicals, LLC, US9771538, September 26, 2017

The invention provides biobased lubricants comprising the reaction product of a natural oil, fatty acid or derivative having unsaturation sites with a suitable substrate such as maleic anhydride that is capable of undergoing an "ene" or Diels Alder reaction with the natural oil to form an adduct; followed by a controlled non-aqueous neutralization with a suitable inorganic base such as lithium hydroxide.

Low-fat chocolate

Norton, I.T., *et al.*, The University of Birmingham, US9775367, October 3, 2017

The application describes comestible products comprising a water-in-oil emulsion, the water-in-oil emulsion comprising cocoa butter and a fat-crystal stabilized aqueous phase dispersed substantially through the cocoa butter continuous phase and optionally one or more additional ingredients of chocolate. Hydrocolloids, such as gelative or carrageenan are typically used to stabilize the aqueous phase. Methods of making comestible products are also provided.

Cochleates made with soy phosphatidylserine

Mannino, R., *et al.*, Matinas Biopharma Nanotechnologies, Inc., US9775907, October 3, 2017

Unpurified or low pure soy phosphatidylserine is used to make cochleates. The cochleates contain about 40–74% soy phosphatidylserine, a multivalent cation and a biological active. A preferred cochleate contains the antifungal agent amphotericin B.

Stable, mildly acidic alcoholic milk-and/or soy protein-based drink

Van Dijk, J.H., *et al.*, FrieslandCampina Nederland Holding BV, US9781941, October 10, 2017

The present invention relates to a stable alcoholic milk and/or soy protein-based drink with a pH ranging from 5.2–6.5 comprising at least one or more milk and/or soy proteins, alcohol, and one or more stabilizers. The invention also relates to a method for preparing the drinks, comprising at least one or more milk and/or soy proteins, which method comprises: a) mixing at least a portion of the milk and/or soy proteins and at least a portion of the stabilizers in an aqueous medium to obtain a mixture; b) setting the pH of the mixture to 3.5–4.4; c) homogenizing the mixture obtained in step b) to obtain a homogenate; d) setting the pH of the homogenate to 5.2–6.5; and e) mixing in the alcohol and optionally a residual portion of the milk and/or soy proteins and of the stabilizers during or after one or more of steps a)-d).

Composition for normalization of infradian rhythm

Akimoto, K., *et al.*, Suntory Holdings Ltd., US9782377, October 10, 2017

A composition having a normalizing action for infradian rhythm and/or a synchronization promoting action for circadian rhythm (biological clock) containing arachidonic acid and/or an arachidonic acid-containing compound.

Patent information was compiled by Scott Bloomer, a registered US patent agent and Director, Technical Services at AOCS. Contact him at scott.bloomer@aocs.org.

welcome

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Fatty Acids: Chemistry, Synthesis and Applications illustrates the expertise and collaboration of AOCS members

How does the idea for a book about fatty acids become a 600-page book with 18 chapters of detailed chemistry? *Fatty Acids: Chemistry, Synthesis and Applications* is the result of a collaborative effort that involved a dozen AOCS Books and Special Publication Committee (BSPC) members, a visionary editor and highly experienced chemist with experience in academia and industry, 17 AOCS member contributors with highly regarded expertise in their fields, and an additional 26 contributing experts. In that sense, it is a shining example of the synergy that is created when AOCS members from diverse fields are brought together.

The results and key features of this particular synergy were recently summarized by Laurence Eyres, AOCS member, New Zealand Institute of Food Science and Technology Fellow, and director of ECG Limited (Aukland, New Zealand).

"Written by a team of industry experts, *Fatty Acids* includes detailed descriptions of fatty acid crystallization, enzymatic synthesis, and microbial production. This book focuses heavily on the chemistry of trans fatty acids, with extensive explanations of their synthesis and measurement. Further, the book addresses advances in the analytical methodology, including mass spectrometry, of fatty acids as well as their derivatives. It is a modern reference text for chemists and is not for the background reader or novice in the field. It would be an excellent modern and advanced addition to classic texts by Gunstone and Pryde.

Key features:

- Includes recent developments in the synthesis of fatty acid derivatives as renewable raw materials for the chemical industry.
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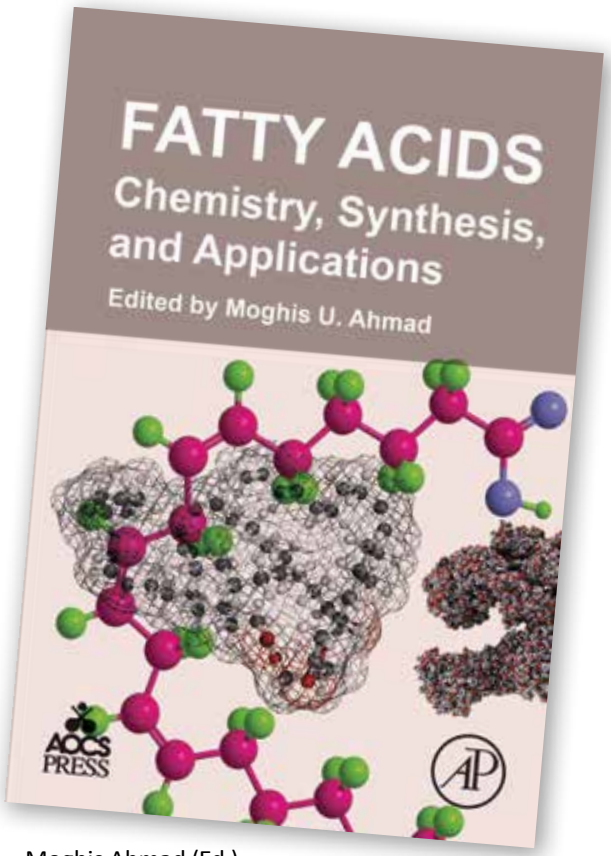
- Addresses uses of fats and fatty acids in foods and nutrition.
- Identifies the roles of fatty acids and derivatives in cosmetic technology.



Moghis Ahmad (Ed.)
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EXTRACTS & DISTILLATES

Corn lecithin for injection from deoiled corn germ: extraction, composition, and emulsifying properties

Hongcheng Liu, *et al.*, *Eur. J. Lipid Sci. Technol. 120*: 1700288, 2018, https://doi.org/10.1002/ejlt.201700288.

Although the lipid fraction of corn germ is rich in lecithin, this material is usually discarded with the residual pulp during industrial corn oil extraction processes. In this study, corn germ, after deoiling by supercritical carbon dioxide (SC—CO2), is used as a raw material to prepare corn lecithin for injection. The physicochemical properties, phospholipid composition, fatty acid composition, and emulsifying properties of the corn lecithin for injection is analyzed. The phospholipid and phosphatidylcholine contents in the prepared corn lecithin are 95.96% and 78.37%, respectively. Linoleic acid (45.99%) and oleic acid (22.31%) is the main unsaturated fatty acids, and the ratio of n-6 polyunsaturated fatty acids (PUFA) to n-3 PUFA (i.e., n-6/n-3) of 6.00 is in accord with World Health Organization recommendations. Emulsions stabilized with the corn lecithin for injection is optically characterized and microscopically inspected, and the droplet size distribution is determined. The results shows that an increase in the corn lecithin concentration lead to a decrease in droplet diameter and an increase in emulsion stability. Furthermore, the corn lecithin for injection creates a more stable emulsion than injection-grade egg yolk lecithin.

Investigation of lipid metabolism by a new structured lipid with medium- and long-chain triacylglycerols from *Cinnamomum camphora* seed oil in healthy C57BL/6J mice

Hu, J.-N., et al., *J. Agric. Food Chem. 66*: 1990–1998, 2018, https://doi.org/10.1021/acs.jafc.7b05659.

In the present study, a new structured lipid with medium- and long-chain triacylglycerols (MLCTs) was synthesized from camellia oil (CO) and *Cinnamomum camphora* seed oil (CCSO) by enzymatic interesterification. Meanwhile, the antiobesity effects of structured lipid were investigated through observing the changes of enzymes related to lipid mobilization in healthy C57BL/6J mice. Results showed that after synthesis, the major triacylgeride (TAG) species of intesterificated product changed to LaCC/CLaC (12.6 ± 0.46%), LaCO/LCL (21.7 ± 0.76%), CCO/LaCL (14.2 ± 0.55%), COO/OCO (10.8 ± 0.43%), and OOO (18.6 ± 0.64%). Through second-stage molecular distillation, the purity of interesterified product (MLCT) achieved 95.6%. Later, male C57BL/6J mice were applied to study whether the new structured lipid with MLCT has the efficacy of preventing the formation of obesity or not. After feeding with different diets for 6 weeks, MLCTs could reduce body weight and fat deposition in adipose tissue, lower plasma triacylglycerols (TG) (0.89 ± 0.16 mmol/L), plasma total cholesterol (TC) (4.03 ± 0.08 mmol/L), and hepatic lipids (382 ± 34.2 mg/mice) by 28.8%, 16.0%, and 30.5%, respectively, when compared to the control 2 group. This was also accompanied by increasing fecal lipids (113%) and the level of enzymes including cyclic adenosine monophosphate (cAMP), protein kinase A (PKA), hormone-sensitive lipase (HSL), and adipose triglyceride lipase (ATGL) related to lipid mobilization in MLCT group. From the results, it can be concluded that MLCT reduced body fat deposition probably by modulating enzymes related to lipid mobilization in C57BL/6J mice.

Validation and verification of a liquid chromatography–mass spectrometry method for the determination of total docosahexaenoic acid in pig serum

Dillon, G.P., *et al.*, *J. Agric. Food Chem. 66*: 2008–2014, 2018, https://doi.org/10.1021/acs.jafc.7b04791.

The paper presents the validation and verification of an analytical method for the determination of total docosahexaenoic acid (DHA) in pig serum by liquid chromatography–electrospray ionization–tandem mass spectrometry. The characteristics studied during the validation included precision and accuracy, limit of quantitation (LOQ), selectivity, calibration range and linearity, parallelism, and stability. A separate verification study was also performed. The method was linear over the range. Precision and accuracy met acceptance criteria at all levels, and the LOQ was determined as 1 µg/mL. Parallelism experiments were conducted to show that there was no bias introduced in using a surrogate matrix to quantify DHA. Recoveries of free DHA were obtained for quality control samples, and stability studies were conducted over 1, 7, 31, and 180 days. The results of the verification study were in line with the validation study, and in conclusion, the method was deemed fit for purpose for measuring total DHA in pig serum.

Food components in health promotion and disease prevention

Langhans, W., *J. Agric. Food Chem. 66*: 2287–2294, 2018, https://doi.org/10.1021/acs.jafc.7b02121.

The current obesity epidemic with its deleterious effects on public health and the increase in the prevalence of non-communicable diseases in our aging society have dramatically increased public awareness of nutrition-related health issues. On one hand, food components, such as fat, sugar, flavors, and spices, are major determinants of the hedonic value of food, and the constant and almost ubiquitous availability of good-tasting food in our affluent societies promotes overeating and weight gain. On the other hand, several food components, including flavoring compounds and the active

ingredients of many plants, such as spices and herbs (e.g., polyphenols and capsaicinoids) or thylakoids, supposedly can decrease food intake and affect gastrointestinal function and metabolism. These substances may act as antioxidants, may stimulate the release of incretins and, hence, insulin, and may improve insulin sensitivity or decrease plasma levels of lipids. Such beneficial effects are often difficult to demonstrate in epidemiological studies because they may occur only at supraphysiological doses and/or when the purified compounds are administered, but they can be present under certain circumstances. This review discusses the putative mechanisms of the health-promoting and disease-preventing effects of some food components and their potential physiological relevance, primarily with respect to counteracting obesity and type 2 diabetes.

Comparative aroma extract dilution analysis (cAEDA) of fat from tainted boars, castrated male pigs, and female pigs

Gerlach, C., *et al.*, *J. Agric. Food Chem. 66*: 2403–2409, 2018, https://doi.org/10.1021/acs.jafc.6b04747.

The aroma profile of porcine fat from tainted boars, female pigs, and castrated male pigs was investigated by application of comparative aroma extract dilution analysis (cAEDA) on a SAFE distillate of volatiles prepared from porcine back fat samples. The AEDA resulted in a total of 16 aroma active compounds for boar fat with flavor dilution (FD) factors ranging from 2 to 2048, whereas 12 aroma active compounds were found in fat of female pigs and 14 in fat of castrated male pigs, both with FD factors ranging from 2 to 32. Odor activity values (OAVs) of key components for each fat were identified: In boar fat androstenone, skatole, indole, and 2-aminoacetophenone showed highest OAVs, whereas 2,5-dimethylpyrazine, 2,4-decadienal, and δ-decalactone showed highest OAVs in fat of female pigs. Fat of castrated male pigs showed highest OAVs for skatole, indole, 1-octen-3-ol and methional. Finally, the off-flavor attributes of boar fat were successfully simulated by a recombinant of all odorants at their natural concentration level in deodorized sunflower oil.

Current strategies for the detoxification of *Jatropha curcas* seed cake: a review

Gomes. T.G., *et al.*, *J. Agric. Food Chem. 66*: 2510–2522, 2018, https://doi.org/10.1021/acs.jafc.7b05691.

Jatropha curcas is an important oilseed plant, with considerable potential in the development of biodiesel. Although *Jatropha* seed cake, the byproduct of oil extraction, is a residue rich in nitrogen, phosphorus, potassium, and carbon, with high protein content suitable for application in animal feed, the presence of toxic phorbol esters limits its application in feed supplements and fertilizers. This review summarizes the current methods available for detoxification of this residue, based upon chemical, physical, biological, or combined processes. The advantages and disadvantages of each process are discussed, and future directions involving genomic and proteomic approaches for advancing our understanding of biodegradation processes involving microorganisms are highlighted.

Increases in phenolic, fatty acid, and phytosterol contents and anticancer activities of sweet potato after fermentation by *Lactobacillus acidophilus*

Shen, Y., *et al.*, *J. Agric. Food Chem. 66*: 2735–2741, 2018, https://doi.org/10.1021/acs.jafc.7b05414.

Phenolic, fatty acid, and phytosterol contents in sweet potato (SP) fermented by *Lactobacillus acidophilus* were evaluated and compared with those of raw and boiled SPs. The differences in the profiles and levels of phenolics between the raw and boiled SPs were not as significant as the differences between those and the fermented SP. The levels of caffeic acid and 3,5-dicaffeoylquinic acid in fermented SP were more than 4 times higher than those in raw and boiled SPs. Two phenolics, p-coumaric acid and ferulic acid, which were not detected in either raw or boiled SP, were found in fermented SP. The level of each fatty acid or phytosterol increased in fermented SP and decreased in boiled SP. Among the hydrophilic and lipophilic extracts obtained from raw and fermented SPs, the hydrophilic extract of fermented SP exhibited the highest capability of inhibiting cancer-cell PC-12 proliferation. However, each of the extracts had very low cytotoxicities to normal-monkey-kidney-cell growth. The results indicated that SP fermented by *L. acidophilus* significantly increased free antioxidant-rich phenolics and inhibited cancer-cell-proliferation activity without cytotoxicity to normal cells.

Dietary wheat bran oil is equally as effective as rice bran oil in reducing plasma cholesterol

Lei. L., *et al.*, *J. Agric. Food Chem. 66*: 2765–2774, 2018, https://doi.org/10.1021/acs.jafc.7b06093.

Rice bran oil (RBO) possesses a plasma cholesterol-lowering activity, while effect of wheat bran oil (WBO) on plasma cholesterol remains unknown. The present study compared the cholesterol-lowering activity of WBO with that of RBO in hamsters. Fifty-four male hamsters were divided into seven groups fed either a noncholesterol diet (NCD) or one of six high-cholesterol diets, namely HCD diet (0.2% cholesterol +9.5% lard), HCD+C diet (0.2% cholesterol +9.5% lard +0.5% cholestyramine), WL diet (0.2% cholesterol +4.8% lard +4.8% WBO), WH diet (0.2% cholesterol +9.5% WBO), RL diet (0.2% cholesterol +4.8% lard +4.8% RBO), and RH diet (0.2% cholesterol +9.5% RBO). Plasma total cholesterol (TC) in HCD group was 327.4 ± 31.8 mg/dL, while plasma TC in two WBO and two RBO groups was 242.2 ± 20.8, 243.1 ± 31.7, 257.1 ± 16.3, and 243.4 ± 46.0 mg/dL, respectively, leading to a decrease in plasma TC by 22–26% ($P < 0.01$). No significant difference in cholesterol-lowering potency was seen between WBO and RBO. Plasma cholesterol-lowering activity of WBO and RBO was accompanied by down-regulation of hepatic 3-hydroxy-3-methylglutaryl-CoA reductase and fatty acid synthase, while up-regulation of cholesterol-7α-hydroxylase. WL, WH, RL, and RH diets increased the fecal excretion of total neutral sterols by 72.8%, 106.9%, 5.4%, and 36.8% ($P < 0.01$) respectively. Results indicated WBO and RBO could inhibit cholesterol absorption via down-regulation of intestinal Niemann-Pick C1 like 1 protein, acyl CoA:cholesterol acyltransferase 2, and ATP bind-

ing cassette transporter 5. In summary, WBO was equally effective as RBO in decreasing plasma cholesterol in hypercholesterolemia hamsters.

Dual functions of Lip6 and its regulation of lipid metabolism in the oleaginous fungus *Mucor circinelloides*

Zan, X., *et al.*, *J. Agric. Food Chem*. *66*: 2796–2804, 2018, https://doi.org/10.1021/acs.jafc.7b06024.

Although multiple roles of lipases have been reported in yeasts and microalgae, the functions of lipases have not been studied in oleaginous filamentous fungi. Lipase Lip6 has been reported in the oleaginous filamentous fungus *Mucor circinelloides* with the consensus lipase motif GXSXG and the typical acyltransferase motif of H-(X)4-D. To demonstrate that Lip6 might play dual roles as a lipase and an acyltransferase, we performed site-directed mutagenesis in the lipase motif and the acyltransferase motif of Lip6. Mutation in the lipase motif increased cell biomass by 12%–18% and promoted lipid accumulation by 9%–24%, while mutation in the acyltransferase motif induced lipid degradation. *In vitro*, purified Lip6 had a slight lipase activity but had a stronger phospholipid:DAG acyltransferase activity. Enzyme activity assays *in vivo* and phospholipid synthesis pathway analysis suggested that phosphatidyl serine and phosphatidyl ethanolamine can be the supplier of a fatty acyl moiety to form TAG in *M. circinelloides*.

Bio-based phenolic-branched-chain fatty acid isomers synthesized from vegetable oils and natural monophenols using modified H+-Ferrierite zeolite

Yan, Z., *et al.*, *Ind. Crops Prod. 114*: 115–122, 2018, https://doi.org/10.1016/j.indcrop.2018.01.053.

There is tremendous demand for the development of new bio-based materials with bioactive properties to replace antimicrobials or antibiotics that are no longer effective against microorganisms. For this current research, a new group of phenolic branched-chain fatty acids (n-PBC-FA), hybrid molecules of natural monophenols (i.e., thymol, carvacrol, and creosote) and mixed fatty acid (i.e., derived from soybean and safflower oils), are efficiently produced through a process known as arylation. The reactions for producing these compounds involve a combination of the modified H+-Ferrierite zeolite catalyst and water co-catalyst which give 72.4%, 77.2%, and 48.8% yields for thymol-safflower branched-chain fatty acids (BCFA), creosote-safflower BCFA, and carvacrol-BCFA, respectively. The ratios (2.2–17 wt/wt) of water co-catalyst to zeolite catalyst were found to have a significant influence on the arylation reaction as the water co-catalyst depressed the isomerization reaction and favored the arylation reaction. This modified H+-ferrierite zeolite can be regenerated by calcining at 500°C in air for 2 h, and the activity of the catalyst can be maintained at a relatively stable level without significant deactivation even after 7 reused cycles. The n-PBC-FA products are thoroughly characterized by gas chromatography and high performance liquid chromatography with high-resolution mass spectrometry. Most importantly, these products can be purified up to 97 wt% by the wiped-film molecular distillation device.

Enhancement of storage stability of wheat germ oil by encapsulation

Karadeniz, M., *et al.*, *Ind. Crops Prod. 114*: 14–18, 2018, https://doi.org/10.1016/j.indcrop.2018.01.068.

Wheat germ oil which is a rich source of α-tocopherol is susceptible to oxidation. The main objective of this study was to encapsulate wheat germ oil to enhance its oxidation stability. It was also aimed to investigate the effects of different homogenization methods on physicochemical properties and storage stability of encapsulated wheat germ oil. As homogenization methods, silent crusher (SC), microfluidization (MF), and ultrasonication (US) were used. SC and MF techniques created more stable emulsions than US. The effects of maltodextrin (MD) in combination with sodium caseinate (NaCa), gum arabic (GA), chitosan (CS), or whey protein concentrate (WPC) and also WPC:CS combination at different ratios on encapsulation efficiency of capsules were studied. Sodium caseinate (NaCa) was found to be better coating material than chitosan (CS), whey protein concentrate (WPC) and gum arabic (GA) for the encapsulation of wheat germ oil in terms of encapsulation efficiency. The rate of increase in totox values of fresh oil was apparently higher than that of microcapsules. The loss of α-tocopherol in encapsulated oil was found to be lower than that in fresh oil during storage at both 15°C and 45°C for 24 days.

The stability of palm oils during heating in a rancimat

Damanik, M. and M. Murkovic, *Eur. Food Res.Technol.* 1–7, online first March, 2018, https://doi.org/10.1007/s00217-018-3044-1.

Crude palm oil (CPO) and refined palm oil (PO) not only have a balance of saturated and unsaturated fatty acids, but also have higher β–carotene and vitamin E than other vegetable oils. A series of aliphatic aldehydes starting from hexanal to decanal was identified by LC-MS/MS and quantified as DNPH derivatives. In addition, the total amount of carbonyls was determined based on the calibration with hexanal. Looking at the kinetic profile of the carbonyl formation in crude palm oil and refined palm oil, both of the oils were still stable until 10 h of oxidation with the Ranzimat at 120°C. The analytical methods for quantifying the vitamin E and β–carotene are quick, reliable, precise, economical, and suitable for routine analysis. For both analyses, a simple dilution of the oil was necessary. The quantitative analysis showed that β–carotene in the oxidized crude palm oil decreased from 2.34 mg/g to 0.33mg/g within 7.5 h of oxidation. However, after 7.5 h, no more β–carotene was detected. In addition, β–carotene was not detected in refined palm oil. The HPLC-DAD method developed for the β–carotene in the crude palm oil was validated. The coefficient of determination (0.999) of the linear regression indicates a good correlation between the peak area and the amount of β–carotene. The linearity of the β–carotene analysis was tested in the range 0.00078–0.05 µg/cm3. The limit of detection (LOD) was 2.65 µg/cm3 and the limit of quantification (LOQ) was 8.83 µg/cm3 for β–carotene.

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Vitamin E in both refined and crude palm oil, δ–tocotrienol and γ–tocotrienol, have a longer shelf life compared to α–tocopherol and γ–tocopherol. The δ–tocotrienol is degraded slowly and can be found even after 15 h of oxidation with 0.035 mg/g remaining in the oxidized crude palm oil. However, in refined palm oil, the δ–tocotrienol could be determined until 11 h of oxidation with 0.49 mg/g.

Rosemary (*Rosmarinus officinalis*) oil: composition and functionality of the cold-pressed extract

Elbanna, K., *et al.*, *J. Food Measure* 1–9, online first March, 2018, https://doi.org/10.1007/s11694-018-9775-7.

The aim of this work was to investigate cold-pressed rosemary oil (RO) for its lipid classes, subclasses, fatty acid composition, tocochromanols, and total phenolics amount. Antiradical activity against 1,1-diphenyl-2-picrylhydrazyl (DPPH•) and galvinoxyl radicals, antioxidant activity, as measured by the Rancimat test, as well as antimicrobial activity against food-borne bacteria, and dermatophytic fungi of RO were evaluated. In RO, the amount of neutral lipids was highest (ca. 86%), followed by phospholipids (0.92%) and glycolipids (0.88%). The percentages of monounsaturated, polyunsaturated, and saturated fatty acids were 41.7, 42.3, and 15.8%, respectively. Linoleic acid (41.7%) and oleic acid (41.2%) were the major fatty acids while linolenic acid accounted for 1.3% of total fatty acids. The following tocochromanols were detected: α-, β-, γ-, and δ-tocopherols, which accounted for 291, 22, 1145, and 41 mg/100 g oil, respectively, as well as α-, β-, γ-, and δ-tocotrienols, which accounted for 18, 12, 29, and 158 mg/100 g oil, respectively. RO also contained high levels of phenolic compounds (7.2 mg GAE/g). After 60 min of reaction with free radicals, 67% of DPPH• and 55% of galvinoxyl radicals were quenched by RO. Rancimat test showed that blending RO with sunflower oil increased the induction period (IP) for blends. The IP of the RO: sunflower oil blend (1:9, v/v) was 390 min, and RO: sunflower oil blend (2:8, v/v) was longer (540 min). RO exhibited high antimicrobial potential against food-borne pathogenic bacteria (*E. coli*, *S. enteritidis*, and *L. monocytogenes*) and high antifungal potential against dermatophyte fungi (*T. mentagrophytes*, and *T. rubrum*). RO had unique high level of γ-tocopherol, which is a scavenger of reactive nitrogen species making it a promising material in food, cosmetic, and pharmaceutical applications.

Influence of seed roasting on pumpkin seed oil tocopherols, phenolics, and antiradical activity

Potočnik, T., *et al.*, *J. Food Compost. Anal. 69*: 7–12, 2018, https://doi.org/10.1016/j.jfca.2018.01.020.

To achieve the aroma and color typical of pumpkin seed oil, production includes a roasting step in which pressed pumpkin seeds are exposed to temperatures of 110°C and above for up to 60 min. Our purpose was to investigate the effect of roasting temperature on pumpkin seed oil tocopherols and phenolics as important compounds for its nutritional value. In this study, pumpkin seeds of two varieties were roasted at temperatures from 90 to 200°C, with one sample left unroasted for comparison purposes. Concentrations of α- and γ-tocopherol and phenolic compounds, as well as antiradical activity, were determined. Among the polyphenols, vanillic, caffeic, transcinnamic, and p-coumaric acid were detected. The highest observed concentrations of these polyphenolic acids were 3.08, 0.42, 2.48, and 1.91 mg/kg, respectively. As roasting temperatures increased, polyphenol concentrations decreased. The least significant changes were observed in α- and γ-tocopherols, with concentrations ranging from 51 to 113 mg/kg and 356 to 646 mg/kg, respectively. Antiradical activity was determined spectrophotometrically via 2,2-diphenyl-1-picrylhydrazyl (DPPH) testing. The antiradical effect values ranged from 31.4 to 70.6% and 19.3 to 47.7% for Gleisdorf and Rustikal samples, respectively. Several chemical parameters (acid, saponification, peroxide and iodine values) were also examined.

Formulation and characterization of novel nanostructured lipid carriers made from beeswax, propolis wax, and pomegranate seed oil

Soleimanian, Y., *et al.*, *Food Chem. 244*: 83–92, 2018, https://doi.org/10.1016/j.foodchem.2017.10.010.

The objective of this study was to develop functional nanostructured lipid carriers (NLCs) using beeswax (BW), propolis wax (PW), and pomegranate seed oil (PSO). NLCs were prepared by a melt emulsification-ultra sonication technique. The influences of solid lipid composition, surfactant blend concentration (2, 4, and 6% of formulation), and PSO content (10, 30, and 50% of total lipid phase) were investigated. Statistical evaluations revealed that the formulation variables had significant effects on physical properties of NLC. The developed nanocarriers presented particle sizes ranging from 71 to 366 nm, leading to excellent physical stability. The optimum formulations with minimum particle size and high zeta potential value were PW and BW + glycerol behenate samples, containing 10% oil and 6% surfactant. DSC and XRD studies indicated that the addition of oil to the lipid phase could disturb the crystalline order and form lattice defects. TEM observations exhibited spherical morphology of the NLCs.

Structural modification of natural product tanshinone I leading to discovery of novel nitrogen-enriched derivatives with enhanced anticancer profile and improved drug-like properties

Ding, C., *et al.*, *J. Med. Chem. 61*: 760–776, 2018, https://doi.org/10.1021/acs.jmedchem.7b01259.

Natural products are a diverse source of chemicals, but it is difficult to convert them into drugs for two main reasons: 1. intellectual property rights issues 2. the tendency of natural products to work in combination with other chemicals within the same place, where the potency of each component is optimized but not maximized. For a drug to be commercially successful, it must exhibit maximum potency against specific molecular targets. In contrast, because natural products tend to have weak potency and poor absorption, distribution, metabolism, and excretion properties,

they are not good drug candidates on their own. However, they can be a good starting point for new drugs. This article describes a more affordable approach to drug discovery in which broad and structural modification is used to create potent derivatives.

The clinical development of natural product tanshinone I (1) for cancer therapy is hampered by its weak potency and poor drug-like properties. Herein, a broader and systemic structural modification on 1 was conducted to generate four series of new tanshinone derivatives. Among them, the lactam derivative 22h demonstrated the most potent antiproliferative activity against KB and drug-resistant KB/VCR cancer cells, which are approximately 13- to 49-fold more potent than 1. Compound 22h possesses significantly improved drug-like properties including aqueous solubility (15.7 mg/mL), metabolic stability of liver microsomes, and PK characters (T1/2 = 2.58 h; F = 21%) when compared to 1. Preliminary mechanism studies showed that 22h significantly induced apoptosis of HCT116 cells, at least partially, through activation of caspase-3/-7. More importantly, administration of 22h at 10 mg/kg significantly suppressed the tumor growth of HCT116 xenograft in vivo without significant loss of body weight of the tested nude mice.

A first step toward a consensus static *in vitro* model for simulating full-term infant digestion

Ménard, O., *et al.*, *Food Chem. 240*: 338–345, 2018, https://doi.org/10.1016/j.foodchem.2017.07.145.

In vitro alternatives to clinical trials are used for studying human food digestion. For simulating infant digestion, only a few models, lacking physiological relevance, are available. Thanks to an extensive literature review of the *in vivo* infant digestive conditions, a gastrointestinal static *in vitro* model was developed for infants born at term and aged 28 days. The model was applied to the digestion of a commercial infant formula. Kinetics of digestion, as well as the structural evolution, were compared with those obtained while submitting the same formula to the adult international consensus protocol of *in vitro* static digestion. The kinetics of proteolysis and lipolysis differed according to the physiological stage resulting mainly from the reduced level of enzymes and bile salts, as well as the higher gastric pH in the infant model. This *in vitro* static model of infant digestion is of interest for scientists, food, or pharmaceutical manufacturers.

Specialized food composition dataset for vitamin D content in foods based on European standards: application to dietary intake assessment

Milešević, J., *et al.*, *Food Chem. 240*: 544–549, 2018, https://doi.org/10.1016/j.foodchem.2017.07.135.

This article describes an effort to develop tools to help analyze existing data as well as identify gaps. A review of national nutrition surveys from 2000 to date, demonstrated high prevalence of vitamin D intakes below the EFSA Adequate Intake (AI) (<15 µg/d vitamin D) in adults across Europe. Dietary assessment and modelling are required to monitor efficacy and safety of ongoing strategic vitamin D fortification. To support these studies, a specialized vitamin D food composition dataset, based on EuroFIR standards, was compiled. The FoodEXplorer™ tool was used to retrieve well documented analytical data for vitamin D and arrange the data into two datasets— European (8 European countries, 981 data values) and US (1836 data values). Data were classified, using the LanguaL™, FoodEX2 and ODIN classification systems and ranked according to quality criteria. Significant differences in the content, quality of data values, missing data on vitamin D2 and 25(OH)D3 and documentation of analytical methods were observed. The dataset is available through the EuroFIR platform.

Chemometric authentication of the organic status of milk on the basis of trace element content

Rodríguez-Bermúdez, R., *et al.*, Food Chem. *240*: 686–693, 2018, https://doi.org/10.1016/j.foodchem.2017.08.011.

The same method for differentiating types of milk described in this article could, with minimal effort, also be used to collect and analyze data that links the product to its geographic location based on soil and water quality. Such tools are important to substantiate the claims and origins of any natural material.

The objective of this study was to develop a method for authenticating organic milk samples in North Spain on the basis of its trace mineral composition. Fourteen elements in 98 samples were determined by inductively coupled plasma mass spectrometry. Although concentrations of Co, Cr, Cu, I, Se, and Zn were statistically higher in conventional milk and As in organic, none of these elements by itself was able to discriminate between organic and conventional milk. The chemical data was examined by principal component analysis and cluster analysis, revealing a natural separation between organic and conventional milk. In a second step, several supervised pattern recognition techniques were used to construct mathematical models for predicting the type of milk (organic or conventional) based on the metal content. The results proved that the model constructed using the artificial neural network is capable of correctly identifying the type of milk in almost 95% of cases.

Hordenine: a novel quorum-sensing inhibitor and antibiofilm agent against *Pseudomonas aeruginosa*

Zhou, J.-W., *et al.*, *J. Agric. Food Chem. 66*: 1620–1628, 2018, https://doi.org/10.1021/acs.jafc.7b05035.

Understanding of microbial quorum sensing elicitors may one day change how we treat pathogens. Controlling microbial behavior and keeping their populations in check by deploying quorum-sensing inhibitors may one day completely eliminate the use of strong antibiotics.

The quorum-sensing (QS) inhibitory activity of hordenine from sprouting barley against foodborne pathogen *Pseudomonas aeruginosa* was evaluated for the first time here. At concentrations ranging from 0.5 to 1.0 mg mL–1, hordenine inhibited the levels of acyl-homoserine lactones. The enhanced susceptibility of hordenine with netilmicin on *P. aeruginosa* PAO1 biofilm formation as well as their efficiency in disrupting preformed biofilms was also evaluated using scanning elec-

tron microscopy and confocal laser scanning microscopy (CLSM). Hordenine treatment inhibited the production of QS-related extracellular virulence factors of *P. aeruginosa* PAO1. Additionally, quantitative real-time polymerase chain reaction analysis demonstrated that the expressions of QS-related genes, lasI, lasR, rhlI, and rhlR, were significantly suppressed. Our results indicated that hordenine can serve as a competitive inhibitor for signaling molecules and act as a novel QS-based agent to defend against foodborne pathogens.

Metabolomics reveals that dietary ferulic acid and quercetin modulate metabolic homeostasis in rats

Zhang, L., *et al.*, *J. Agric. Food Chem. 66*: 1723–1731, 2018, https://doi.org/10.1021/acs.jafc.8b00054.

Microbial communities in the gut and skin are influenced by food and many other factors. Tools are being developed to study these communities and their how they affect our health. Here, ferulic acid and quercetin are used to study the behavior of microbial communities in the gut, but the tools developed in the process would be useful to study other products as well as drugs.

Phenolic compounds ingestion has been shown to have potential preventive and therapeutic effects against various metabolic diseases such as obesity and cancer. To provide a better understanding of these potential benefit effects, we investigated the metabolic alterations in urine and feces of rat ingested ferulic acid (FA) and quercetin (Qu) using NMR-based metabolomics approach. Our results suggested that dietary FA and/or Qu significantly decreased short-chain fatty acids and elevated oligosaccharides in the feces, implying that dietary FA and Qu may modulate gut microbial community with inhibition of bacterial fermentation of dietary fibers. We also found that dietary FA and/or Qu regulated several host metabolic pathways, including TCA cycle and energy metabolism, bile acid, amino acid, and nucleic acid metabolism. These biological effects suggest that FA and Qu display outstanding bioavailability and bioactivity and could be used for treatment of some metabolic syndromes, such as inflammatory bowel diseases and obesity.

Pretreatment with ethanol as an alternative to improve steviol glycosides extraction and purification from a new variety of stevia

Formigoni, M., *et al.*, *Food Chem.* Volume *241*: 452–459, 2018, https://doi.org/10.1016/j.foodchem.2017.09.022.

Leaves of a new variety of *Stevia rebaudiana* with a high content of rebaudioside A were pretreated with ethanol. The ethanolic extract showed high antioxidant potential and 39 compounds were identified, by UPLC/HRMS, among them one not yet mentioned in the literature for stevia leaves. From the *in natura* leaves and pretreated leaves, the conditions of aqueous extraction of steviol glycosides were investigated using response surface methodology. The aqueous extracts obtained were purified by ion exchange chromatography techniques and membrane separation methods. The recuperation of steviol glycosides was 4.02 g for pretreated leaves and 2.20 g for *in natura* leaves. The level of purity was, respectively, 87% and 84.8%. The results obtained demonstrate that pretreatment increases the yield and purity level of stevia sweeteners by the use of environmentally friendly methodologies and the final product presented acceptable sensory characteristics.

Sterols in infant formulas: a bioaccessibility study

Islam, J.A., *et al.*, *J. Agric. Food Chem. 66*: 1377–1385, 2018, https://doi.org/10.1021/acs.jafc.7b04635.

The design of infant formulas (IFs) seeks to resemble human milk (HM) composition and functionality. The fat sources used usually comprise vegetable oil blends to mimic the fatty acid composition of HM and introduce changes in the animal/plant sterol ratio. In contrast, the use of milk fat globule membrane (MFGM)-rich ingredients could improve this aspect by increasing the ratio. The present study evaluates the bioaccessibility (BA) of sterols (cholesterol, desmosterol, brassicasterol, campesterol, stigmasterol, and β-sitosterol) in three IFs (with or without MFGM) using an *in vitro* digestion method simulating infant conditions. Analytical parameters confirmed the suitability of the method for all of these sterols. Results showed the presence of MFGM to increase cholesterol content (6–7 vs 2 mg/100 mL), this being the most bioaccessible sterol in the IFs. Although the BA of cholesterol was reduced in MFGM-enriched IF (65.6–80.4% vs 99.7%), the intake of bioaccessible cholesterol from these IFs was higher.

Natural products containing a nitrogen–sulfur bond

Janusz, J., *et al.*, *J. Nat.* Prod. *81*: 423–446, 2018, https://doi.org/10.1021/acs.jnatprod.7b00921.

Only about 100 natural products are known to contain a nitrogen–sulfur (N–S) bond. This review thoroughly categorizes N–S bond-containing compounds by structural class. Information on biological source, biological activity, and biosynthesis is included, if known. We also review the role of N–S bond functional groups as post-translational modifications of amino acids in proteins and peptides, emphasizing their role in the metabolism of the cell.

Hydrothermal liquefaction of high- and low-lipid algae: mass and energy balances

Cheng, F., et al., Bioresour. Technol. *258*: 158-167, 2018, https://doi.org/10.1016/j.biortech.2018.02.100.

Hydrothermal liquefaction (HTL) of high-lipid microalgae *Nannochloropsis salina* (*N. salina*) and low-lipid microalgae *Galdieria sulphuraria* (*G. sulphuraria*) were run under subcritical conditions (310–350°C and 10–17 MPa) in a 1.8 L batch autoclave system. HTL mass and energy balances for both species were compared under different operating conditions to predict the optimum reaction conditions for new algae strains based on their feedstock composition. Bio-crude oils and chars were characterized by bomb calorimetry, elemental analysis, inductively coupled plasma optical emission spectrometry (ICP-OES), and thermogravimetric analysis (TGA). Under the optimized conditions, 59 wt% and 31 wt% bio-crude oil yields were obtained from HTL of *N. salina* and *G. sulphuraria*, while 85% and 59% of the feedstock energy were partitioned into *N. salina*-derived and *G. sulphuraria*-derived bio-crude oils, respectively. More favorable energy balances were related to shorter reaction times and higher algal solid contents.