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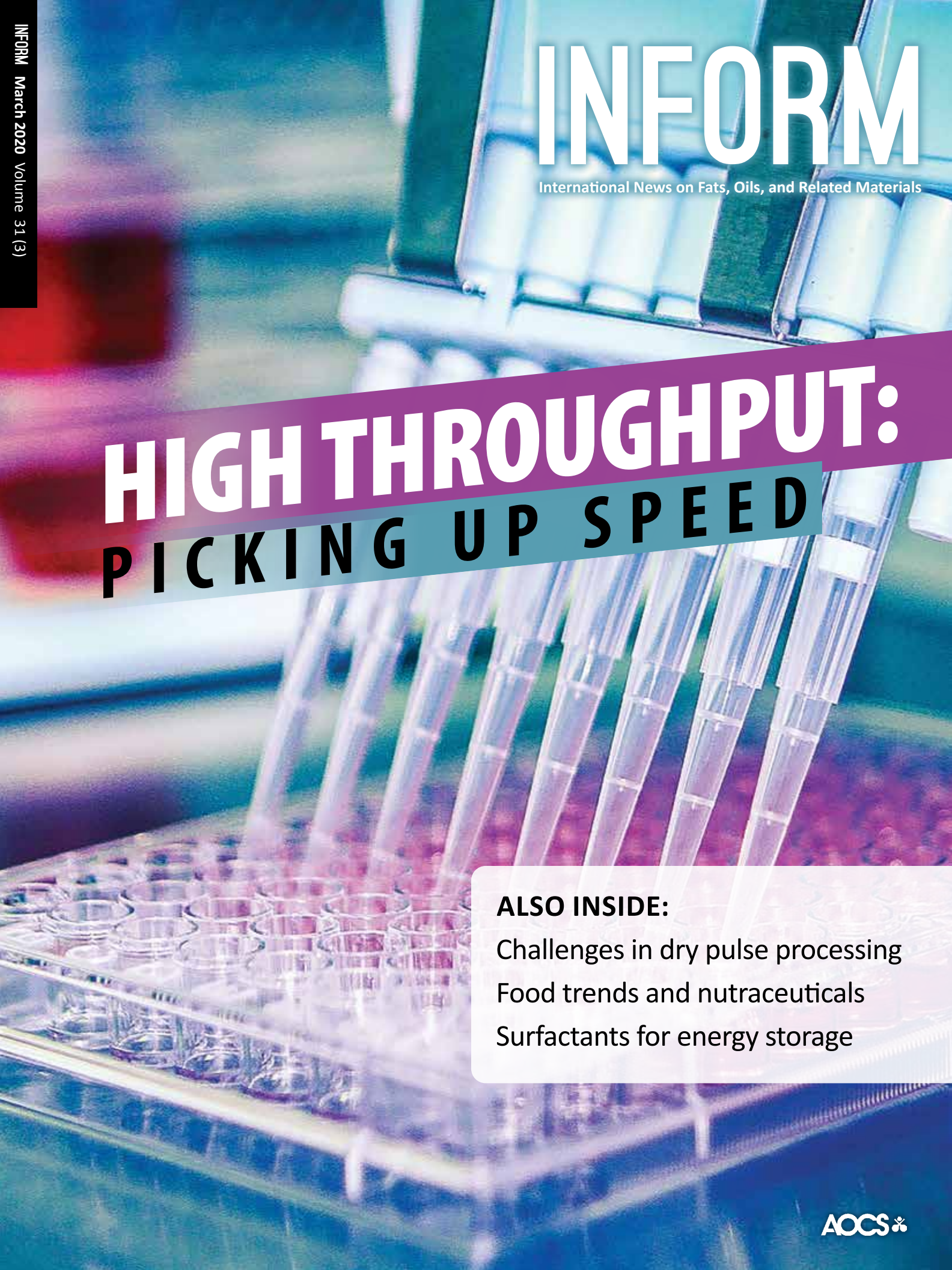

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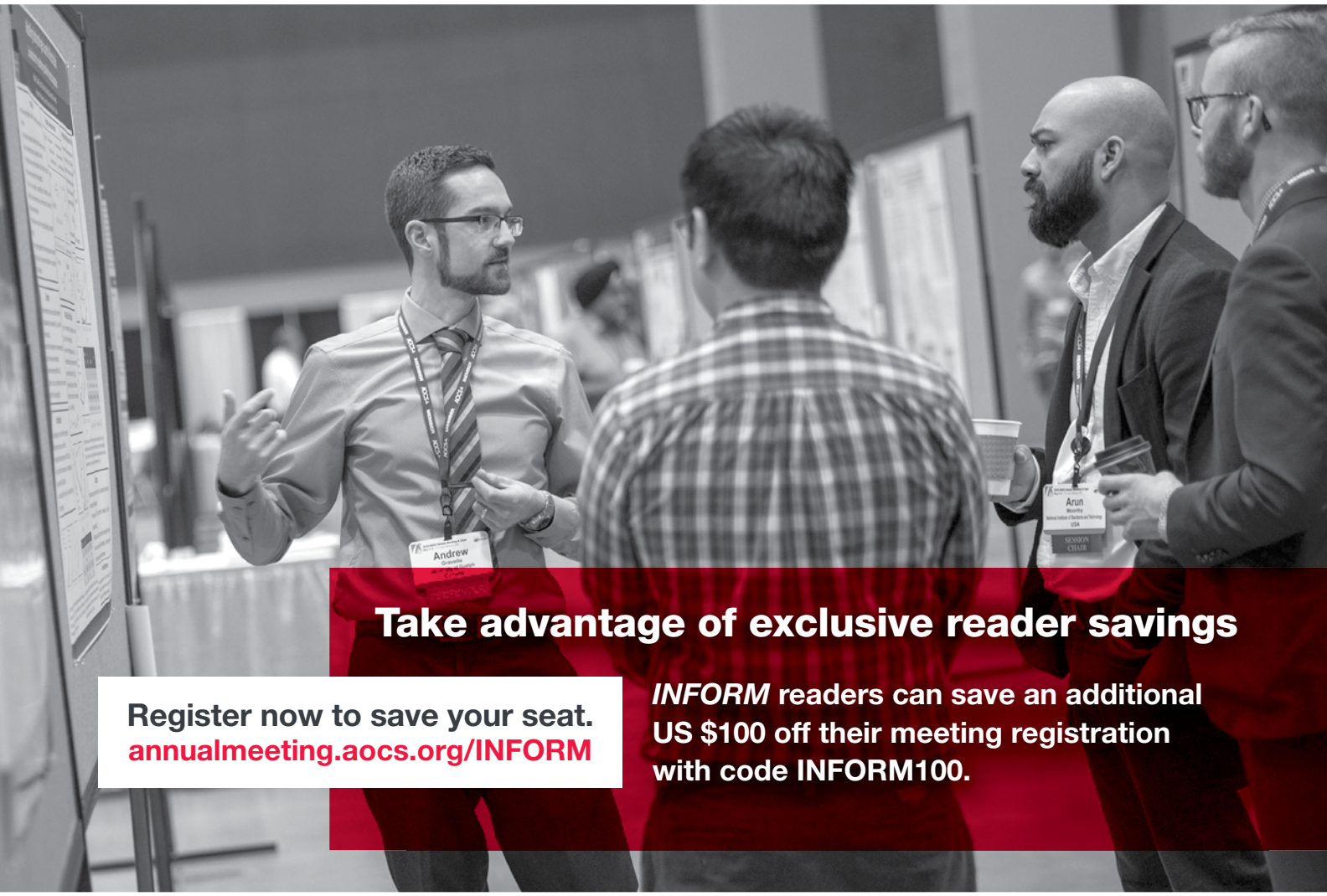

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The high-throughput frontier

Rebecca Guenard

There was a time when drug discovery was mostly serendipitous—take penicillin, for example. Then came a new way to screen molecules, and the discoveries ramped up exponentially. In 2019, the US Food and Drug Administration alone approved 48 novel drugs. The year before it was 59. This rapid development of new treatments in the past 30 years is due to two things: the identification of targets (such as proteins) through genome sequencing, and the high-throughput screening of compounds that could be used to affect those targets.

- **The drive to solve problems faster initiated the development of computer-controlled instruments that spit out data on exploratory experiments for hundreds of samples.**
- **More and more high-throughput applications are being applied to create solutions in the fats and oils industries.**
- **However, even after decades of use, the methods still suffer from a lack of standardization that makes cross-referencing data difficult.**

Many research centers across the United States opened their doors to assist with finding answers to biological questions. The University of California, Los Angeles, has a facility called the Molecular Screening Shared Resources (MSSR) laboratory that routinely screens 100,000 molecules a day (http://www.mssr.ucla.edu/). Similar facilities exist at the University of Illinois at Champaign-Urbana, Illinois (https://scs.illinois.edu), and at Rockefeller University in New York, New York (https://www.rockefeller.edu/htsrc/). These programs have cataloged as many as 300,000 small molecules. Researchers test hundreds of molecules at a time against various biological assays that are dispensed into microli-

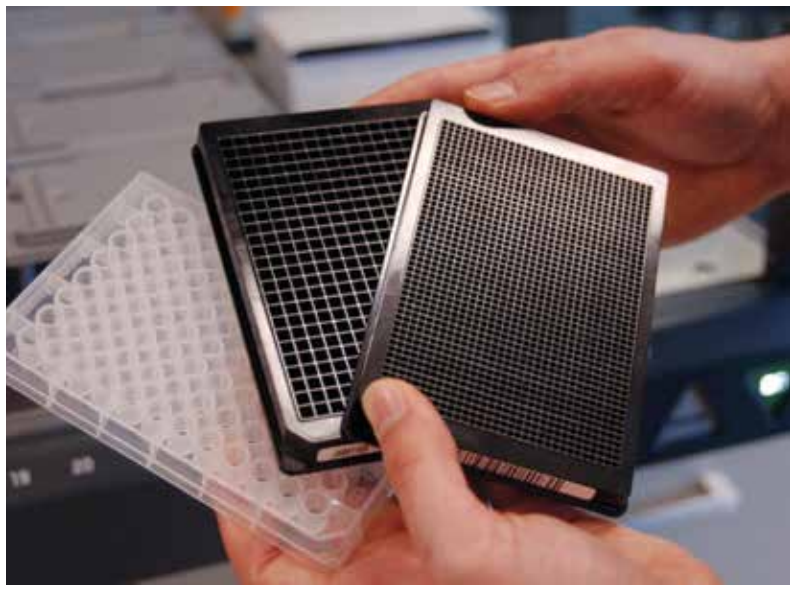
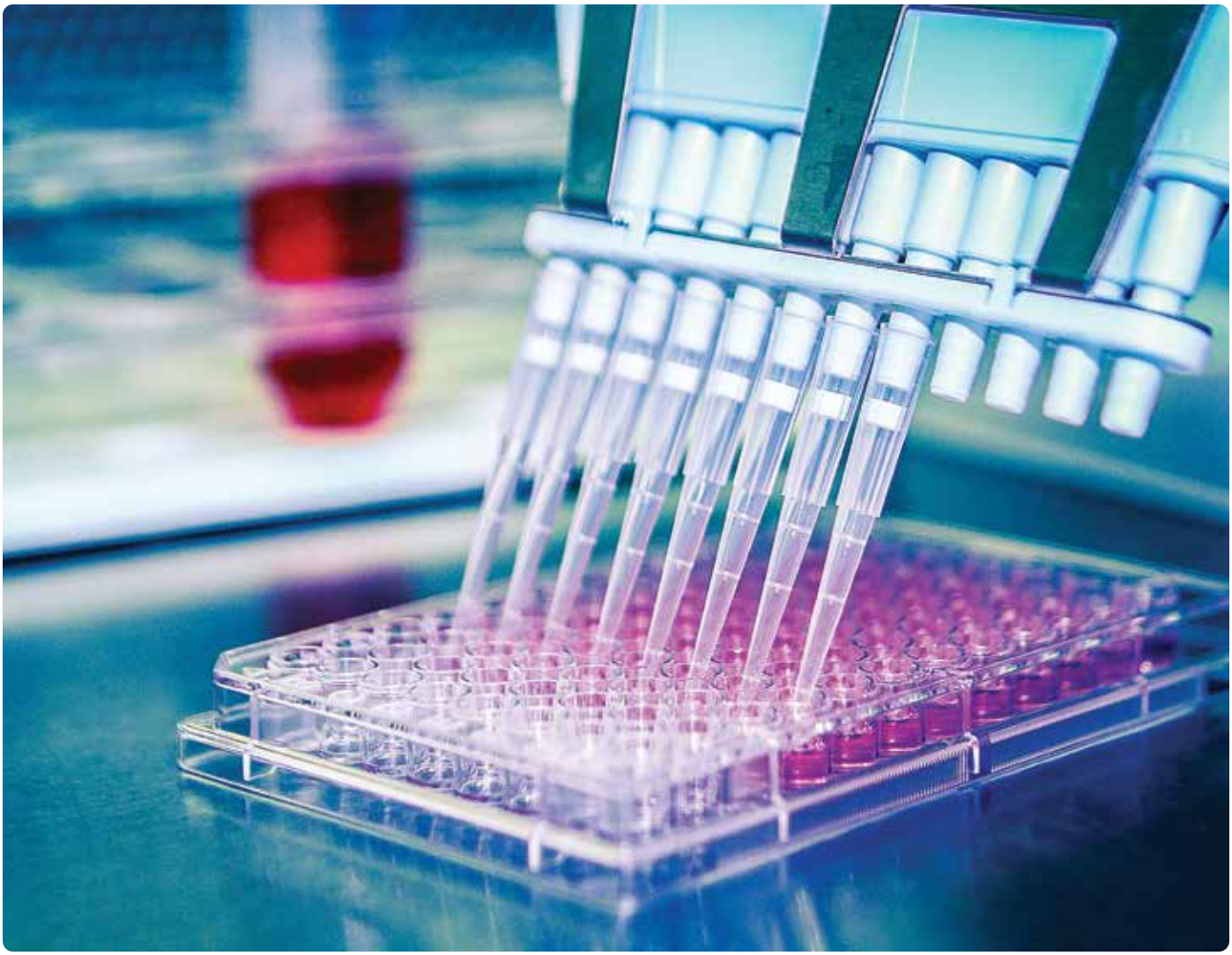


FIG. 1. An example of 96, 384, and 1536 well plates for high-throughput micro- and nanoscale experiments. Source: labautopedia.com



ter or nanoliter well-plates by automation (Fig. 1). The plates are then analyzed by spectroscopic methods, churning out a wealth of data on biological reactions that often lead to a new drug treatment in record time.

"Contract research organizations are now carrying out large amounts of screening without the need to sink a large capital investment, it gives smaller companies a lot more flexibility and in fact many large companies are taking this approach too," said Bill Janzen, an expert in drug development and editor of the book, *High Throughput Screening*, during an interview with the online magazine *Technology Networks.*

The big mechanical arms, robotic instruments, and data processing machinery used for high-throughput technology were once financially out of reach for smaller companies or start-ups. Today, that is no longer the case thanks to the increased availability of reliable and cost-effective outsourcing.

Given the capacity for speed such technology offers, it is only natural that other high-throughput methods are now being developed and used for a wide range of applications that go beyond biological systems. Chemical synthesis is a particularly tedious process that requires many iterations of failed experiments before a researcher successfully produces a new molecule. New contract labs are teaching the next generation of scientists to be fluent in high-throughput systems and gathering data that will eventually lead to completely automated chemical synthesis. Formulations are also benefiting from a high-throughput advantage. The personal care and coatings industries are applying high-throughput methods to speed the production of new formulations and bring products to market faster.

THE FUTURE OF FORMULATIONS

The United Kingdom has established a network of technology centers, known as the Catapult Network, with the mission of driving innovation by bridging the ideas of academia with the know-how of industry. The Center for Process Innovation (CPI), whose head office is in Wilton, UK, was established nearly 15 years ago to help companies launch new products (https://www.uk-cpi.com/). A little over four years ago, they started applying high-throughput methods to evaluate and optimize formulations. "We support businesses across all sectors in the formulations space," says Tony Jackson, formulations business unit director at CPI.

CPI has the capability to evaluate the performance of hundreds of variations of a formulation. Automated robots dispense a range of ingredients in complex mixtures to optimize a desired formulation (Fig. 2). Like the screening labs mentioned earlier, CPI is a facility open to companies that are interested in developing or improving a product, without investing in pricey, high-throughput equipment. According to Jackson, this is crucial to the way today's consumer goods businesses are trying to keep up with customer expectations.

"They are thinking about, in the future, going from making big batches of paint or washing powder to making more personalized products," Jackson says. His business unit at CPI works with companies who want fast analytical measurements so they can understand formulation properties and quickly scale-up to batch processes. Companies are also interested in exploring options for continuous production that will give them the versatility to alter their manufacturing schedule according to consumer trends.

"Consumers expect their products to solve the problems that they have today," says Jackson. That might mean personalized medicine that is tuned to seasonal cold outbreaks, or laundry detergents with more stain-fighting ingredients in summer, when clothes get dirtier from more time spent outdoors. To achieve seamless conversion of products during continuous production, companies must first understand the chemical and physical properties of a wide range of formulations, he explains. High-throughput methods are ideal for gathering this information.

HIGH-SPEED STABILITY TESTING

Aside from assisting with how best to incorporate ingredients into a formulation, CPI has spent the past two years designing a new high-throughput way to test formulation stability. Currently, even with these multiplate, robotic devices, formulas require periodic testing over long periods of time to determine if or when a formulation becomes unstable. This slows down the launch of new products dramatically. Jackson and his team at CPI have been collaborating with two UK universities to take the wait out of stability testing by developing a microfluidics technology that can cut testing down to days, possibly hours.

"Instead of making a formulation, sticking it in a vial, and checking it periodically, this method uses microfluidics to impart mechanical and temperature stresses onto products," says Jackson (Fig. 3). "You can detect changes more quickly and with much less volume."

Working with Procter & Gamble and BP, CPI is in the process of testing and validating their high-throughput stability system at the pilot level. Jackson says they hope that in another year, the method will be useful as both a pass/fail stability screen and a mechanistic means for understanding why a formulation fails. "It will be a significant tool in the formulations armory," he says.

FIG. 2. A robotic arm retrieves well plates for analysis in a high-throughput screening contract lab maintained by the National Institutes of Health in Bethesda, Maryland, USA. Source: https://ncats.nih.gov

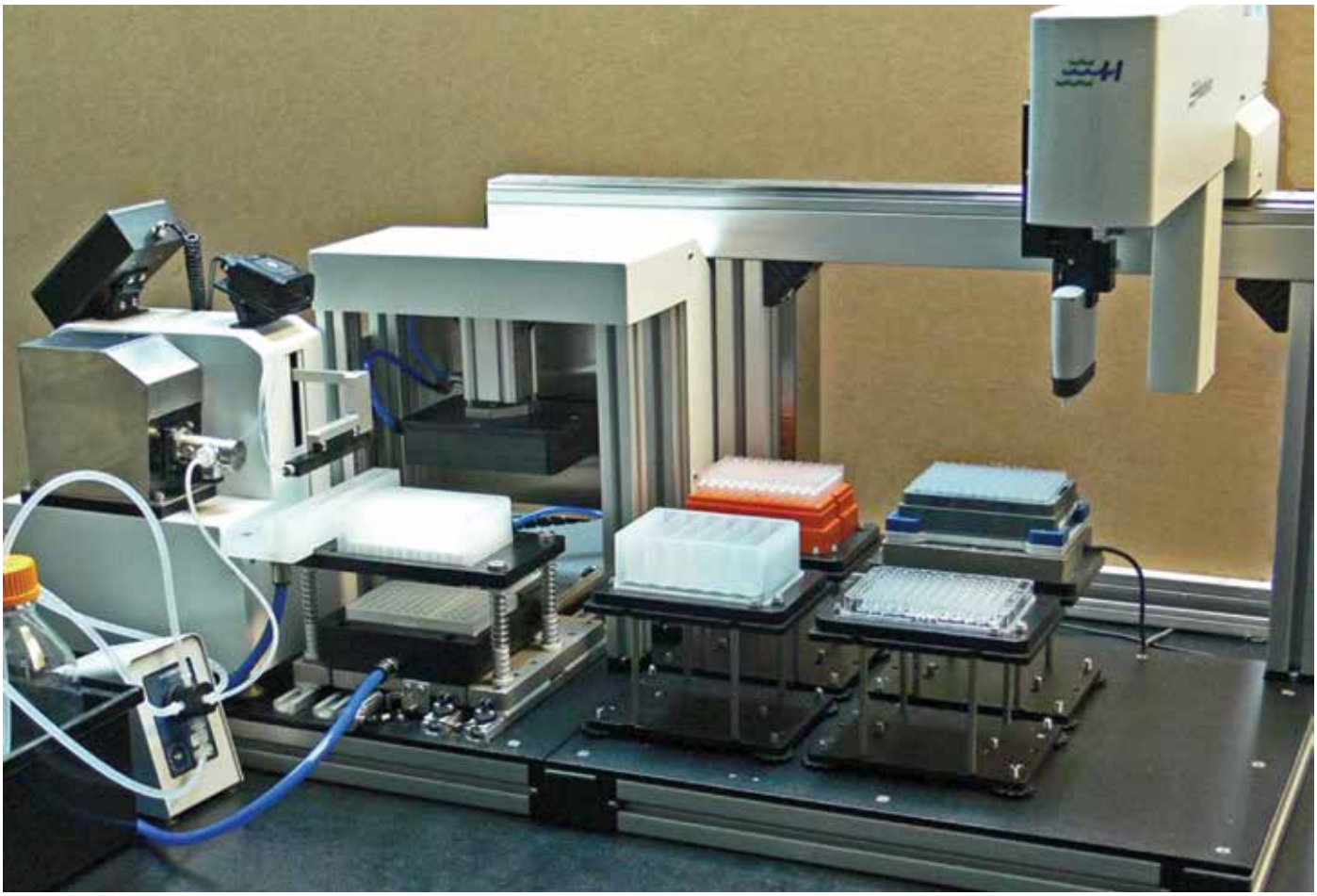


FIG. 3. An example of an instrument that can be used to dispense reagents for high-throughput experiments. Source: hudsonrobotics.com

High-throughput screening is being applied to other types of formulations testing as well. At the AOCS annual meeting last year, Carol Mohler, of the Dow Chemical Company in Midland, Michigan, USA, described a high-throughput method of measuring viscosity. The viscometer the company created for internal use can measure hundreds of samples in an hour. The instrument quickly identifies samples with undesirable flow behaviors, narrowing the sample size needed for detailed rheological characterizations.

As more companies recruit these computer-controlled methods to conduct research, scientists with high-throughput savvy will have an advantage in the workplace.

TRAINING SCIENTISTS TO TRAIN ROBOTS

The Imperial College of London offers a doctoral program, called Next Generation Synthesis and Reaction Technology, in which students learn to use continuous-flow reactors and high-throughput robotics platforms to create new molecules. The training occurs at Imperial's Center for Rapid Online Analysis of Reactions (ROAR), a public facility that opened in early 2019. ROAR has the capability to evaluate reactions in real time with instruments that identify intermediates, providing insight into the synthesis with each step of a reaction. The students in the program also learn data science, a burgeoning area of chemistry and biology that uses statistical analysis to interpret the data that results from running thousands of iterations of the same reaction that each took place under slightly different reaction conditions.

Like CPI and others, ROAR is open to anyone in the chemistry community who proposes an experiment to the lab's full-time staff (http://www.imperial.ac.uk). While exposing future scientists to the variety of problems that can be solved with high-throughput systems, ROAR is also teaching the computers.

A wealth of synthesis instructions can be found in the scientific literature, and researchers hope they could teach machines to use them. Many have tried, but creating an algorithm to teach a machine to collect the information published in scientific papers is not like teaching a supercomputer to play chess. The instructions are written out in an analog way that is not easy for a computer to comprehend. In addition, literature synthesis instructions can be vague or incomplete and they do not include mistakes. Scientists do not publish the starting material and reaction conditions that were attempted but did not result in a product. These are details that a machine would need to be able to think like a synthetic chemist.

"Synthetic chemists in academic labs are not collecting the right data and not reporting it in the right way," ROAR's facility manager, Benjamin J. Deadman, said in an October 2019 article in C&EN (https://cen.acs.org/synthesis).

However, as ROAR begins to routinely collect large amounts of data on a variety of synthetic reactions, that data can be used to establish machine-learning algorithms to eventually teach robots to do independent synthesis. Some scientists are imagining a future of robot laboratory technicians. Tell the robot what molecule to synthesize and, using artificial intelligence, it will get the job done. Collecting synthesis data in real time, as ROAR does, gets us to that future sooner.

Though high-throughput methods may speed up the process of machine learning, they are not going to replace human scientists any time soon. As data collection from high-throughput screening for drug development has proven, having large amounts of data can cause a whole new set of problems.

HANDLING HIGH-THROUGHPUT DATA

The intention of any high-throughput process is to perform research faster. Though employing computers to perform thousands of experiments may speed up the work, researchers are left with the burden of making sure their work has meaning. For the purpose of drug development or any other biotech application, the use of living organisms further complicates the analysis.

Along each step in the high-throughput screening process, a scientist must make a choice about algorithms. When determining the genes expressed in thousands of single cells, for example, a mathematical function is used to visualize the resulting, extensive data set. More than 100 such tools exist, according to Catalina Vallejos, a researcher at the University of Edinburgh, Scotland, and scientists need to prioritize the task of establishing reproducible benchmark schemes for high-throughput methods.

Measuring the activity of a compound on a drug target is one thing, but quantifying efficacy requires non-linear regression, which means selecting from several mathematical models. The wrong model could result in a false positive or in a viable compound being overlooked. The size and complexity of high-throughput data sets means performing uncertainty calculations for each result would require too much attention, negating the benefit of the time-saving technique.

In recent years, software developers have built models that specifically address data handling for high-throughput analysis. These products can boost the confidence of the results within an organization, but for data to be shared or evaluated outside a company, researchers using high-throughput methods need standardized procedures. Continuous-flow systems operated by robots do not record fine grain data, such as batch and plate number, which makes evaluating another researcher's results difficult. There is no way to make sure everyone is looking at the same thing.

Pharmaceutical companies are making efforts to remove these pitfalls. AstraZeneca, GlaxoSmithKline, Novartis, and Pfizer founded a collaboration called Pistoia Alliance meant to lower the barriers to innovations in healthcare. Last year, they released the Unified Data Model (https://www.pistoiaalliance.org/news) which specifies an agreed-upon file format for chemical reaction information. As more ingredient manufactures rely on biotechnology as a source for their products, eventually they may realize the need to reach a similar agreement on data collection and management.

Despite the lack of standardized methods, high-throughput technology continues to expand into more applications. Its platforms provide formulators with information about new materials and new mixtures on a faster timescale. In turn, formulation scientists can correlate this information with findings from traditional methods and provide the product attributes that appeal to the consumer. With high-throughput technology available to measure fundamental properties like rheology, friction, and wear, the process continues to prove its relevance in the consumer goods market.

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In vitro digestion studies of the impact of food matrix effects on vitamin and nutraceutical bioaccessibility

Yunbing Tan and David Julian McClements

- In studies using an *in vitro* gastrointestinal model, the bioaccessibility of fat-soluble vitamins was considerably lower when the oil phase was indigestible than digestible.
- The bioaccessibility of vitamin D was reduced by certain types of dietary fibers. Cationic chitosan may have reduced bioaccessibility by binding to anionic bile salts, mixed micelles, or fat droplets.
- High levels of soluble calcium reduced the bioaccessibility of pro-vitamin A (beta-carotene), probably because the cationic calcium ions caused the beta-carotene-loaded mixed micelles to precipitate.

Food, nutrition, and pharmaceutical scientists are researching the factors that impact the bioavailability of bioactive agents, such as nutraceuticals, vitamins, minerals, and pharmaceuticals. Fat-soluble bioactive agents are often dissolved in a lipid phase, which may then be converted into lipid droplets, prior to or after ingestion. Before ingestion, homogenization is usually carried out using mechanical homogenizers, whereas after ingestion it is carried out by physical and chemical processes occurring inside the body. The bioactive-loaded lipid droplets formed are digested by enzymes (gastric and pancreatic lipases) inside the small intestine, which releases the bioactives, thereby allowing them to be incorporated into the mixed micelles formed by free fatty acids (FFA), monoglycerides, phospholipids, and bile salts. The bioactive-loaded mixed micelles then migrate to the periphery of the epithelium cells where they can be absorbed. The fraction of ingested bioactive agents that ends up within the mixed micelles is referred to as the *bioaccessibility*.

For strongly hydrophobic bioactives, like fat-soluble vitamins and carotenoids, the bioaccessibility is often the rate-limiting step that determines their overall bioavailability (McClements, Li, *et al*., 2015). Consequently, many researchers have been trying to establish the major factors that impact the bioaccessibility of these substances (McClements, 2018). Both *in vitro* and *in vivo* methods have been developed to measure the bioaccessibility of hydrophobic bioactive agents. *In vitro* digestion models are often preferred because they are relatively simple and inexpensive to perform and allow researchers to rapidly screen many different factors affecting bioaccessibility. Moreover, they can provide useful insights into the physicochemical mechanisms involved and do not have the ethical concerns associated with animal or human feeding studies.

Many recent studies have shown that food matrix effects may increase, decrease, or have no impact on the bioaccessibility of hydrophobic bioactives. An improved understanding of the impact of food matrix effects may therefore lead to the formulation of functional foods with higher and more consistent biological activities, as well as to the development of more accurate nutritional guidelines for dietary supplementation. In this article, we highlight the importance of food matrix effects by describing some of our recent research on the impact of specific food components on the bioaccessibility of fat-soluble vitamins and nutraceuticals using an *in vitro* gastrointestinal model. Most of these studies were carried out using the recently updated standardized gastrointestinal model known as the INFOGEST method (Brodkorb, Egger, *et al*., 2019). This method was established and validated by a consortium of international scientists with the aim of producing a simulated gastrointestinal model that is relatively straightforward to carry out, leads to reproducible results, and can be compared between different research laboratories.

DIGESTIBLE OIL BOOSTS VITAMIN D BIOACCESSIBILITY

In principle, the utilization of indigestible oils in functional foods and beverages may be advantageous because of their higher chemical stability, zero calorie content, and potential for prolonging the release of encapsulated bioactive agents. For this reason, we examined the impact the digestibility of the oil phase has on the bioaccessibility of a fat-soluble vitamin *(Tan, Liu, et al*., 2019). Four kinds of nanoemulsions were prepared using different combinations of a digestible oil (corn oil) and an indigestible oil (mineral oil). Nanoemulsions were prepared using only digestible oil, only digestible oil, or a digestible/indigestible oil combination. In the latter case, the two different oils were combined before homogenization (by mixing the oils) or after homogenization (by mixing the nanoemulsions).

As expected, the lipid digestion rate and vitamin bioaccessibility decreased as the amount of indigestible oil in the nanoemulsions increased (Fig. 1a, page 14). This effect was attributed to two effects: (i) some of the vitamin was trapped inside the indigestible oil droplets; (ii) there were fewer lipid digestion products (free fatty acids and monoglycerides) generated to form mixed micelles. In a kinetic study, the vitamin bioaccessibility in the digestible oils increased to a maximum value after about 30 minutes, but then decreased over longer times (Fig. 1b, page 14). This effect was attributed to an initial solubilization of the vitamin within the mixed micelles, followed by their precipitation during prolonged incubation. For indigestible oil nanoemulsions, the bioaccessibility remained low throughout the digestion period.

The result of this study suggests that the bioavailability of vitamin D may be increased by encapsulating it within small lipid droplets containing digestible (rather than indigestible) oils.

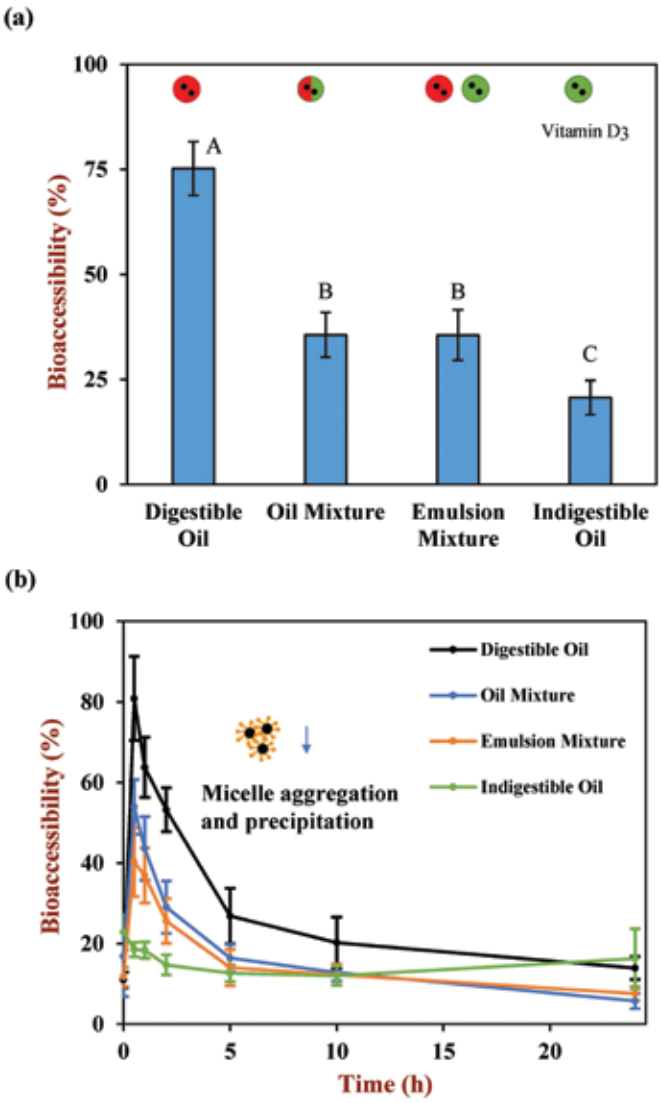

FIG 1. Influence of oil phase digestibility on vitamin D bioaccessibility in four emulsion-based delivery systems

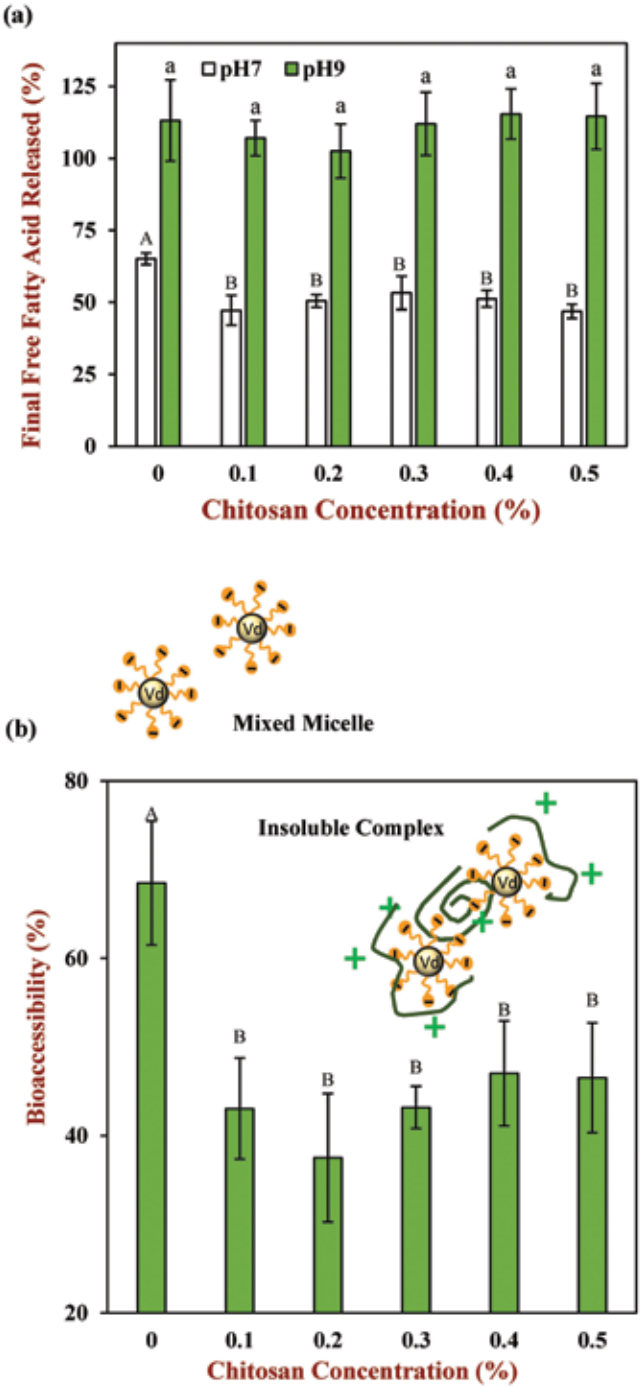

FIG. 2. Influence of chitosan concentrations on the vitamin D bioaccessibility of the corn oil in water emulsion

CHITOSAN REDUCES VITAMIN D BIOACCESSIBILITY

Dietary fibers are known to exhibit a range of potentially beneficial health effects when consumed at sufficient levels. Studies have shown that dietary fiber can modulate the rate and extent of lipid digestion in emulsion-based foods (Qin, Yang, *et al.*, 2017), as well as the bioaccessibility of any encapsulated fat-soluble vitamins (Gence, Servent, *et al.*, 2018, Winuprasith, Khomein, *et al.*, 2018). The ability of dietary fibers to reduce the bioaccessibility of fat-soluble vitamins depends on their molecular features, such as molar mass, conformation, functional groups, and charge. In a recent study, we examined the impact of food-grade chitosan on vitamin bioaccessibility. Chitosan is an unusual dietary fiber because it has a positive charge under acidic conditions due to protonation of the aliphatic amino groups ($-NH_3^+$; $pK_a \sim 6.5$).

We found that vitamin-enriched lipid droplets were highly susceptible to aggregation under simulated small intestine conditions, which was attributed to binding of the chitosan to the lipid droplet surfaces. Interestingly, droplet aggregation did not seem to alter the lipid digestion process, with complete digestion being observed at all chitosan levels used (0.1–0.5%) when a back titration (pH 9) was carried out (Fig. 2a). A comparison of the results with (pH 9) and without (pH 7) the back-titration suggested that chitosan altered the ionization state of the free fatty acids. The presence of chitosan did, however, decrease the bioaccessibility of vitamin D by about 37%, but this effect did not

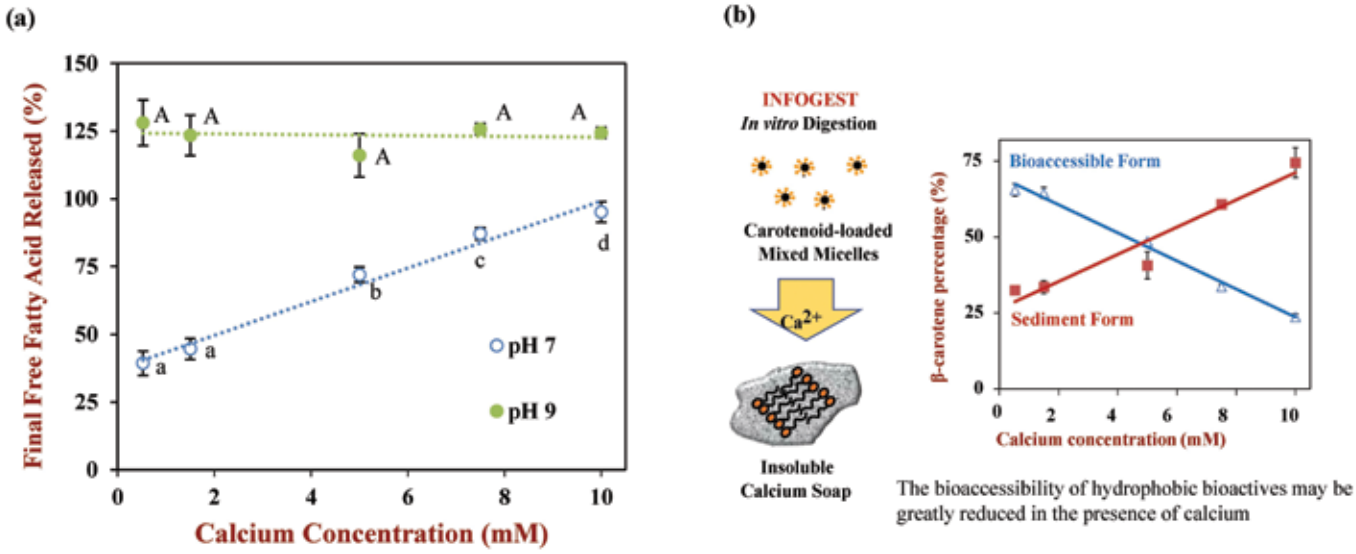

FIG. 3. Effect of calcium concentration on the percentage of beta-carotene in corn oil-in-water emulsions, which was attributed to precipitation of the mixed micelles

depend strongly on the chitosan concentration (0.1–0.5%) used (Fig. 2b).

As the triglycerides in all samples were fully digested, we attribute the reduction in vitamin bioaccessibility to the ability of chitosan to modulate the micellization process. Cationic chitosan molecules bind to anionic vitamin-loaded mixed micelles, promoting the formation of insoluble precipitates. Therefore, incorporating chitosan into foods as a functional ingredient could have a negative impact on vitamin bioaccessibility. It should be noted, however, that precipitated mixed micelles might be liberated when the chitosan is digested by gut microbiota in the colon. If so, the vitamin would be released and become bioaccessible again. *In vivo* studies would be needed to establish this.

CALCIUM REDUCES BETA-CAROTENE BIOACCESSIBILITY

Calcium is a vital mineral with several important functions for maintaining human health, but dietary levels are often low. For this reason, supplementation of calcium has become routine. Some studies have shown that calcium may interfere with the lipid digestion process and therefore influence the bioaccessibility of hydrophobic bioactives (Lin, Liang, *et al*., 2017, Corte-Real and Bohn 2018, Dima and Dima 2020). Cationic calcium ions can promote flocculation of oil droplets, especially in emulsions stabilized by anionic emulsifiers, resulting in less surface area for the lipolysis reaction. They may also promote the precipitation of mixed micelles, thereby reducing bioaccessibility. Conversely, calcium ions can facilitate lipid digestion due to their ability to act as co-factors for pancreatic lipase and their ability to precipitate free fatty acids generated at the lipid droplet surfaces.

In the absence of a back-titration step (pH 7), the extent of lipid digestion appeared to increase with increasing calcium level (Fig. 3a, page 15). When this step was included (pH 9), however, the lipids were seen to be fully digested in all the nanoemulsions, regardless of the calcium levels used. This effect was attributed to the ability of the calcium ions to change the ionization state of the carboxylic acid groups on the free fatty acids. At neutral pH, the FFAs are not fully ionized and so they are not titrated by sodium hydroxide in the pH-stat method. In the presence of calcium, however, the FFAs form calcium soaps and release protons (H^+) that can be titrated. This study therefore highlights the importance of including the back-titration step in the INFOGEST method in order to get accurate measurements.

We found that increasing the level of calcium in the small intestine decreased the bioaccessibility of the carotenoids. This was attributed to the ability of the cationic calcium ions to precipitate the anionic beta-carotene-loaded mixed micelles (Fig. 3b, page 15). As a result, the carotenoids were no longer present in the mixed micelle phase generated during lipid digestion. The ability of calcium ions to reduce carotenoid bioaccessibility may have important implications for the nutritional benefits of these nutraceuticals. Consuming carotenoid-rich foods with calcium-rich foods could lead to a reduction in carotenoid bioavailability and efficacy.

In summary, food matrix effects have a major impact on the bioaccessibility of fat-soluble bioactive agents. More research is clearly needed, using both *in vitro* and *in vivo* methods, to establish the influence specific food components have on bioaccessibility.

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Technologies and challenges involved in the dry processing of pulses

Shuyang (Zoe) Wang, Yun (Cathy) Wang, and Mehmet C. Tulbek

Pulses, such as pea, lentils, chickpea, and faba beans, are high in protein (especially the essential amino acid lysine), dietary fiber, and minerals compared to cereal crops. As the plant-based and health-focused trend gains more momentum, pulse ingredients (starch, protein, and fiber)—especially protein concentrates—are becoming increasingly popular in food applications like meat/dairy alternatives, snacks, and pet foods. These valuable pulse ingredients can be attained through different milling technologies, but variations in pulse characteristics and mill parameters can make it challenging to achieve uniformity of the flour, and differences in the functionality of protein concentrates can be problematic for product development and consistency of the final product.

- **Dry fractionation (dry milling in combination with air classification) is the most commonly used milling process for producing protein and starch concentrates from pulses.**
- **Unfortunately, pulse flours have a wide range of particle size, starch damage, and partial gelatinization after milling, and these variations can be a stumbling block to producing a uniform product.**
- **Milled pulse ingredients have great commercial potential, but more research and collaboration are needed to overcome these processing and product development challenges.**

While wet milling produces higher yields (80–90%) and more expensive protein isolates, dry fractionation (dry milling in combination with air classification) is the more commonly used method for producing pulse protein concentrates (55–60%), as it is more economical and environmentally friendly (i.e., uses less water and energy), and offers the additional advantage of retaining the native functionality of the proteins. In the dry milling process, the pulses are typically cleaned, dehulled/split, milled, and finally air-classified into starch-rich and protein-rich flours.

Following is a brief discussion about the technologies and challenges involved in the dry milling of pulses.

Starch is the main component (~43%) in pulses, followed by protein (~22%) and fiber (19%); the fat level is generally very low (2%) except for chickpea (~6%) (Fig. 1, page 18).

The bulk composition of protein and starch and their discrete sizes and density allows them to be fractionated into light fine protein (2–20 micron) or heavy coarse starch (20–40 micron) fractions (Fig. 2, page 18).

The milling process begins with cleaning and dehulling/splitting of seeds, followed by which the pulse splits can be dry milled and further reduced into fine flour that is ready for air classification (Fig. 3, page 19).

Dehulling uses impact to remove the outer kernel (87% dietary fiber, 2% ash, 2% protein, and 1% starch) of dry seeds that accounts for 10–12% of seed weight. During this process, pulses are fed through a hollow shaft in the machine to the center of a rotor with

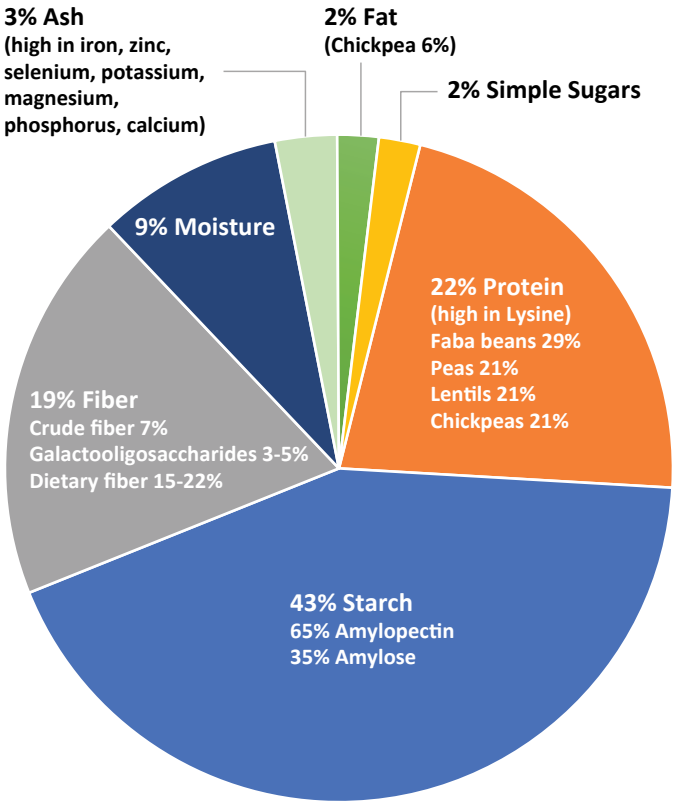

FIG. 1. General composition of pulses [1]

vanes. Dehulling could be challenging in edible beans, as they are more prone to cracking and cotyledon deformation due to crop characteristics.

The most widely used milling method for pulses is impact milling with hammer mills. Sometimes direct pressure milling (roller mills, cracking mills, oscillating mills) and attrition milling (knife mills, dicing mills, guillotine mills) which is typically applied for fibrous material that cannot be reduced through impact milling are also used by the industry.

The screen size and rotor speed of the hammer mill used have significant impact on the final product. In general, higher rotor speed and smaller screen size yield finer flour and higher temperature of the final product, which can be challenging in a single-pass milling process. For example, at 7200 RPM, lowering the screen opening from 0.177 to 0.081 mm can cause the final pea flour temperature to increase from 42 to 51°C, resulting in cooked flour on the bottom of the collection bin. The final product temperature can be better handled in double-pass hammer milling, where the first pass has much smaller rotor speed and screen opening compared to the second pass. For instance, milling split peas with rotor speed 2400 RPM and 2.83 mm screen opening yielded coarser flour (~50% through 60 mesh) at 22°C final temperature; the second pass at 6000 RPM rotor speed and 0.053 mm screen opening yielded finer flour (100% through 60 mesh) with final temperature at 33°C [1].

The initial dry milling yields pulse flour/semolina with larger particle size, which is further reduced to fine pulse flour containing at least 19% protein; this fine flour is classified in a spiral air stream to separate starch from protein. To obtain optimal enrichment of the protein fraction, pulse seeds must be milled fine enough to a particle size smaller than 40 micrometers to separate protein-rich particles from starch granules before air classification [2]. However, a portion of protein cannot be separated from the starch granules despite repeated milling [3]. Therefore, the protein concentrate obtained by air classification is lower than that from wet milling, and the starch concentrate still contains about 12% protein.

One of the big challenges is that the milled and fractionated pulse flours tend to have a wide range of particle size distribution that varies from batch to batch. This could greatly affect functionality—especially emulsion, foaming, and pro-

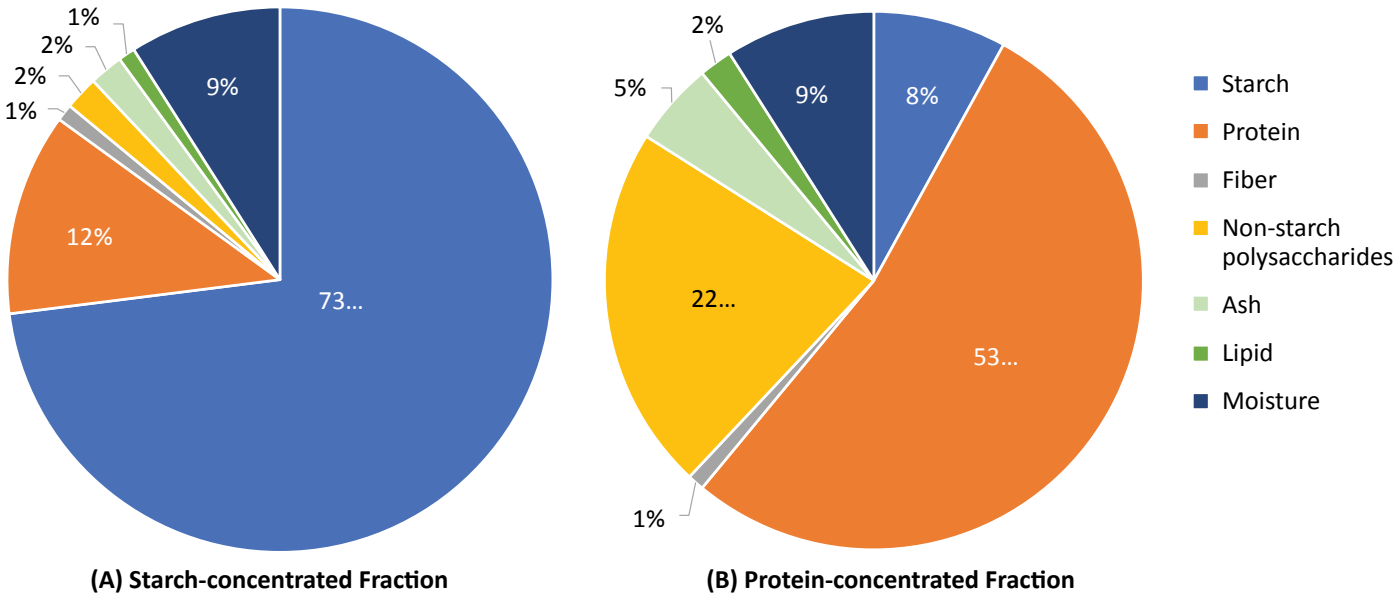

FIG. 2. Composition of starch (left) and protein (right) concentrate fractionated from pea flour [1]

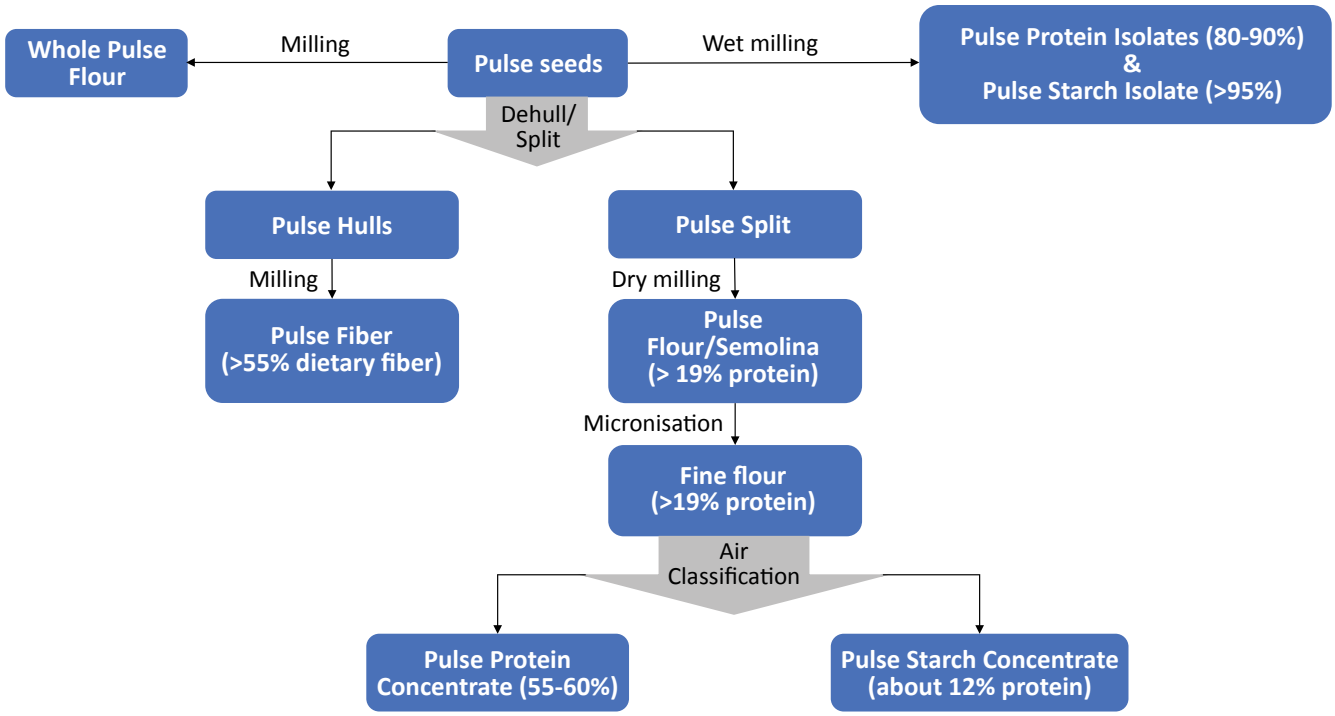

FIG. 3. Pulse milling process flow [1]

tein solubility, as well as mouthfeel of the flour. Such variations in ingredients give product developers and food companies headaches as they strive to provide quality, standardized, and uniform products. Starch damage is also inevitable during pulse milling. Regardless of the milling method, 5 to 12% of the starch granules are damaged. Damaged starch absorbs 2 to 4 times more water than intact starch granules and is therefore more susceptible to enzymatic degradation from alpha- and beta-amylases. The Rapid Visco Analysis (RVA) profile of damaged starch has a high instant viscosity but very low pasting viscosity. Damaged starch changes flour characteristics in dough mixing, which in turn will greatly influence the production of baked goods. To reduce undesirable enzyme activities such as starch degradation, lipid oxidation, and color change, pulse seeds can be roasted and/or precooked prior to milling [1]. The shelf life of precooked flour is extended from as short as 3 months up to 2 years. Although precooking does not significantly alter the composition of pulse flours, it does result in partial gelatinization and thus lowers pasting viscosity. A 7–10% increase in resistant starch in green and yellow pea was observed after roasting at 170°C (12.5 min) before milling [1], which could be of interest for lowering glycaemic index.

During the past few years, the increasing popularity of plant-based meat has increased the demand for pulse protein, which is typically extruded into texturized vegetable protein (TVP) chunks, slices, strips, and granules used to produce plant-based burgers, chicken nuggets, "pork" stir-fry, chili, and many other products. The TVPs' meat-like fibrous appearance and texture, high protein content (50–80%), and zero saturated fat and cholesterol attributes make them a great fit for allergen-free and clean-label meat alternatives. Pulse proteins

can also be added to pasta and noodles to improve nutritional attributes. Pulse-based dairy alternatives like pea milk are gradually entering the marketplace. The pulse proteins serve as an emulsifier in dairy alternatives, high-protein beverages, soups, and sauces as well as protein enhancers. For example, at pH 7, AGT de-flavored faba bean protein concentrate (60%) has similar emulsifying capacity as egg white protein. Pulse proteins and starches are great gelling agents and can be applied in products like sausage and canned meat products. Pulse proteins can act as a functional ingredient, which is highly dependent on its solubility and may be affected by processing procedure, food matrix pH, salt content, and temperature, as well as protein characteristics and content. Thus, more research and cross-sector collaboration is needed to better understand and utilize certain pulse proteins.

As we approach the estimated 9.5 billion global population by 2050, plant-based food is projected to reach 28 billion USD in retail to compensate the unreachable 70% increase for meat protein consumption. This is not only a promising future for the pulse milling industry, but also a responsibility to produce quality ingredients to meet customer demands. The complete utilization of pulse ingredients remains a challenge and is largely based on the functionality requirement of specific applications.

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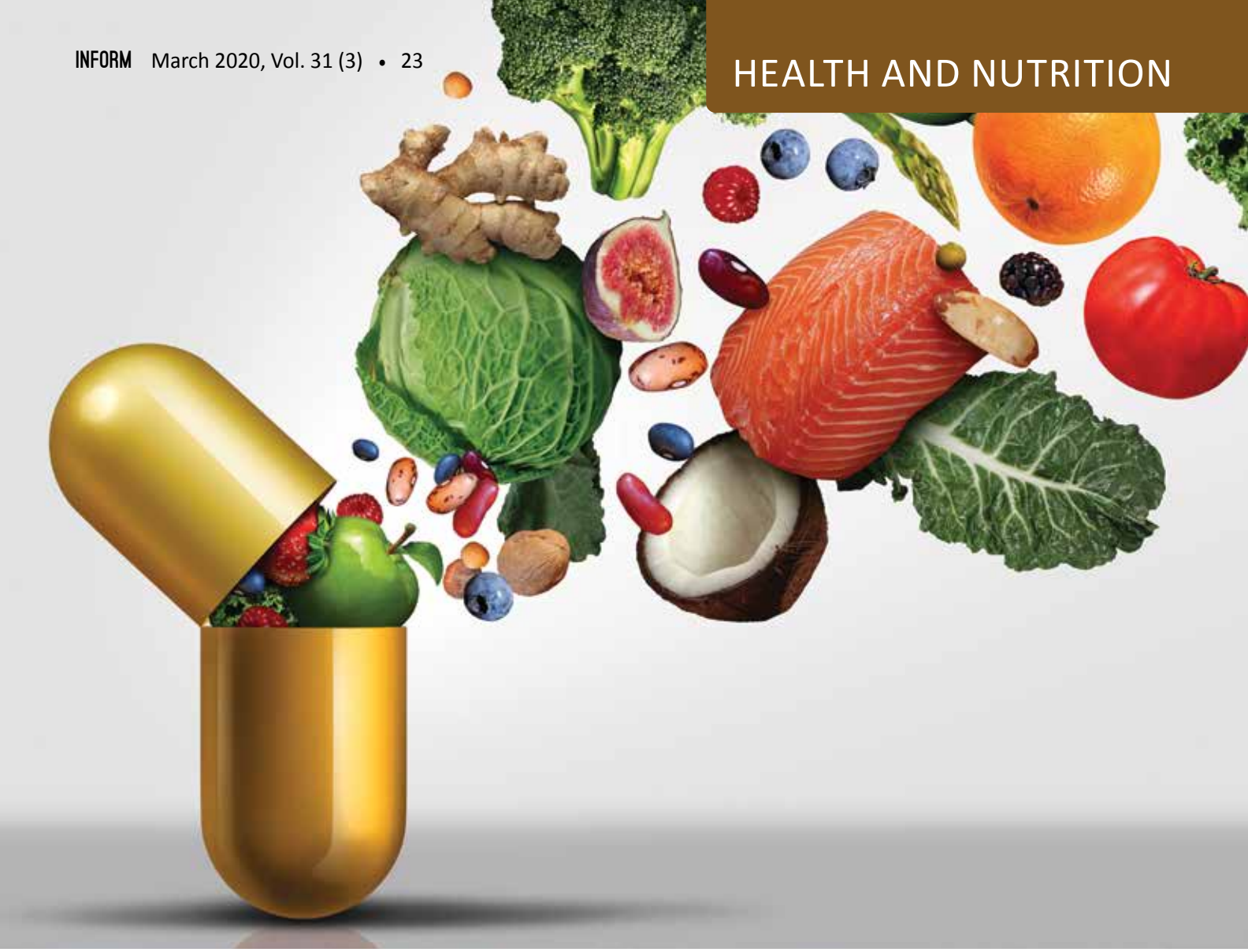
Where do nutraceuticals fit in the current food trends?

Ashok Patel

The term "nutraceutical" (a contraction of nutrients + pharmaceuticals) was coined in 1989 by Stephen L. Defelice, who defined it as "food or part of a food, that has a medical or health benefit, including the prevention and treatment of disease." There is no legal definition of nutraceuticals, and it is often used interchangeably with terms like functional food and dietary supplement, though there are slight distinctions. Relationships that link nutrition, diet, and healthcare could be used to understand similarities and dissimilarities among these different product categories. As seen in Figure 1, nutraceuticals, dietary supplements, and functional foods occur as distinctly separate categories from both conventional food (used for basic nourishment) and fortified food with extra nutrients that are added to: i) replenish nutrients lost during the processing of food (eg., vitamin enrichment in processed flour); ii) make up for nutrients which are generally expected from that class of food (e.g,. calcium fortification of soy milk); and iii) address specific nutrient deficiencies responsible for health issues in the community (e.g., iodized salt).

- **Health is ranked as the number one driver for food choices made by today's tech-savvy and hyper-connected consumers. Consequently, many trends in the food sector are tailored to suit the demands of such health-conscious, modern consumers.**
- **Due to their health promoting effects, nutraceuticals fit snugly into many of the health-forward food trends that are gaining public interest and global popularity.**
- **This article provides a brief update on how and where nutraceuticals fit into current trends in food and nutrition.**

Because of their high concentration of health-promoting nutrient(s), all three product categories (functional foods, dietary supplements and nutraceuticals) provide functionality or enhanced nutrition. Forming part of a special diet, functional foods incorporate health-promoting nutrients in a food matrix (such as essential fatty acids in milk), whereas nutraceuticals and dietary supplements are taken to complement diets and are formulated in pharmaceutical dosage forms (pills, capsules, powders, and so on) from extracts of nutrients plus nonfood additives (such as cod liver oil capsules). The health-promoting nutrients in dietary supplements are micronutrients (vitamins, minerals) and essential nutrients (omega fatty acids and certain amino acids), whereas nutraceuticals are generally formulated with bioactive compounds such as caffeine, polyphenols, and flavonoids. Depending on how they are formulated, products may sometimes qualify to be grouped into either of these three categories, thereby blurring the boundaries within these closely related groups. In this article, nutraceuticals will be used as a collective term that also includes functional foods and dietary supplements.



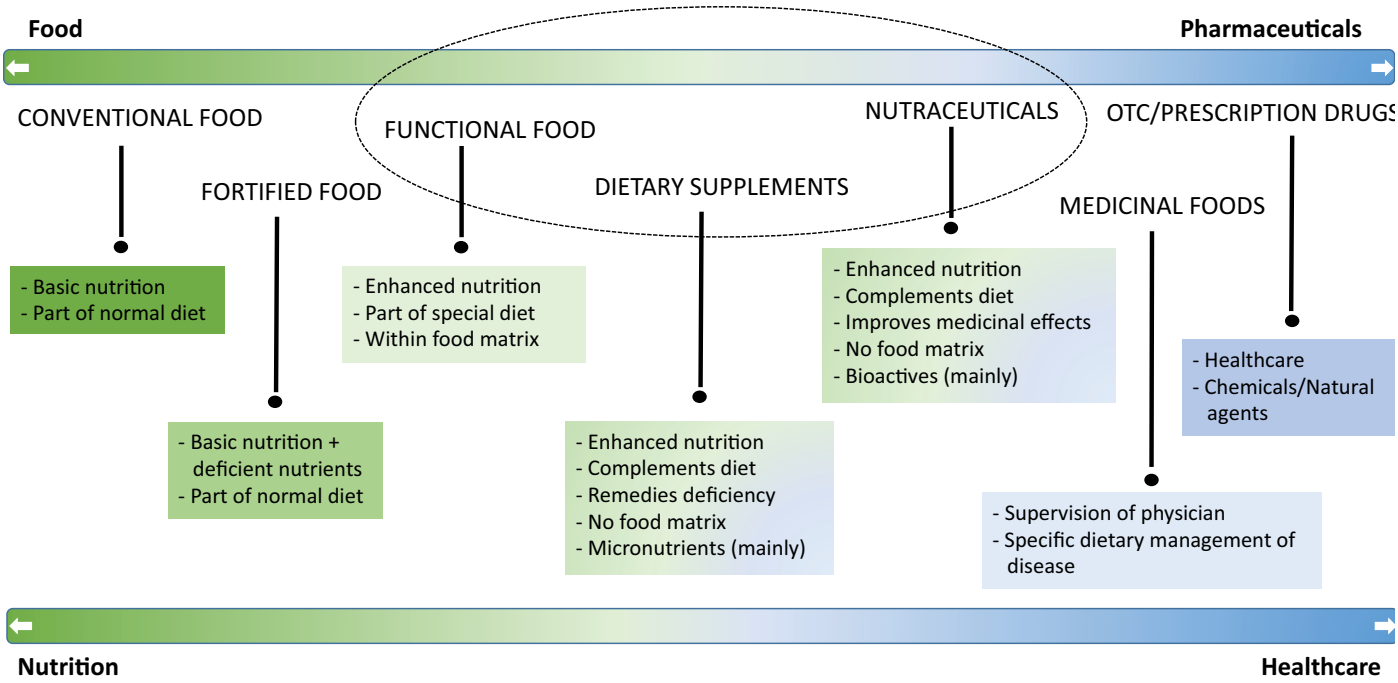


FIG. 1. Products categorized based on the relationship between diet-nutrition-healthcare

CURRENT TRENDS IN FOOD AND NUTRITION

The food and nutrition sector is in the midst of a major revolution. Emerging technologies, mushrooming start-ups, disruptive innovations, and most importantly, hyper-connected consumers, are shifting the trend for adventurous food experiences toward diet-based health improvements. Major social challenges (such as urbanization and ageing population) are further fueling these trends.

Rapid urbanization and rising incomes are leading a major change in diets and food consumption patterns. Urban food environments such as supermarkets, restaurant chains, and on-demand delivery services, have improved access to premium nutritious foods for those who can afford them. And, due to rising health and environmental consciousness among younger generations—millennials (and generation Z)—younger people are increasingly drawn to globally sourced, exotic food products that are also beneficial to their health in the long run. The age-old Asian notion, "Let food be thy medicine," is gaining popularity among those who are trying to overcome health issues related to body weight management, diabetes, heart health, etc.—and/or looking to upgrade their diet and food choices to get a balanced nutritional supply that is specifically tailored to their biological needs. Ageing populations are also driving the demand for nutraceuticals, especially ones that promote healthy aging by improving joint health, digestive health, and cognitive development. The main product types and categories where nutraceuticals could be incorporated to derive health-promoting effects are discussed in the next section and shown in Figure 2.

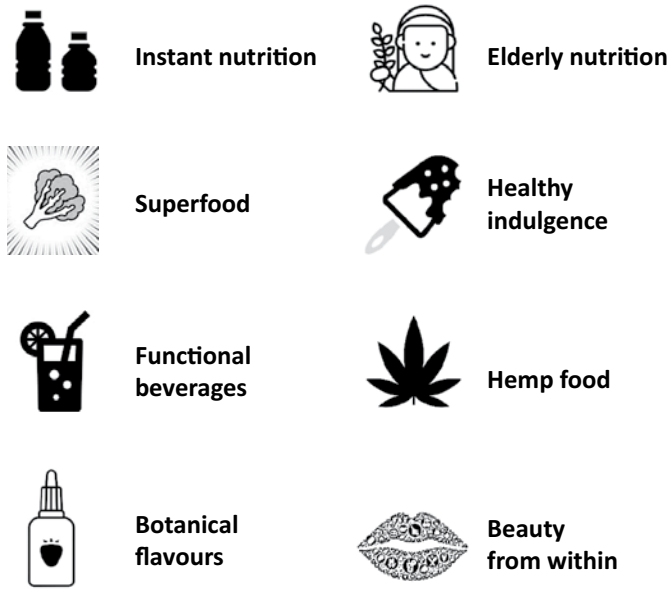


FIG. 2. Infographic depicting how nutraceuticals fit in current food trends

MAIN PRODUCT TYPES/CATEGORIES CATERED TO THE CURRENT TRENDS

Instant nutrition products, also called replacement meals, include compact product types formulated for weight reduction and appetite control—and/or to provide complete nutrition to time-starved millennials with busy lifestyles. Such products are offered as powder mixes for reconstitution with liquids such as water, milk or juices; breakfast, protein, or energy bars; and/or beverages.

Super foods are nutrient-dense food packed with vitamins, minerals, antioxidants, and phytonutrients. Popular types of foods in this category include: antioxidant-rich green vegetables, such as spinach, broccoli and kale; nuts that are rich in phytosterols, such as walnuts and almonds; orange fruit and vegetables that contain carotenoids, such as carrots; and teas and berries, which are high in polyphenols.

Health-positioned drinks, or functional beverages, are the fastest growing nutraceuticals category. Globalization has created opportunities for cross-cultural exchange, making traditional therapies and wellness concepts from regions such as Asia, Africa, and Latin America popular in other parts of the world. Ready-to-drink functional beverages offer convenient alternatives to conventional formulations of traditional herbs, such as moringa, which are time-consuming and often unpalatable.

Botanical flavors in premium drinks are becoming more of a staple thanks to their natural sweetness, exotic appeal, and functional capabilities. Bioactive-loaded flavors from exotic fruits (such as dragon fruit, citrus varietals, passion fruit, acerola, guaraná, lychee, mangosteen, acai, tamarind, etc.) and florals (such as lavender hibiscus, elderflower, and chamomile) are currently being explored for use in alcoholic and non-alcoholic beverages, such as sparkling waters, tonic, cocktails, wines, and so on.

Robot cooks, drone food delivery, and bean-less coffee

Nutraceuticals are just one of many disruptive innovations that are changing the very concept of food. Learn how the global food industry is embracing these innovations to stay competitive and relevant to hyper-connected modern consumers of today's world by reading Ashok Patel's new book, *Disruptive Technologies Catalyzing Innovation in the Food Sector,* Kindle Direct Publishing, USA 2019.

Elderly nutrition is aimed at the growing population of aging adults (65 years and above). As people grow old, their metabolism decreases and they require fewer calories but more nutrients to maintain proper health and ward-off age-related chronic diseases and associated disabilities (mainly neurodegenerative, cardiovascular and cognitive disorders). Nutrients, such as antioxidants, phytosterols, and nootropics (such as gingko biloba) are ideal ingredients to design health foods that can meet specific nutritional needs of aging populations.

Healthier indulgence is a current trend that promotes consumption of indulgence products such as ice creams, chocolates, and high-calorie drinks formulated with added health-promoting components aimed at providing more than just "empty calories" and "culinary pleasures."

Hemp food, a craze that has really gone mainstream. Ranked as one of the hottest trends in 2019, much of the interest is linked to the untapped potential of its main phytoconstituent: cannabidiols as dietary supplement ingredients. FDA has recently approved the following ingredients as GRAS under their intended conditions of use: hulled hemp seed, hemp seed protein powder, and hemp seed oil. These ingredients can be added as source of protein, carbohydrates, oil, and other nutrients to beverages, desserts, baked goods, snacks and nutrition bars.

Beauty from within, a hugely popular concept a decade ago, is set to make a comeback. Based on the notion that beauty comes from within, nutraceuticals are being developed with proven, science-based research to address all kinds of beauty matters, such as skin and nail health.

As nutraceuticals are at the heart of many of these latest food trends, the prospective market for nutraceuticals (as foods) is expected to grow exponentially in the coming years, However, there are two main obstacles that must be overcome to fully exploit the untapped potentials of nutraceuticals: a) legal regulations which are complex, fragmented, and not harmonized throughout many regions of the globe; and b) the bioactivity and biological effects of nutraceuticals which are still a subject of debate. The expected high-value market potential of nutraceuticals has already led government agencies to establish regulatory frameworks for development, quality checking, and marketing of these products. However, the details are confusing, and large-scale legislative efforts should be made to overcome this specific bottleneck.

Bioactivity and biological effects are currently claimed based on *in-vitro* and animal studies, but translating laboratory results to *in-vivo* conditions in humans is not as straightforward as the proponents would have us believe. Moreover, nutraceuticals are very complex matrices, making it difficult to attribute an observed bioactivity to one specific component. Therefore, it is imperative to characterize the chemical composition (in terms of qualitative and quantitative profiles) of the matrix. Furthermore, interactions between nutraceuticals and food components and/or microbiota may also occur, thus influencing the bioaccessibility and pharmacokinetics (adsorption, distribution, metabolism, and excretion) of all components present in the nutraceutical matrix. Well-planned biological studies (such as controlled clinical trials) are therefore needed to achieve the promised revolution in food and health that could be achieved through introduction of nutraceuticals into regular diets. Also, well-designed toxicological evaluations should be conducted to ascertain the safety of nutraceuticals, especially when delivered in concentrated forms.

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Fermented dairy foods: impact on intestinal microbiota and health-linked biomarkers

S. González, T. Fernández-Navarro, S. Arboleya, C.G. de los Reyes-Gavilán, N. Salazar, and M. Gueimonde

- Fermented dairy foods have been associated with obesity prevention and reduced risk of metabolic disorders and immune-related pathologies.
- We recently evaluated the relationship between the consumption of fermented dairy products and the intestinal microbiota, serum lipid profile, and pro-oxidant/inflammatory status of 130 healthy adults.
- This article describes what we learned.

Fermented foods have played an important role in the human diet since the development of civilization and represent a special feature of some dietary patterns, such as the Mediterranean one. The initial goal of the fermentation process was to prolong the useful life of some foods and beverages and improve their safety, digestibility, and organoleptic properties. Today, fermented products have become more popular than ever due to their health-promoting benefits.

Fermented dairy foods have received special attention because of epidemiological studies associating them with obesity prevention, and various other studies linking them with reduced risk for different conditions, including metabolic disorders, cardiovascular and immune-related diseases, and cognitive decline, among others. Apart from their content of fatty acids, vitamins, and minerals, these products contain bioactive peptides and living microorganisms that could modulate the immune responses and impact on the intestinal microbiota (IM) composition and functionality.

Among the living organisms are the yogurt starter culture organisms, *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp bulgaricus as well as *Bifidobacterium* and *Lactobacillus* strains that are added for their probiotic properties. In contrast, for other fermented foods, such as sauerkraut, kimchi, and miso, fermentation is initiated by autochthonous microbes present in the raw material. In both cases, for

these fermentation-associated microbes to influence the gut microbiome and contribute to host health, they must overcome, at least transiently, colonization resistance and other host defense factors. Culture and culture-independent methods have now clearly established that many of these microbes present in fermented dairy and nondairy foods do reach the gastrointestinal tract. Several studies have shown that consumption of yogurt and other fermented foods may improve intestinal and extraintestinal health and might be useful in improving lactose malabsorption, treating infectious diarrhea, reducing the duration and incidence of respiratory infections, and enhancing immune and anti-inflammatory responses.

The human IM is a complex and dynamic community, represented by trillions of microorganisms, that plays an important role in the maintenance of health. Indeed, recent studies have consistently identified disease-specific microbiota signatures in different health disorders (Duvallet, *et al*., 2017, https://doi.org/10.1038/s41467-017-01973-8). The microbiota of healthy adults is represented mainly by anaerobic bacteria from the Firmicutes and Bacteroidetes phyla. While the genera *Clostridium, Enterococcus, Lactobacillus* and *Faecalibact erium* are predominant within the Firmicutes phylum, others such as *Bacteroides* and *Prevotella* are the most representative of the Bacteroidetes phylum. All are present in different proportions depending on the specific microbial composition of each individual (Eckburg, P.B., *et al*., https://doi.org/doi: 10.1126/science.1110591)

The disruption and alteration of the microbiota may be related to different pathologies and, for this reason, the search for strategies capable of reversing the IM dysbiosis to improve the health status of the host has become a key area of interest for the scientific community. In this regard, long-term dietary habits, as well as specific food constituents, such as fiber or phenolics, have been identified as critical drivers of gut microbiota composition.

Fermented products may also modulate the IM, however, the association between fermented foods as part of the regular diet and the IM composition has not been sufficiently studied yet. In this regard, a recent work examining the impact of consuming a fermented milk containing microorganisms from the genera *Lactobacillus* and *Bifidobacterium* on the IM has reported a gender-specific increase in the levels of these two bacteria in the feces of volunteers (Lisko, *et al*., 2017, https://doi.org/10.3390/microorganisms5010006). The administration of a probiotic fermented milk, containing *Streptococcus thermophilus*, *Lactobacillus bulgaricus, Lactobacillus acidoph-*

TABLE 1. Differences in the concentration of major microbial groups and short-chain fatty acids according to the intake of the different types of fermented dairy foods consumed by the sample

	Yogurt (g/day)		Natural Yogurt (g/day)		Sweetened Yogurt (g/day)		Cheese (g/day)		Matured/semimatured cheese (g/day)		Fresh cheese (g/day)		Fermented milk (mg/day)	
	Non-consumers	Consumers	Non-consumers	Consumers	Non-consumers	Consumers	Non-consumers	Consumers	Non-consumers	Consumers	Non-consumers	Consumers	Non-consumers	Consumers
	(*n* = 27)	(*n* = 103)	(*n* = 50)	(*n* = 80)	(*n* = 106)	(*n* = 24)	(n = 27)	(*n* = 103)	(*n* = 47)	(*n* = 83)	(*n* = 86)	(*n* = 44)	(*n* = 122)	(*n* = 8)
Microbial target (log no. cells per gram of feces)														
Akkermansia	4.9 ± 2.4	5.6 ± 2.3	4.9 ± 2.3	5.8 ± 2.2	5.6 ± 2.3	5.0 ± 2.2	5.4 ± 2.5	5.5 ± 2.3	5.2 ± 2.3	5.6 ± 2.4	5.6 ± 2.4	5.2 ± 2.3	5.6 ± 2.4	4.6 ± 2.5
Bacteroides group	8.3 ± 2.0	8.3 ± 1.8	8.0 ± 2.0	8.5 ± 1.7	8.5 ± 1.7	7.6 ± 1.9	8.9 ± 1.0	8.3 ± 1.8	8.2 ± 2.0	8.4 ± 1.7	8.4 ± 1.6	8.3 ± 2.2	8.4 ± 1.9	8.1 ± 1.1
Bifidobacterium sp	7.4 ± 1.6	7.4 ± 1.7	7.3 ± 1.7	7.7 ± 1.7	7.6 ± 1.7	7.3 ± 1.8	7.6 ± 1.7	7.5 ± 1.7	7.6 ± 1.8	7.5 ± 1.7	7.5 ± 1.7	7.6 ± 1.8	7.6 ± 1.8	7.5 ± 0.5
Clostridium cluster XIVa	7.0 ± 2.4	7.0 ± 2.3	6.9 ± 2.7	7.0 ± 2.1	7.0 ± 2.2	6.9 ± 3.0	6.9 ± 2.3	7.0 ± 2.3	7.1 ± 2.2	6.9 ± 2.4	6.9 ± 2.3	7.2 ± 2.3	7.1 ± 2.3	6.0 ± 2.8
Lactobacillus group	5.5 ± 1.6	5.8 ± 1.9	5.7 ± 1.8	5.8 ± 1.8	5.7 ± 1.8	5.9 ± 2.0	6.2 ± 2.2	5.6 ± 1.7	6.0 ± 2.1	5.6 ± 1.7	5.9 ± 1.8	5.6 ± 1.9	5.8 ± 1.9	5.6 ± 1.1
Faecalibacterium prausnitzii	6.8 ± 1.5	6.8 ± 1.8	6.8 ± 1.6	6.8 ± 1.7	6.8 ± 1.7	6.9 ± 1.7	6.3 ± 2.4	7.0 ± 1.5	6.5 ± 2.1	7.0 ± 1.4	6.8 ± 1.8	6.8 ± 1.6	6.9 ± 1.8	6.7 ± 0.9
SCFA concentration (mM)														
Acetate	33.2 ± 15.9	36.5 ± 19.6	37.5 ± 18.2	34.7 ± 17.9	34.2 ± 17.5	42.6 ± 17.1	28.9 ± 14.5	37.6 ± 18.5	34.6 ± 20.7	36.5 ± 17.4	34.4 ± 17.4	38.4 ± 20.4	36.4 ± 18.8	27.4 ± 19.9
Propionate	12.5 ± 6.5	13.1 ± 7.6	13.1 ± 7.2	13.0 ± 7.3	12.8 ± 7.1	13.8 ± 7.6	9.8 ± 5.9	13.9 ± 7.2	12.6 ± 7.7	13.3 ± 7.1	12.1 ± 7.3	14.7 ± 7.1	13.2 ± 7.4	10.6 ± 7.6
Butyrate	11.7 ± 9.0	10.0 ± 7.1	11.2 ± 7.2	9.8 ± 7.6	10.4 ± 8.1	10.1 ± 4.4	7.7 ± 5.7	11.1 ± 7.7	9.8 ± 7.0	10.7 ± 7.8	9.4 ± 6.9	12.1 ± 8.4	10.5 ± 7.7	8.7 ± 5.6

Results from univariate analyses, adjusted by age and gender, were presented as mean ± standard deviation. Bacteroides group, Bacteroides-Prevotella-Porphyromonas; SCFA, Short chain fatty acids. Variables included in natural yogurt: whole natural yogurt, skimmed natural yogurt and lactose-free natural yogurt. Variables included in sweetened yogurt: whole flavored yogurt, whole sweetened yogurt, whole yogurt with fruits, skimmed flavored yogurt, skimmed sweetened yogurt, skimmed yogurt with fruits and Greek yogurt. Variables included in matured/semi-matured cheese: blue cheese, matured/semi-matured cow cheese, matured/semi-matured goat cheese and processed cheese. Variables included in fresh cheese: fresh goat cheese and fresh cow cheese. Variables included in fermented milks: natural milk with Bifidobacterium, milk with Bifidobacterium and fruit, natural milk with Lactobacillus and milk with Bifidobacterium and sterols. *p* value ± 0.05. Bold characters indicate statistically significant differences ($p < 0.05$).

ilus LA5 and *Bifidobacterium animalis* subsp. *lactis* BB12, during the third trimester of pregnancy has been related with a reduced risk of maternal insulin resistance (Asemi *et al*., 2013, https://doi.org/10.1038/ejcn.2012.189).

Yogurt consumption has been associated with immune effects, including a reduced concentration of inflammatory markers in pregnant women. It has also been reported that yogurt modulates both humoral (Meyer, *et al*., 2007, https://doi.org/10.1111/j.1365-277X.2007.00807.x) and cellular immunity (Chaves, *et al*., 2011, https://doi.org/10.4315/0362-028X.JFP-10-375). Unfortunately, very often observational nutritional studies do not inform us as to whether the positive effect of fermented dairy foods is mediated by the microorganisms present, by some specific components of the product, or by the potential role of some of these products, i.e., yogurt, as a marker of a good overall diet. Nevertheless, it is worth underlining that some studies draw attention to the impact yogurt could have, independent of diet.

Based on this evidence, it seems reasonable to hypothesize that some of the described beneficial effects of fermented dairy product on several pathologies, such as those affecting the cardiovascular and metabolic systems, might be partly explained by the potential changes induced in the gut microbiota. Thus, in this study we aimed at evaluating the relationship between the consumption of fermented dairy products within the regular diet and the intestinal microbiota.

130 healthy adults were evaluated. Dietary fermented food intake was assessed by an annual food frequency questionnaire (FFQ), including 26 fermented dairy products. Levels of the major phylogenetic types of the intestinal microbiota were determined by qPCR, and concentration of fecal short chain fatty acids were assessed by gas chromatography. Serum glucose and lipid profile, as well as serum malondialdehyde (MDA), C-reactive protein (CRP), and leptin levels were determined by standardized protocols. Among fermented dairy foods, natural yogurt, sweetened yogurt and matured/semi-matured cheese were the most consumed. While natural yogurt consumers showed increased fecal levels of *Akkermansia* with respect to non-consumers, sweetened yogurt intake was associated to lower levels of *Bacteroides*. Serum levels of CRP were also significantly reduced in yogurt consumers.

The total consumption of milk and dairy products (388.23 g/day) corresponded, in 33% of the sample, to the intake of fermented dairy foods, mainly yogurt and cheese (75 and 19%, respectively). Among fermented dairy foods, natural yogurt (77.82 ± 102.38 g/day), sweetened yogurt (18.64 ± 51.40 g/day) and matured/semi-matured cheese (13.83 ± 22.29 g/day) were the most consumed. Among them, natural yogurt was the main contributor.

The consumption of fermented dairy foods presented a significant positive association with the intake of total dairy products, oils and fats, and dried fruits. In more detail, yogurt was negatively related to the intake of non-alcoholic beverages, and the consumption of cheese presented a direct relation with cereals and fruits from the regular diet. Focusing on yogurt types, natural yogurt was directly related to the intake of dairy products and fruits, and negatively associated with

TABLE 2. Differences in anthropometric parameters and mean concentrations of serum health-related biomarkers according to the intake of the different types of fermented dairy foods consumed by the sample

	Yogurt (g/day)		Natural Yogurt (g/day)		Sweetened Yogurt (g/day)		Cheese (g/day)		Matured/semimatured cheese (g/day)		Fresh cheese (g/day)		Fermented milk (mg/day)	
	Non-consumers	Consumers	Non-consumers	Consumers	Non-consumers	Consumers	Non-consumers	Consumers	Non-consumers	Consumers	Non-consumers	Consumers	Non-consumers	Consumers
	(*n* = 27)	(*n* = 103)	(*n* = 50)	(*n* = 80)	(*n* = 106)	(*n* = 24)	(*n* = 27)	(*n* = 103)	(*n* = 47)	(*n* = 83)	(*n* = 86)	(*n* = 44)	(*n* = 122)	(*n* = 8)
BMI (kg/m²)	27.0 ± 4.5	27.0 ± 4.4	27.5 ± 4.9	26.7 ± 4.1	26.8 ± 4.2	27.9 ± 5.2	26.7 ± 5.0	27.1 ± 27.1	27.2 ± 4.7	26.93 ± 4.2	27.0 ± 4.1	27.1 ± 4.9	27.1 ± 4.4	25.9 ± 3.7
Body fat (%) n63	37.3 ± 10.6	35.1 ± 12.0	38.1 ± 12.4	33.9 ± 11.3	34.8 ± 11.1	38.7 ± 13.9	34.7 ± 12.8	35.6 ± 11.6	35.7 ± 13.4	35.44 ± 11.0	35.1 ± 11.1	36.1 ± 12.1	–	–
Blood parameters														
Glucose (mg/dL)	96.0 ± 9.6	100.3 ± 20.3	96.7 ± 9.9	101.0 ± 22.1	99.5 ± 19.9	98.7 ± 10.5	97.2 ± 19.7	100.0 ± 18.6	97.0 ± 16.2	101.0 ± 20.2	100.5 ± 21.4	97.1 ± 11.1	99.6 ± 19.1	96.2 ± 11.5
Triglycerides (mg/dL)	115.4 ± 70.1	116.6 ± 60.0	117.0 ± 79.0	116.1 ± 50.2	115.9 ± 55.3	119.2 ± 90.9	126.9 ± 60.7	113.5 ± 62.2	117.7 ± 65.1	115.6 ± 60.3	118.4 ± 63.8	112.34 ± 57.7	117.5 ± 62.4	94.7 ± 47.8
Total cholesterol (mg/dL)	212.0 ± 40.8	212.4 ± 40.3	207.6 ± 37.6	2015.1 ± 41.6	214.2 ± 41.3	202.6 ± 33.6	201.4 ± 47.6	215.3 ± 38.0	206.1 ± 42.8	216.2 ± 38.5	209.7 ± 41.6	217.7 ± 37.3	211.6 ± 40.1	226.4 ± 43.8
LDL/HDL ratio	2.1 ± 0.8	**2.6 ± 0.9***	2.2 ± 0.8	**2.7 ± 0.9***	2.5 ± 0.9	2.4 ± 0.9	2.4 ± 0.9	2.5 ± 0.9	2.4 ± 0.9	2.6 ± 0.9	2.6 ± 0.9	2.4 ± 0.8	2.5 ± 0.9	2.0 ± 1.0
Leptin (ng/mL)	11.1 ± 7.9	9.9 ± 6.5	11.2 ± 6.9	9.6 ± 6.5	9.9 ± 6.8	10.9 ± 6.0	9.4 ± 7.4	10.3 ± 6.5	9.7 ± 7.1	10.2 ± 6.4	9.9 ± 6.8	10.6 ± 6.3	–	–
CRP (mg/L)	5.5 ± 10.5	**2.1 ± 4.6***	4.2 ± 9.1	2.0 ± 3.9	2.8 ± 5.9	1.6 ± 7.3	3.4 ± 4.2	2.4 ± 6.5	3.9 ± 7.0	1.9 ± 5.4	2.5 ± 5.6	3.1 ± 7.1	–	–
MDA (μM)	2.6 ± 1.7	2.4 ± 0.6	2.8 ± 1.3	**2.3 ± 0.6***	2.4 ± 0.87	2.9 ± 0.8	2.7 ± 0.5	2.3 ± 1.0	2.6 ± 1.1	2.3 ± 0.69	2.5 ± 0.6	2.3 ± 1.3	–	–

Results from univariate analyses, adjusted by age and gender, were presented as mean ± standard deviation. CRP, C-reactive protein; MDA, malondialdehyde. Variables included in natural yogurt: whole natural yogurt, skimmed natural yogurt and lactose-free natural yogurt. Variables included in sweetened yogurt: whole flavored yogurt, whole sweetened yogurt, whole yogurt with fruits, skimmed flavored yogurt, skimmed sweetened yogurt, skimmed yogurt with fruits and Greek yogurt. Variables included in matured/semi-matured cheese: blue cheese, matured/semi-matured cow cheese, matured/semi-matured goat cheese and processed cheese. Variables included in fresh cheese: fresh goat cheese and fresh cow cheese. Variables included in fermented milks: natural milk with Bifidobacterium, milk with Bifidobacterium and fruit, natural milk with Lactobacillus and milk with Bifidobacterium and sterols. (–) Data not available. *p* value ± 0.05. Bold characters indicate statistically significant differences ($p < 0.05$).

sugars, sauces, and non-alcoholic beverages; on the contrary, the intake of sweetened yogurt was positively related to these latter food groups.

In the case of cheese, matured/semi-matured cheese consumption presented a positive relationship with the intake of cereals, while fresh cheese did it with fruits. Fermented milk has not been significantly associated with the intake of none of the other assessed food groups.

Regarding fecal microbial composition, natural yogurt consumers showed significantly higher fecal levels of *Akkermansia,* and sweetened yogurt consumers displayed significantly lower fecal levels of *Bacteroides* than non-consumers. Moreover, cheese consumers (considering all types jointly) presented significantly higher levels of the major fecal SCFA, acetate, propionate and butyrate, whereas the consumers of fresh cheese specifically presented higher levels of propionate and butyrate than non-consumers (Table 1).

Delving into the impact of fermented dairy foods on health status, the association between them and serum health biomarkers was analyzed. While the intake of yogurt, especially natural yogurt, showed a direct association with LDL/HDL ratio values, serum CRP was significantly lower in yogurt consumers (5.5 ± 10.5 vs. 2.1 ± 4.6 mg/L). Moreover, natural yogurt was associated with the oxidant status, the consumers of this product showing also lower levels of serum MDA (2.80 ± 1.33 vs. 2.28 ± 0.59 μM) than non-consumers. The intake of cheese and its different types or fermented milk did not show any association with any health-related biomarker (Table 2).

Our study analyzed the relationship between the intake of fermented dairy foods within the regular diet, the gut microbial profile and health related biomarkers, considering the subject's global diet. Previous studies identified diets rich in fruits, vegetables, or whole grains as critical modulators of the gut microorganisms, based on their content in fibers, phenolic compounds, and prebiotics. However, the association among the different live microorganisms provided by the diet within the intestinal ecosystem offers a novel way to look at gut microbiota composition and its metabolic activity.

In this regard, our results showed that, among the fermented dairy products assessed, yogurt was the product which showed higher ability to modulate the fecal microbiota. Interestingly, while the consumption of natural yogurt was directly associated with *Akkermansia* levels, the sweetened yogurt was inversely related with *Bacteroides* counts.

The consumption of yogurt has been correlated with a good quality diet and some studies pointed out differences among yogurt types. A Danish cohort study suggested that consumption of whole-fat yogurt instead of low-fat products may be associated with a lower risk of type-2 diabetes (Ibsen, *et al*., 2017, https://doi.org/10.1017/S0007114517002896).

In the present sample, unfortunately, the low consumption of skimmed yogurt (consumed by only 6 out of the 80 volunteers consuming natural yogurt) precluded a skimmed vs. whole-fat comparison. However, it is worth mentioning that we have observed differences among the yogurt types assessed (natural vs. sweetened) with regards to the microbiota profile. These results underline the need for a full subcate-

gorization of yogurt types in intervention and epidemiological studies, since different types may differ in their effects on health.

Given the descriptive nature of our study, we are not able to elucidate the mechanism of action explaining the observed associations. In spite of the lack of information about the modulation of intestinal *Akkermansia* in humans, recent research in mice treated with antibiotics has reported an increase in this bacterial group after the administration of a probiotic mix of *Lactobacillus* (Shi, *et al*., 2018, https://doi.org/10.1111/jam.13687). Therefore, it may be plausible that the intake of such microorganisms, present in yogurt, might play a role in this association.

At this point, it should be mentioned that since labels of products do not provide information about the viable microorganisms present, we cannot know the exact amount and specific strains consumed by the study sample. According to the CODEX regulation (CODEX STAN 243-2003), yogurt must include a minimum bacterial counts of 10^7 cfu per gram from the symbiotic cultures of *Streptococcus thermophilus* and *Lactobacillus bulgaricus.* This, according to the intake data obtained, would correspond with intakes between 5×10^8 and 10^9 bacterial cells/day of each of these microorganisms. Nevertheless, although as shown in this study these levels can be easily reached within the context of a normal diet, it is also true that in interventional studies higher levels have been often used.

Results from intervention studies, both in animals and humans, have shown that the increase in *Akkermansia muciniphila* is associated with lower adiposity and a better metabolic status, suggesting this microorganism could be a potential candidate for obesity control. In the current study, we found that natural yogurt consumers presented not only higher intestinal *Akkermansia* levels with respect to non-consumers, but also a "healthier metabolic profile" based on lower inflammation and serum lipid peroxidation, measured through serum CRP and MDA. These immune variables have been reported to be moderately reduced in intervention studies with probiotic yogurt by other authors.

These findings are coherent with recent data from the Kuopio Ischaemic Heart Disease Risk Factor Study showing a cardiovascular protective effect in men consuming fermented dairy products (Koskinen, *et al*., 2018, https://doi.org/10.1017/S0007114518002830), and with several epidemiological studies supporting a protective role of fermented dairy products against the chronic "low-grade" inflammation associated with the metabolic syndrome and related diseases. Despite the values of LDL/HDL ratio in our sample were higher for yogurt consumers than for non-consumers, these are far from the established levels of atherogenic risk (>4.5). It is also important to underline that, in contrast to some of the previous studies, age and gender have been introduced as covariates in the analyses performed in our study, and global diet has been determined.

Fermented dairy foods may present nutritional properties independent of the presence of microorganisms, as seems to occur with the sweetened yogurts. Although the lower levels of *Bacteroides* observed in the consumers of sweetened yogurt in our sample could be *a priori,* surprisingly, this result is in consonance with previous reports indicating a reduction in the intestinal level of *Bacteroides* associated with the consumption of certain sweeteners such as sucralose. Therefore, it could be interesting to examine if the addition of additives (flavors, sweeteners, etc.) to traditionally considered healthy products, such as yogurt, could influence on the gut microbiota and, therefore, on the health status of the host.

No statistical differences were found in the levels of intestinal microbial groups as related to cheese consumption. However, cheese consumers showed higher fecal concentrations of the major SCFA. These compounds have been widely related with different metabolic effects, directly modulating host health through a range of tissue-specific. From a nutritional point of view, differences in the relationship with health may be expected depending on the types of cheese considered. Notwithstanding, we have not observed differences in our sample in health-related parameters according to cheese intake.

It is also important to be aware that this study contains some limitations. As mentioned before, although the FFQ has been carried out with a high grade of detail, it has not been possible to collect information on the specific microbial strains contained in the products. On the other hand, even though the multivariate models were adjusted by age and gender, we cannot rule out possible residual confounders often present in this sort of study. In spite of this, the present work has the strength of being conducted within the context of the habitual and global dietary pattern of the volunteers, and points out natural yogurt as a healthy product that, as previously suggested, should have a more visible role in dietary recommendations and guidelines. Our data suggests that fermented dairy products in general, and yogurt in particular, could be a key element affecting the relationship between diet and health by means of the modulation of gut microbial composition and functionality.

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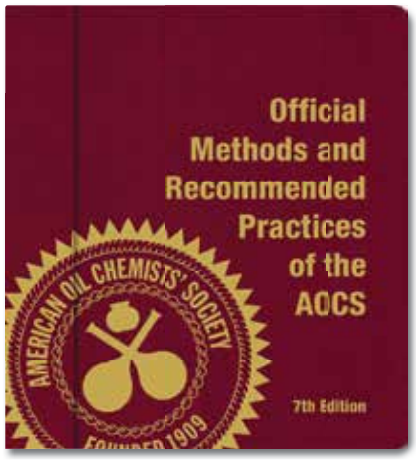

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Will using surfactants lead to even better energy storage?

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

Rebecca Guenard

Our ubiquitous mobile devices could never have come to life if not for the lithium ion battery. Since first being produced in the early 1990s, the battery's energy storage and dispensing has continually improved. Innovations in electrode materials have increased the performance and capacity of batteries, begetting longer-lasting devices with evermore functions. As proof of the strides scientists have made with this technology, the lithium ion battery now powers the automobile (Fig. 1).

The beloved battery does have flaws. Anyone with a cellphone knows that batteries degrade over time. The more the phone is charged, the faster the charge runs out. There are also safety concerns associated with lithium ion batteries. The batteries contain a flammable electrolyte that explodes if pressurized. Several electronic devices have been recalled over the past decade because their batteries were prone to catch fire.

Yet, demand for energy storage continues to grow. The progression of the lithium ion battery from hand-held and laptop devices to the automobile could eventually be used to power the electrical grid. But some scientists are concerned that the limitations of the lithium ion battery may prevent its use as a renewable power source. Could new research out of the Massachusetts Institute of Technology in Cambridge, Massachusetts, be an indication that an even better battery is possible?

"Initially, we were trying to find a safer electrolyte," says Xianwen Mao, a researcher on the project. Instead, the team identified a new electrochemical system when they combined ionic liquids and surfactants in a supercapacitor cell. The technology could eventually compete with the lithium ion battery. "This is the first time we have seen that self-assembled nanostructures can facilitate energy storage," says Mao.

One of the current applications of a supercapacitor is as the defibrillator of the battery world, delivering a quick energy jolt until a continuous source takes over. They boost a battery but cannot store enough energy themselves to dispense a voltage long-term. They are used in new cars with start-stop technology that reduce emissions by shutting off engines instead of idling. Supercapacitors restart the engine with a minimal delay.

The research that Mao (currently at Cornell University in Ithaca, New York) collaborated on proves that supercapacitors may be capable of more than just auxiliary energy storage. With the right kind of surfactant, the supercapacitor can act as a battery, storing an equivalent amount of electricity to the lithium ion battery, but discharging it faster.

Supercapacitors are fast because all their charge resides on the electrode surface where they can be released quickly. However, this design also inhibits the supercapacitor's ability to store energy. In a typical battery, the entire electrode is the charge receptacle since the surface area is significantly less than that of the bulk. The MIT researchers ramped up the amount of charge at the electrode's surface using a relatively new class of electrolytes composed of ionic liquids mixed with

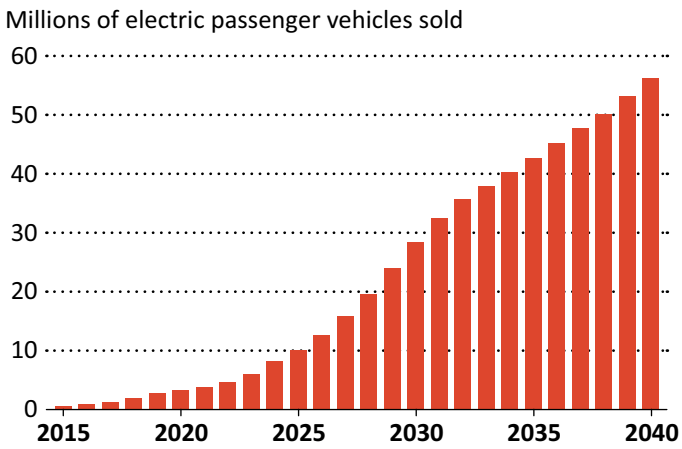

FIG. 1. According to market research, the sale of electric vehicles will continue to increase, causing an increased demand for light, efficient batteries. Source: Bloomberg

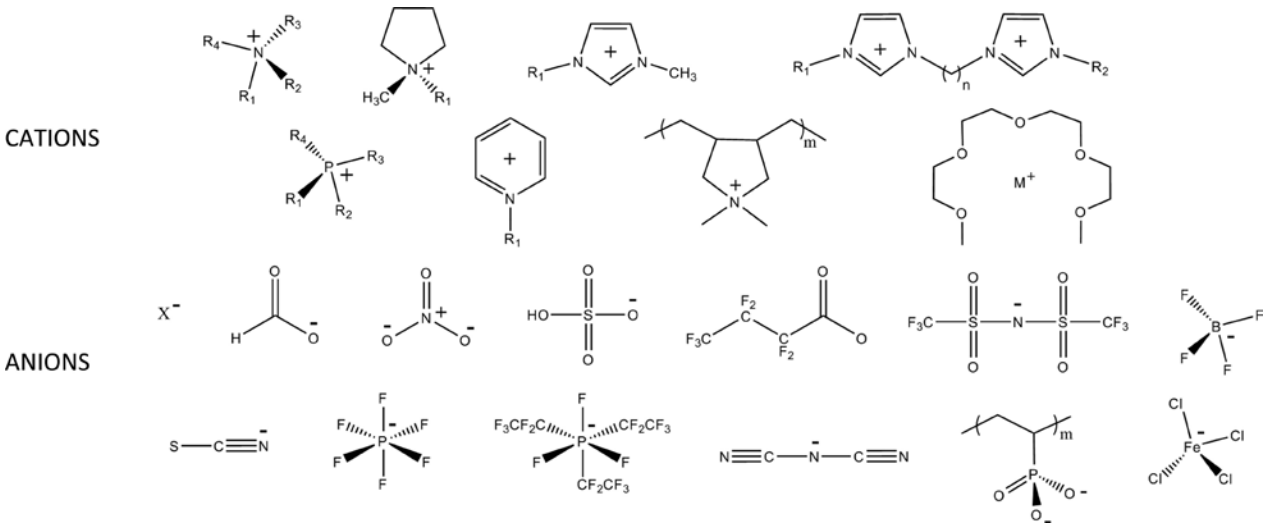

FIG. 2. Common anions and cations used in ionic liquids. Source: Hayes, *et al. Chem. Rev. 115*: 6357–6426, 2015.

a surfactant. The energy density of the supercapacitor was five times greater when they used the mixture, known as a surface-active ionic liquid (SAIL).

"Conventional ionic liquids have much lower energy density, but with the addition of these surfactants we can enhance the energy density significantly; in addition, we get all the other advantages like being a safe, nonflammable, green liquid," says Mao (Fig. 2).

An ionic liquid is a salt that exists as a liquid at room temperature. Like all liquids containing mobile ions, ionic liquids are amphiphilic—capable of conducting electricity. When synthesizing the liquids, scientists select anions and cations that will destabilize a solid-phase crystal and encourage a liquid to form. Due to the range of ion pair combinations, the properties of ionic liquids are difficult to generalize and are an active research area for scientists. In the past decade, scientists have also realized that the addition of a surfactant to an ionic liquid induces the spontaneous self-assembly of an amphiphilic nanostructure. Professor Alan Hatton, director of MIT's School of Chemical Engineering Practice, and principle investigator on the supercapacitor project, explains that when applied in a supercapacitor, the SAIL nanostructure reduces shielding.

"There is a much higher density of cations at the surface," says Hatton. "They stabilize because of the steric effect of the surfactants forming a structure that prevents a mixing."

The non-polar surfactant tails in a SAIL extend away from the electrode surface and experience van der Waals forces with each other that maintain a fixed spacing of the molecule. In turn, this eliminates a jam-up of counter ions on the electrode surface, an effect known as overscreening. Without the clog of counter ions, more cations can fix on the electrode surface, increasing the energy density of the supercapacitor.

The MIT research team performed atomistic molecular dynamics simulations to model these systems and determine why certain electrolytes provide greater electricity than others. They found that the surfactants induced a lamellar structure of alternating charges about eight ion layers deep. Aside from theoretical measurements, they also performed atomic force microscopy and verified the physical existence of the interfacial layers.

More research is needed to better understand how to optimize the complex ordering of SAILs at the surface of an electrode to maximize the energy storage of a superconductor, but it is not likely to come from the original team of researchers. Hatton says that the research Mao did in his lab informed many of the projects that are the main research focus of his group. He is using electrochemical systems like pseudo- and supercapacitors as a means of environmental clean-up. His group recently gained attention when they announced that they had developed a battery that could capture the greenhouse gas, carbon dioxide, from the air (http://news.mit.edu/2019). He has since transferred the knowledge gained during the supercapacitor experiments to other projects, but Hatton says he has no plans to continue research on these systems as a means of energy storage. Mao has moved on to other projects as well.

The researchers have laid out a clear design framework for anyone interested in pursuing the task of developing a new battery. But, for now, the reign of the lithium ion battery is unthreatened.

Rebecca Guenard is the associate editor of Inform *at AOCS. She can be contacted at rebecca.guenard@aocs.org.*

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California research tool visualizes working women's chemical exposures

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

Kelly Franklin

The California Breast Cancer Research Program has developed a tool to look at women's exposure to chemicals in the workplace.

The tool shows data on 1,000 chemicals of concern and is based on data for 6.5 million working women in 160 different occupations in California.

It will serve as a first step toward better understanding breast cancer risks associated with occupational chemical exposures, the CBCRP says. Researchers will be able to use the data collected to identify the potential scope of the problem, characterize the populations most affected, and guide future research.

The tool will also give the state's working women access to information about the chemicals they may be exposed to at work, according to the program.

EXPOSURE INSIGHTS

In some preliminary insights, the CBCRP reports that about 1.7 million women may be exposed to solvents at work through using products such as paints, adhesives, and cleaning products.

These include endocrine disruptors, such as ethylbenzene and toluene, as well as mammary gland carcinogens, such as 1,2-dichloroethane and nitrobenzene.

While phthalate exposures are common in everyday life, some 4.4 million women may be additionally exposed to them in working life, the program found. It lists 16 endocrine-disrupting phthalates that workers are likely to encounter in their jobs. Regulators in the United States, the European Union, and other countries are in the process of evaluating various phthalates (see "More on phthalates").

The CBCRP also warns that maids and housekeeping workers have a high probability of exposure to potentially harmful antimicrobials, phthalates, fragrance ingredients, and alkylphenols.

Cashiers may be exposed to bisphenol A in till receipts and fragrance ingredients, and registered nurses are probably exposed to chemicals of concern in phthalates, fragrances, cleaning products, and antimicrobial chemicals.

DATA SOURCES AND CHEMICALS OF CONCERN

The tool uses a list of chemicals of concern for breast cancer risk, which includes:

- mammary gland carcinogens taken from the Silent Spring Institute mammary gland carcinogen database;
- endocrine disruptors from the endocrine disruption exchange (https://members.chemicalwatch.com/article?id=85099); and
- mammary gland developmental toxicants from a paper published in *Environmental Health Perspectives* in 2011.

The CBCRP fed the tool with data from the American Community Survey, a mandatory survey conducted by the US Census Bureau on demographics and where women are employed in California.

It then calculated the probabilities for chemical exposures in each occupation with a matrix developed by its own research team.

Two independent industrial hygienists conducted the exposure assessments, the CBCRP says.

The tool was developed in partnership with the California Department of Public Health, the Occupational Health Branch and the University of California, San Francisco.

MORE ON PHTHALATES

In the European Union

On December 19, 2019, the European Commission said it will ask the European Food Safety Authority (EFSA) to conduct another risk assessment of phthalates in plastic food contact materials (FCMs).

The move follows publication, earlier this month, of an update to EFSA's 2005 risk assessment of five phthalates authorized for use in FCMs.

In the update, the Panel on Food Contact Materials, Enzymes and Processing Aids (CEP panel) calculated a group tolerable daily intake (TDI) for the four substances:

- di-butylphthalate (DBP);
- butylbenzylphthalate (BBP);
- bis(2-ethylhexyl)phthalate (DEHP); and
- di-isononylphthalate (DINP).

They also calculated a conventional, individual TDI for di-isodecylphthalate (DIDP).

The 2005 assessment and update focused on reproductive toxicity as a hazard endpoint. An EFSA spokesperson told Chemical Watch this was because of limited time for review of new data and for its completion.

In the United States

On December 20, 2019, the US EPA finalized its selection of 20 high-priority substances that will undergo a TSCA risk evaluation. The list includes six phthalates, as well as seven chlorinated solvents, four flame retardants, formaldehyde, a fragrance additive, and a polymer precursor.

The agency's announcement is significant in that it initiates the next set of risk evaluations that must be completed within the next three and a half years.

It also starts the clock on a flurry of TSCA-related activities that must be completed by this coming June.

In other words, the agency has only six months to publish documents setting out the "scope" of these next risk evaluations, even while it continues to wrap up its first ten reviews under roughly the same timeframe.

The agency's recent approval of two manufacturer-submitted requests for evaluations on the phthalates DINP and DIDP means it will have 32 reviews underway in total.

Industry, too, is likely to see a flurry of activity in the coming months, as work intensifies to build consortia around identified substances and see to the allocation of the $1.35 million fee that comes with each EPA-initiated risk evaluation.

Kelly Franklin is North America Editor for Chemical Watch.

2019: about 1,000 dairy farm closures in Argentina

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

eslie Kleiner

The dairy industry was consistently present in the news during 2019. As the year came to an end, a report from *Observatorio de la Cadena Láctea Argentina, Ocla* (or *Argentinean Dairy Chain Observatory*, as translated from Spanish to English) estimated that approximately 1,000 dairy farms had shut down in Argentina during 2019. The following information from the report, which has been converted to Q&A format, looks at the economics behind the closures and the effect the closures have had on milk production.

Q: How did milk production during 2019 compare to the amount of milk produced in 2018?

The official milk production for the year 2019 was 10,343 million liters, and this was 1.7% lower than 2018 numbers. From this data and from statistics provided by Servicio Nacional de Sanidad y Calidad Agroalimentaria, Senasa (National Agricultural Sanitation and Quality Service, as translated to English), Ocla calculates an initial estimate of a 8.7% reduction in dairy farms, from 11,273 in 2018 to 10,287 in 2019 [1].

Q: How does milk production relate to cowherds?

Ocla estimates that the herds of Holando cows include approximately 1,623,176 heads, which is a 5.9% decrease from the number of cows in 2018. However, despite dairy farm closures and lower cowherd numbers, productivity per dairy farm and per cow improved. On average, in 2019 every dairy farm produced 2.755 liters of daily milk, which is a 7.7% increase from daily milk production per dairy farm in 2018. Per cow, the milk production in 2019 increased 4.4%, from 6.100 liters to 6.370 liters [1]

Q: How was 2019 in terms of profitability for dairy farms?

The Dirección Nacional de Lechería (National Managment of Dairy) indicates that milk producers received an 81% increase in pay from that received in 2018 (inflation was 53.8% in 2019). However, this doesn't transfer to a considerable financial benefit. In dollars, as of last December, the increase was only 27 cents, which is less than the 30 cents required as a base for profitability [2].

Q: How does the price per liter of milk paid to the dairy farmer compare to that paid in other countries?

In October 2019, a dairy farmer in Argentina received 0.281 US dollars/ liter of milk (21.6% more than in 2018). For the same period, a dairy farmer in Uruguay, Chile, Brazil, the United States, and New Zealand received $0.301, $0.340, $0.334, $0.439, and $0.322 US dollars/liter of milk, respectively.

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Latin America Update is produced by Leslie Kleiner, a senior research scientist and contributing editor of *Inform*.

Meet Nuria Acevedo

Member Spotlight is a regular column that features members who play critical roles in AOCS.

Nuria Acevedo (left) shares a cup of mate with Silvia Matiacevich, a good friend and associate professor in the Department of Food Science and Technology at the University of Santiago de Chile.

Fast facts

Name	Nuria Acevedo
Joined AOCS	2008
Education	Ph.D. from the University of Buenos Aires
Job title	Assistant professor in the Department of Food Science and Human Nutrition
Employer	Iowa State University (Ames, Iowa, USA)
Current AOCS involvement	Leader team member of the Professional Educator Common Interest Group and chair of one of the Edible Applications sessions for the 2020 AOCS Annual Meeting & Expo

PROFESSIONAL

What's a typical day like for you?
One of my biggest joys is checking in with my students and assessing their progress on their research projects. I like to read and discuss their reports with them, hear their priorities for the week and their goals for the upcoming weeks. In a typical day, I am also focused on my own research for future projects.

My favorite part of my job is…
Collaborating with a diverse group of multidisciplinary scholars from my institution, and the international community is a perk. Learning not only about new research avenues but also about their cultures and individual stories makes it a unique platform for growth.

Flash back to when you were 10 years old. What did you want to be when you grew up?
When I was 10 years old, I dreamed of becoming a ballerina. After guidance from my family, I decided to study what I also love…science.

Why did you decide to do the work you are doing now?
I developed the passion for chemistry and science during my early years in school. I am a very curious person, and chemistry always left me wanting more answers.

Is there an achievement or contribution that you are most proud of? Why?
As a post doc at the University of Guelph in Canada, I was asked to conduct a research project for one of the world's largest food science companies. My research not only fulfilled the company's objectives, it also led to my first international patent and multiple research papers, all of which really helped me at the start of my career.

PERSONAL

How do you relax after a hard day of work?
I like going to the gym after my family is in bed. It helps me to release stress and unwind. I don't hate a nice glass of red wine, either!

What is the most impressive thing you know how to do?
I can make a traditional Canadian poutine. It is the national dish of Canada and consists of fried potatoes, squeaky Quebec cheese curds, and is topped with a succulent gravy.

What skill would you like to master?
I would love to learn how to speak Mandarin Chinese. It is such a unique language, and I am fascinated by the complexity of it.

What are some small things that make your day better?
A nice morning mate, which is a traditional Argentinian infusion from the leaves and twigs of the yerba mate plant. Mate is a social drink; I grew up sitting around the table with friends and family sharing this wonderful drink and talking about how we were doing. Not what we did that day, but how it all felt. In fact, every two weeks now I have a web-based conversation with my childhood friends. And each of us, of course, has a mate in hand.

Why do so many people choose A

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30–34

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"The best part of being an AOCS member is the networking and the quality of people that you meet. Membership in AOCS is important to me because of the opportunities it has provided to me over the course of my career in terms of new ideas to develop new products for chromatography."

—LEN SIDISKY, R & D MANAGER, MILLIPORESIGMA, PENNSYLVANIA, USA

"I know there is a lot of competition for joining of trade organizations, but I really think AOCS is one of those organizations that you have to join, especially if you are in the fats and oil sector. Everybody is here. We are one of the oldest, most established and most credible organization around and you get a lot of benefit for your dollar with AOCS."

—DOUG BIBUS, LIPID TECHNOLOGIES, LLC, MINNESOTA, USA

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40–49

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"One of the highlights for me with AOCS is having a group of colleagues I interact with on a regular basis who have played a mentorship role for me and now I can play that same role back to other young scientists."

—DOUGLAS HAYES, UNIVERSITY OF TENNESSEE, TENNESSEE, USA

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PATENTS

Composition for removing organic deposits from oil and gas wells and other subsurface systems and method for removing organic deposits using the remover composition

Cezario, W.R., *et al.*, Petroleo Brasileiro S.A.-Petrobras, US10351757, July 16, 2019

The present invention relates to a method for removing organic deposits from oil and gas wells and other subsystem systems comprising cumene and biodiesel. The invention also relates to a method for removing organic deposits, including the steps for pumping said remover composition through a riser and/or through peripheral pipes of the umbilical and/or production pipe, leaving the composition in contact with the deposit for a sufficient time for removal of at least 50% of such.

Sprayable topical carrier and composition comprising phosphatidylcholine

Herslof, B., *et al.*, Lipidor AB, US10363314, July 30, 2019

A pharmaceutical or cosmetic carrier for topical administration substantially consists of phosphatidylcholine, monoglyceride, fatty acid ester of C.sub.1-C.sub.3 alcohol; volatile solvent selected from ethanol and its combinations with C.sub.3-C.sub.4 alcohol and/or volatile silicone oil. Also disclosed are pharmaceutical and cosmetic compositions comprising the carrier and pharmaceutically or cosmetically active agent(s).

Oil-containing rubber compositions and related methods

Srinivasan, P., *et al.*, Bridgestone Americas Tire Operations, LLC, US10370526, August 6, 2019

Disclosed herein are rubber compositions comprising bio-oil produced by a recombinant cell. Also disclosed are methods of controlling the variability of fatty acid content in bio-oil containing rubber compositions or tires comprising at least one component incorporating the bio-oil containing rubber composition, and a method of providing a bio-oil-containing tire with a reduced carbon footprint.

Extraction of lipid from cells and products therefrom

Cherinko, S.R., *et al.*, DSM IP Assets B.V., US10385289, August 20, 2019

The present invention relates to processes for obtaining a lipid from a cell by lysing the cell, contacting the cell with a base and/or salt, and separating the lipid. The present invention is also directed to a lipid prepared by the processes of the present invention. The present invention is also directed to microbial lipids having a particular anisidine value, peroxide value, and/or phosphorus content.

Production method for oil and fat

Watanabe, S., Fuji Oil Holdings Inc., US10385369, August 20, 2019

The present invention provides a commercially viable-level, highly efficient production method for oil and fat that are rich in USU.

Method of making lipids with improved cold flow properties

Sun, Z., *et al.*, MARA Renewables Corp., US10385370, August 20, 2019

Provided herein are methods of producing oils with reduced saturated fatty acids. The methods include culturing oil-producing microorganisms in a fermentation medium in the presence of one or more antifoaming agents under a controlled carbon consumption rate, wherein the culturing produces oils comprising fatty acids and wherein less than 35% of the fatty acids in the oil are saturated fatty acids.

Seed oil-based reactive diluent

Yu, W., *et al.*, Rust-Oleum Corp., US10392580, August 27, 2019

A seed oil-based reactive diluent is synthesized via a two-step process wherein in the first step, unsaturated seed oils such as soybean oil first react with mono-hydroxy functional amines to form an intermediate mixture composed of mono-hydroxy functional seed oil based derivatives and in the second step, a core molecule having multiple hydroxyl-reactive groups reacts with the intermediate mixture prepared from the first step and a polyol cross-linker to form a reactive diluent with a star-branched shape.

Detergent compositions with lipase and biosurfactant

De Rose, S.A., *et al.*, Conopco, Inc., US10400197, September 3, 2019

Compositions comprising lipases and biosurfactants, especially psychrophilic lipases and biosurfactants.

Detergent compositions comprising a protease

Astrid, B., *et al.*, Novozymes A/S, 10407650, September 10, 2019

A detergent composition comprising a polypeptide having protease activity is disclosed. The composition may be used in laundry or hard surface cleaning such as automated dish wash, and it has improved performance compared with a commercial protease.

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.

Could your paper be eligible for a best paper award?

Every spring, AOCS recognizes outstanding papers with four best paper awards. These are traditionally presented at the AOCS Annual Meeting (this year's meeting will be held in Montreal, Canada, April 26–29), and authors of the winning papers join an exclusive circle of best paper authors whose work has advanced the science and technology of oils, fats, proteins, surfactants, and related materials. A high percentage of these authors become leaders in their respective fields and/or AOCS journal editors.

Although each award has a unique history and its own sponsors, eligibility requirements, and selection processes, one thing they all have in common is that there is no nomination process. Authors do not have to know someone important or nominate themselves to get one, because all papers eligible for a best paper award are automatically considered.

Three of the awards are only for papers published with AOCS. Depending on the specific requirements of the award, best papers could come from one or more of the three AOCS journals (*Journal of the American Chemists' Society, Journal of Surfactant's and Detergents, Lipids*) or even other AOCS publications. Imagine how surprised Karen Schaich, a professor in the Food Science Department at Rutgers University, New Brunswick, New Jersey, USA, was when she learned that she won the 2015 Archer Daniels Midland Award for Best Paper in Protein and Co-Products in the chemistry/nutrition category for the article she contributed to *Inform*, "Lipid co-oxidation of proteins: one size does not fit all," (*Inform* 25: 134–139, Mar. 2014)! In contrast, the Phospholipid Division Best Paper Award is not limited to papers published with AOCS; papers published in any journal or in the area of phospholipid research or applications during the year before the annual meeting are eligible.

All best papers are for papers published the year before the Annual Meeting, so if your paper is published in 2020, you might be eligible for a best paper award in 2021. To learn more, check out this brief summary of the four awards.

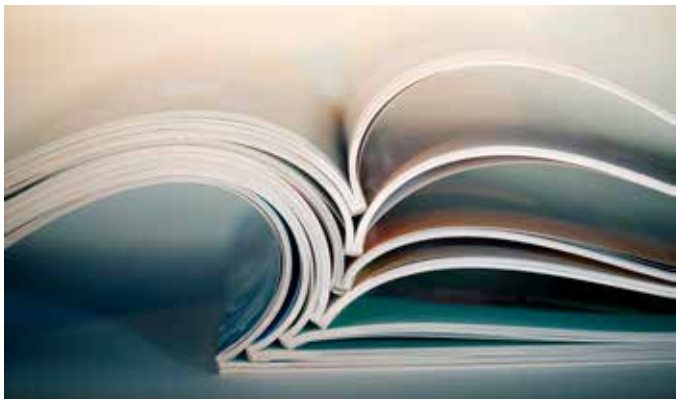
AMERICAN CLEANING INSTITUTE DISTINGUISHED PAPER AWARD

Established in 1979, first presented in 1980

The AOCS Surfactants and Detergents Division recognizes an outstanding paper published in the area of surfactants and detergents. *Sponsored by American Cleaning Institute (ACI).*

What do recipients receive?

- Plaque for the main author
- Certificates for all contributing authors



Who is eligible?

All papers published in the *Journal of Surfactants and Detergents* (*JSD*) during the calendar year before the AOCS Annual Meeting, with the exception of papers listing author(s) who received the award within the previous three years. Authors do not need to be members of AOCS or the Division.

Who selects the winners?

An awards committee identified by the Surfactants and Detergent Division Chair selects the winning paper after publication of the 4th quarter of *JSD*.

What is the paper selection process?

The award selection committee chair, in collaboration with selected committee members, determines which papers meet the eligibility requirements. Committee members evaluate the papers using the following criteria: importance to the advancement of knowledge in areas of the Division's interest, overall quality, timeliness, significance, and validity of experimental design and methods.

First paper to win this award:

"Oily soil removal from a polyester substrate by aqueous nonionic surfactant systems," Dillan, K.W., E.D. Goddard, and D.A. McKenzie, *JAOCS 56*: 59–70, 1980.

AOCS remembers Edwin N. Frankel

Edwin N. Frankel, the famous lipid oxidation scientist for whom the Edwin N. Frankel Award for Best Paper in Lipid Oxidation and Quality is named, died of natural causes on Nov. 20, 2019, at his home in Davis, California, USA.

A 63-year member of AOCS who was named an AOCS Fellow in 1998, Dr. Frankel received the Alton E. Bailey Award in 1985, the Stephen S. Chang Award in 1999, and the Supelco AOCS Research Award in 2007. He had a long and distinguished career at UC Davis as an adjunct professor in the department of food science and technology, where he led a research lab that made substantial scientific contributions to the field of lipid oxidation and antioxidants in food and biological systems. In partnership with scientists in Davis and throughout the world, Edwin published research studies on the stability of fats and oils and natural antioxidants, including a major study on the benefits of phenolics in red wine. Prior to joining the UCD faculty in 1989, Edwin spent 30 years as a research chemist with the U.S. Department of Agriculture in Peoria, Ill.

His memory lives on in the Edwin N. Frankel Award for Best Paper in Lipid Oxidation and Quality, which was established in 1997 to recognize his 50 years of lipid oxidation research and continues to inspire and reward outstanding work in his beloved field of lipid oxidation.

ARCHER DANIEL MIDLAND AWARD FOR BEST PAPER IN PROTEIN AND CO-PRODUCTS

Established in 1983, first presented in 1984

This award recognizes outstanding papers that report original research in the categories of *chemistry/nutrition* and *engineering/technology* of protein and co-products. One paper is selected from each category. The award is presented by the Protein and Co-Products Division. *Sponsored by Archer Daniel Midland (ADM).*

What do recipients receive?
- Plaque for the main author
- Certificates for all contributing authors

Who is eligible?
All papers published within the *Journal of American Oil Chemists' Society* (*JAOCS*) and other pertinent AOCS publications during the calendar year before the AOCS Annual Meeting with original research on proteins or co-products of oilseeds and animal products. Authors do not need to be members of AOCS or the Division.

Who selects the winners?
An awards committee identified by the Protein and Co-Products Division Chair selects the winning paper(s) after publication of the 4th quarter of *JAOCS*.

What is the paper selection process?
The award selection committee chair, in collaboration with selected committee members, determines which papers meet the eligibility requirements. Committee members evaluate the papers using the following criteria: overall quality, timeliness, significance, and validity of experimental design and methods.

First papers to win this award:
Chemistry/Nutrition Category
"Protein conformations and their stabilities," Pace, C.N., *JAOCS* 60: 970–975, 1984.
Engineering/Technology Category
"Soy protein hydrolysis in membrane reactors," Cheryan, M. and D. Deeslie, *JAOCS 60*: 1112–1115, 1984.

EDWIN N. FRANKEL AWARD FOR BEST PAPER IN LIPID OXIDATION AND QUALITY

Established 1997, first presented in 1998

This award recognizes an outstanding paper in the area of lipid oxidation or quality. This award is presented by the Lipid Oxidation and Quality Division in recognition of Edwin Frankel's 50 years of lipid oxidation research (see "AOCS says farewell to Edwin N. Frankel"). *Sponsored by Kalsec.*

What do recipients receive?
- Plaque for the main author
- Certificates for all contributing authors

Who is eligible?
All papers published within an AOCS journal during the calendar year before the AOCS Annual Meeting that address oxidation, stability, quality or flavor of lipids are eligible. Authors do not need to be members of AOCS or the Division.

Who selects the winners?
An awards committee identified by the Lipid Oxidation and Quality Division Chair selects the winning paper after 4th quarter publications.

What is the paper selection process?
The award selection committee chair, in collaboration with selected committee members, determines which papers meet

the eligibility requirements. Committee members evaluate the papers using the following criteria: importance to the advancement of knowledge in the areas of the LOQ Division's interest, overall quality, timeliness, significance and validity of the experimental design and methods, and clarity of presentation.

First paper to win this award:
"Photo-initiated peroxidation of lipids in micelles by azaaromatics in lipids," Edwards, C., E. Crowe, and R. Barclay, *Lipids 32*: 237–245, 1998.

PHOSPHOLIPID DIVISION BEST PAPER AWARD

Established in 1998, first presented in 1999

This award recognizes an outstanding paper or monograph in the area of phospholipids. *Sponsored by International Lecithin & Phospholipid Society (ILPS).*

What do recipients receive?
- Plaque for the main author
- Certificates for all contributing authors
- Up to a US $1,500 travel allowance
- Presentation at the AOCS Annual Meeting to give an award lecture

Who is eligible?
All papers published from any journal or monograph (*not limited to AOCS Press*) in the area of phospholipid research or applications during the calendar year before the AOCS Annual Meeting.

Who selects the winners?
An awards committee identified by the Phospholipid Division Chair selects the winning paper after 4th quarter publications.

What is the paper selection process?
The award selection committee chair, in collaboration with selected committee members, determines which papers meet the eligibility requirements. Committee members evaluate the papers using the following criteria: importance to the advancement of knowledge in the areas of the PHO Division's interest, overall quality, timeliness, significance and validity of the experimental design and methods, and clarity of presentation.

First paper to win this award:
"Soy lecithin reduces plasma lipoprotein cholesterol and early atherogenesis in hypercholesterolemic monkeys and hamsters: beyond linoleate," Wilson, T.A., R.J. Nicolosi, and C.M. Meservey, *J. Atherosclerosis 140*: 147–153, 1999.

EXTRACTS & DISTILLATES

The full version of all AOCS journal articles are available online to members at www.aocs.org/journal. This column builds on that member benefit by primarily highlighting articles from other journals.

ANA Analytical
BIO Biotechnology
EAT Edible Applications
LOQ Lipid Oxidation and Quality
H&N Health and Nutrition
IOP Industrial Oil Products
PRO Processing
PCP Protein and Co-Products
S&D Surfactants and Detergents

Review Articles

ANA H&N Key aroma compounds in oats and oat cereals

McGorrin, R.J., *J. Agric. Food Chem.* 67: 13778–13789, 2019. https://doi.org/10.1021/acs.jafc.9b00994.

Oat crop and seed is extensively studied for its benefits. Both oatmeal and oat oil are used in food as well as cosmetics and are a rich source of chemistry that provides health benefits to the skin or the gut when consumed as a food. This article reviews the catalog of chemical diversity naturally expressed by oat.

Oats possess a unique flavor, comprising grain and nut-like sensory characteristics. The first gas chromatography–mass spectroscopy investigations of the flavor chemistry of oat groats identified 110 volatile components in oat groats, and another early study of heat-processed oats and cooked oatmeal identified a series of Maillard-derived compounds. In the subsequent 38 years since these initial research findings, additional identifications of aroma compounds in oat flakes and flours have been reported. This review addresses significant recent developments of the current understanding of oat flavor chemistry and the key aroma compounds that contribute to the unique flavor of oat cereals.

LOQ H&N Antioxidant compounds from microbial sources: a review

Chandra, P., *et al.*, *Food Res. Int.* 129: 108849, 2020, https://doi.org/10.1016/j.foodres.2019.108849.

Microorganisms are a potential source of novel bioactive compounds to be used in medical, agricultural, and industrial sectors. As compared to plants, microbes can be grown under controlled conditions at a faster rate, which make them a potential source of natural bioactive molecules for food and nutraceutical applications. This review summarizes the potential of different microorganisms including actinomycetes, bacteria, blue green algae, fungi, lichens, and mushrooms to be explored as the source of such bioactive compounds.

Original Articles

ANA H&N LOQ Effects of hydrogen-rich water on the nutrient composition and antioxidative characteristics of sprouted black barley

Guan, Q., *et al.*, *Food Chem.* 299: 125095, 2019, https://doi.org/10.1016/j.foodchem.2019.125095.

This piece of experimentation shows the beneficial effects of a minor component on quality of the crop. Understanding minor nutrients in soil and water are important to fully appreciate the fragrance and nutrient content of a crop produced in a certain environment.

Hydrogen gas (H_2), a multifunctional signaling molecule, has received increasing attention in recent years. In the present study, hydrogen-rich water (HRW) (2 ppm) was used for the processing of sprouted black barley (*Hordeum distichum* L.), and the results showed that the HRW treatment could significantly increase the germination rate and growth rate of black barley ($P < 0.05$). A chemical component analysis showed that in sprouted black barley, the HRW treatment could change the distribution of phytochemicals (e.g., the ionic strength of guanosine), increase the concentrations of free vanillic acid, coumaric acid, sinapic acid, conjugated sinapic acid, Ca and Fe, and the hydroxyl radical scavenging rate, and decrease the protein, fat, starch and dietary fiber contents compared with the results obtained after treatment with ultra-pure water ($P < 0.05$). HRW can be used for the processing of sprouted grains to effectively increase their germination efficiency and concentrations of bioactive phytochemicals.

BIO ANA Alternative splicing of key genes in lox pathway involves biosynthesis of volatile fatty acid derivatives in tea plant (*Camellia sinensis*)

Xu, Q., *et al.*, *J. Agric. Food Chem.* 67: 13021–13032, 2019, https://doi.org/10.1021/acs.jafc.9b05925.

Most of the aroma and flavor of tea is driven by the presence of volatile components, such as volatile fatty acids and other aromatic compounds. Hence, understanding the expression of volatiles in tea is expected to boost its value and associated health benefits.

Volatile fatty acid derivatives (VFADs) produced in tea plants (*Camellia sinensis*) not only have been shown to function as defense compounds but also impart a "fresh green" odor to green tea products; however, little is known about alternative splicing (AS) of genes in regulating the production of VFADs in plants. In this

study, the contents of VFADs and corresponding transcriptome profiles were obtained in five different months (April, June, August, September, and October). Correlation analysis identified seven unique transcripts of enzyme-coding genes (CsLOX2, CsLOX4, CsADH4, CsADH8, and CsADH10), which are responsible for regulating VFAD biosynthesis; four AS transcripts of these genes (CsLOX2, CsLOX4, CsADH4, and CsADH8) were validated by RT-PCR. By employing the gene-specific antisense oligodeoxynucleotide-mediated reduction method, we found the expression levels of alternatively spliced transcripts of CsLOX4-iso1, CsLOX4-iso2, and CsADH4-iso3 were lower, and the contents of cis-3-hexenol were correspondingly reduced in the leaves of tea plant; this result suggested that the AS play important roles in regulating biosynthesis of VFADs in *C. sinensis*. Our results provide new insights into the important contribution of AS events in regulating the VFAD biosynthesis in tea plant.

H&N Fish oil is more potent than flaxseed oil in modulating gut microbiota and reducing trimethylamine-N-oxide-exacerbated atherogenesis

He, Z., *et al.*, *J. Agric. Food Chem. 67*: 13635–13647, 2019, https://doi.org/10.1021/acs.jafc.9b06753.

Trimethylamine-N-oxide (TMAO) is a risk factor for atherosclerosis. We compared the potency of fish oil with flaxseed oil in reducing TMAO-exacerbated atherogenesis. Five groups of ApoE–/– mice were given one of five diets, namely, a low-fat diet, a Western high fat diet (WD), a WD plus 0.2% TMAO, and two WDs containing 0.2% TMAO with 50% lard being replaced by flaxseed oil or fish oil. TMAO accelerated atherosclerosis and disturbed cholesterol homeostasis. Compared with flaxseed oil, fish oil was more effective in inhibiting TMAO-induced atherogenesis by lowering plasma cholesterol and inflammatory cytokines. Both oils could reverse TMAO-induced decrease in fecal acidic sterols. Fish oil promoted fecal output of neutral sterols and downregulated hepatic cholesterol biosynthesis. Fish oil was more effective than flaxseed oil in promoting the growth of short-chain fatty acid-producing bacteria and lowering microbial generation of lipopolysaccharide. In conclusion, fish oil is more potent than flaxseed oil to ameliorate TMAO-exacerbated atherogenesis.

H&N ANA Rubber seed oil supplementation enriches n-3 polyunsaturated fatty acids and reduces cholesterol contents of egg yolks in laying hens

Wen, Z., *et al.*, *Food Chem. 301*, 125198, 2019, https://doi.org/10.1016/j.foodchem.2019.125198.

Rubber seed oil contains almost 80% unsaturated fatty acids, so it is no surprise that feed containing higher levels of unsaturated fatty acids help to increase the same in egg yolk with simultaneous opposite effects on cholesterol levels. Chicken feed with high content of unsaturated fatty acids is desirable and can be achieved via rubber seed oil or other similar oils, such as linseed or soybean.

The experiment was conducted to evaluate the effects of five rubber seed oil (RSO) levels (0, 1%, 2%, 4%, and 6%) on hens laying performance, egg quality, and yolks fatty acid composition and cholesterol contents. Three hundred and sixty 30-week-old Lohmann Brown laying hens were allotted to five groups. The results showed that egg production was increased in the 4% RSO group ($P < 0.05$), but egg quality parameters and the contents of dry matter, lipid, and protein in yolks were not influenced among treatments ($P > 0.05$). Yolk cholesterol contents were reduced in RSO supplemental groups ($P < 0.05$). The concentration of total n-3 PUFA in yolks increased gradually while the ratio of n-6/n-3 decreased gradually with increasing dietary RSO levels ($P < 0.001$). In conclusion, dietary RSO supplementation increased yolk n-3 PUFA levels, improved yolk color, and reduced yolk cholesterol contents without negative influence on laying performance parameters.

LOQ EAT Use of tannins to enhance the functional properties of protein-based films

Cano, A., *et al.*, *Food Hydrocol. 100*: 105443, 2020, https://doi.org/10.1016/j.foodhyd.2019.105443.

In this study, three tannins from different sources—white peel grape (W), red peel grape (R) and from oak bark (O)— were used to obtain active films based on proteins (caseinate and gelatin) based on their natural origin and potential antioxidant and antimicrobial activity. Films were obtained using in two different ways: by homogeneously blending the tannins with the proteins and bilayer films, by coating the previously obtained protein film with the dif-

ferent tannin solutions. The microstructural, physicochemical characterization, as well as the antioxidant and antimicrobial activities of the films were analyzed. The interactions developed between tannins and protein matrices determined the physico-chemical properties of the films. Significant changes were only observed in tannin-caseinate films, due to the establishment of hydrogen bonding and hydrophobic interactions, especially when using the tannin with the greatest phenolic content (W). Thus, the W tannin-, caseinate- based films turned thicker, with markedly improved ($p < 0.05$) water solubility and WVP values and became mechanically stiffer and less stretchable. All of the films incorporating tannins exhibited remarkable antioxidant and antimicrobial activities against *E. coli* and *L. innocua*, being the bilayer films containing W tannin the ones exhibiting the best antioxidant and antimicrobial activity against both bacteria (5 log of reduction), due to the greater availability of the active component when incorporated as a bilayer.

LOQ EAT H&N Assessment of active chitosan films incorporated with gallic acid

Zarandona, I, *et al., Food Hydrocol. 101*: 105486, 2020, https://doi.org/10.1016/j.foodhyd.2019.105486.

Chitosan films with antioxidant and antimicrobial properties were prepared by the incorporation of gallic acid as a bioactive. The films obtained were homogeneous, transparent, and colorless with high mechanical resistance. Results indicated that films had antimicrobial activity against *E. coli*, especially those films plasticized with 15 wt % glycerol and containing 20 wt % gallic acid, which showed the biggest inhibition halo. Additionally, gallic acid-incorporated chitosan films exhibited a great antioxidant activity with DPPH scavenging capacity values of 99% and a bioactive release of 33% after 4 days, suggesting the potential suitability of these modified chitosan films as active films for food or pharmaceutical purposes.

LOQ EAT Dietary citrus pulp and grape pomace as potential natural preservatives for extending beef shelf life

Tayengwa, T., *et al., Meat Sci. 162*: 108029, 2020, https://doi.org/10.1016/j.meatsci.2019.108029.

The shelf-life of beef was compared from 7-months old Angus steers (281 ± 15.4 kg initial body weight) fed 150 g/kg DM dried citrus pulp (DCP) or grape pomace (DGP) for 90 days. The antioxidant activity, bacterial load, and lipid and protein oxidation were evaluated on the longissimus lumborum subjected to air-permeable packaging at days 1, 3, 5, 7, and 9 post-slaughter. Beef antioxidant activity was DGP > DCP > control ($P \leq 0.05$). Beef from steers fed DGP or DCP had higher L* values ($P \leq 0.05$) and fewer ($P \leq 0.05$) coliform counts than steers fed the control diet. Beef antioxidant activity was DGP > DCP > control ($P \leq 0.05$). Beef TBARS and carbonyl contents were DGP < DCP < control ($P \leq 0.05$). Overall, antioxidant activity decreased ($P \leq 0.05$), while bacterial loads, TBARS, and carbonyl contents increased ($P \leq 0.05$) during retail display for all diets. Current findings indicate that DGP could be a better natural preservative than DCP when included in beef cattle finishing diets.

LOQ H&N Development of functional edible oils enriched with pistachio and walnut phenolic extracts

Giuseppe Fregapane, G., *et al., Food Chem. 310*: 125917, 2020, https://doi.org/10.1016/j.foodchem.2019.125917.

The purpose of this research was the development of functional edible oils with potential health promoting effects, enriched with phenolic-rich extracts obtained from pistachio and walnut. A high phenolic content, 10860 mg/kg and 7030 mg/kg in walnut and pistachio kernels respectively, with a corresponding strong radical scavenging effect (DPPH, 106 and 20 mmol/kg Trolox) were found. The remarkable antioxidant capacity of the phenolic-rich extracts prepared form walnut (255 mol/kg Trolox, measured by DPPH, 1500 times higher than its kernel) and pistachio (13 mol/kg, 630 times higher) makes them good candidates to evaluate their potential as bioactive ingredients. In the different enriched edible oils studied, a phenolic concentration of 340–570 mg/kg has been reached, showing the functional oils a great antioxidant activity, which was apparently much higher when walnut extracts were employed (e.g., 54 mmol/kg Trolox, as DPPH).

PCP PRO LOQ A comparative study of the functional properties and antioxidant activity of soybean meal extracts obtained by conventional extraction and electro-activated solutions

Gerliani, N., *et al., Food Chem. 307*: 125547, March 2020, https://doi.org/10.1016/j.foodchem.2019.125547.

Functional properties and antioxidant activity of soybean meal extracts obtained by conventional chemical method were compared to those obtained by using electro-activated solutions. The conventional extract obtained at pH8 had the highest WAC (400 ± 7 g/100 g), while the lowest was that of samples extracted under pH3. Extract obtained using electro-activated solution Anolyte_300mA-30 min had WAC value (25 ± 1 g/100 g). OAC was the highest for samples extracted under alkaline conditions whatever the extraction mode used with values of 5.50 ± 0.54 to 6.85 ± 0.62 mL/g. FC of the conventional extracts was higher compared to those extracted by electro-activation with maximal value of 52% for the conventional sample obtained at pH9, whereas the maximal FC of 28% was observed for the electro-activated sample obtained by using Anolyte_450mA-50 min. Electro-activated showed higher EP. Conventional extracts showed higher antioxidant activity (92.31 ± 1.5%) than those obtained by electro-activation (47.46 ± 0.94%).

PRO EAT Sunflower wax recovered from oil tank settlings: revaluation of a waste product from the oilseed industry

Redondas, C.E., *et al., J. Sci. Food Agric. 100*: 201–211, 2020, https://doi.org/10.1002/jsfa.10017

The sunflower oil industry produces a large amount of waste that is not currently commercially exploited, as in the case of oil-tank settlings. The recovery of a high value-added by-product, such as

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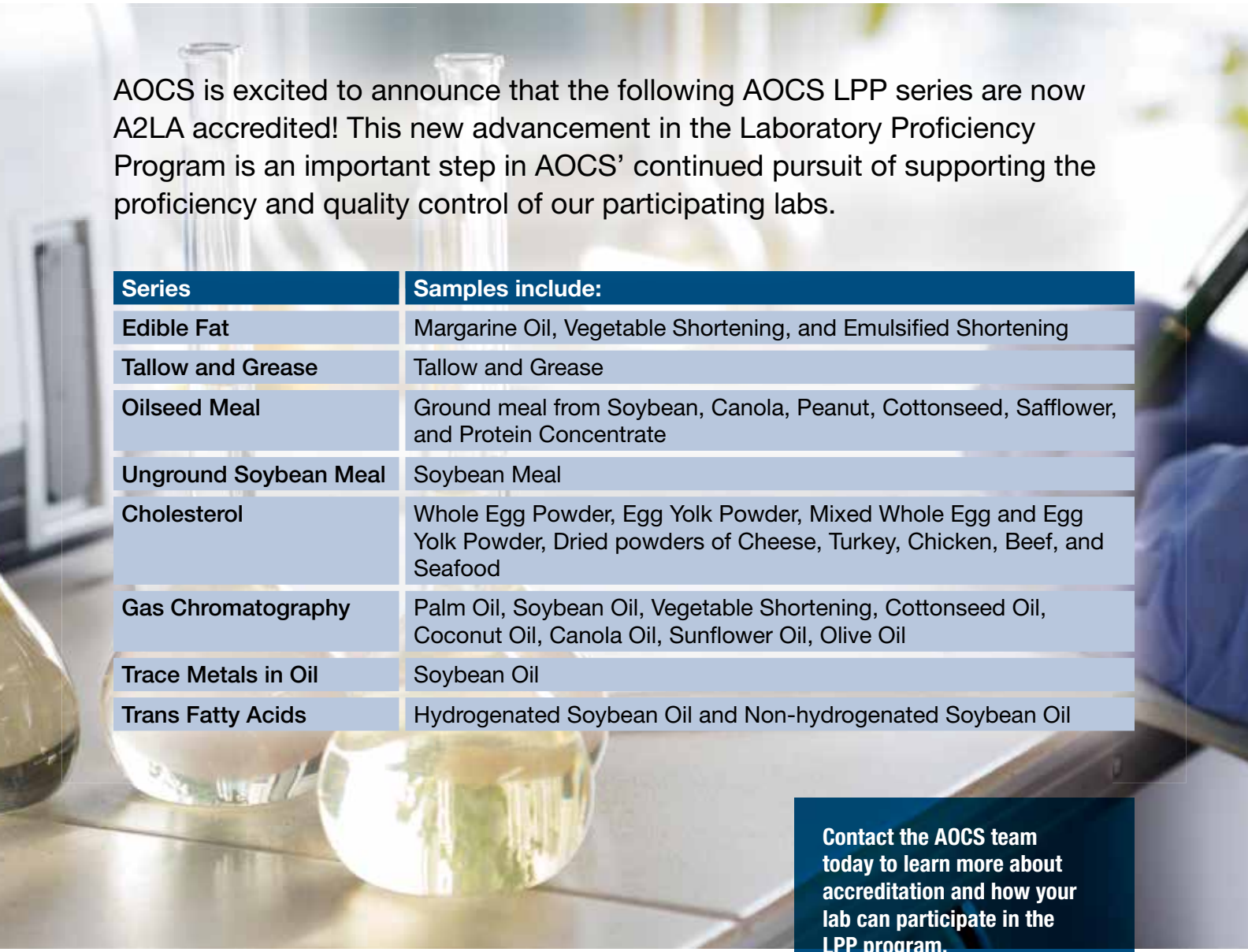

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sunflower wax, would increase the commercial value of this waste. A waste sample composed of 45.1% oily material (16.9% being impure waxes) was purified, characterized, and investigated for potential use as an organogelator agent. Purification was performed through two different methods. Three waxes with different degrees of purity were obtained. All were composed of wax esters with a range of 40–60 carbon atoms, exhibiting traces of carotenes, free fatty acids, and free fatty alcohols. Phospholipids were observed in two of them. The third wax presented a higher total wax ester content and physicochemical characteristics (color and thermal behavior) similar to those of commercial sunflower waxes. It was also the most efficient organogelator agent, requiring only a small amount of wax (1.5%) to structure high oleic sunflower oil. We verified that sunflower wax could be recovered from oil-tank settlings. A purification method that allowed sunflower wax with similar physicochemical properties to those of commercial waxes to be obtained was also developed. The purified waxes were capable of structuring high-oleic sunflower oil.

PRO ANA Comparison of oil extraction between screw press and solvent (n-hexane) extraction technique from beauty leaf (*Calophyllum inophyllum* L.) feedstock

Bhuiya, M.M.K., *et al.*, *Ind. Crops Prod. 144*: 112024, February 2020, https://doi.org/10.1016/j.indcrop.2019.112024.

An experimental investigation was conducted to evaluate the effects of the processing of the raw materials, such as preparation and extraction, grating (whole and grated), drying, and moisture conditioning of the seed kernels on the yield of oil extraction. Both mechanical and chemical methods were used to extract oil from the beauty leaf (BL) seed kernel using a screw press expeller and n-hexane as an oil solvent, respectively. Both whole kernel (WK) and grated kernel (GK) were used in screw press technique, whereas, only GK was used in n-hexane technique. The study indicated that the kernels prepared for 14.4 % moisture content (MC) produced the highest yield of oil in both methods. The highest oil yield of 86.4 % was obtained based on the weight of the kernel in n-hexane method for the GK. On the other hand, the oil yield of 78.0 and 72.1% was achieved using a screw press technique for the GK and WK, respectively. The gas chromatography (GC) analysis was conducted to determine the fatty acid compositions of beauty leaf oil. The physico-chemical properties of the beauty leaf oil (BLO) were evaluated. A comparison of fossil energy ratio (FER) was made between n-hexane and screw press methods. The FER in-hexane method was found 4.9, whereas, in screw press method it was found 3.4 and 3.1 for the GK and WK, respectively, which indicates that n-hexane method is more efficient than screw press technique. This study provides an understanding of the basis of selecting an appropriate oil extraction technique for oil extraction users in large-scale applications.

PRO Efficient degumming of crude canola oil using ultrafiltration membranes and bio-derived solvents

Abdellah, M.H., *et al.*, *Innov. Food Sci. Emerg. Technol. 59*, 102274, January 2020, https://doi.org/10.1016/j.ifset.2019.102274.

While hexane has been traditionally used for oilseed extraction, toxicity concerns are likely to restrict its industrial use in the future. This article provides information to engineers and food scientists on the use of terpenes as an alternative solvent. In particular, the potential for ultrafiltration to be used in degumming of canola oil/terpene mixture is assessed. This research shows that polymeric membranes are unlikely to be useful at scale in this application, as they are not readily cleaned for reuse. Conversely, a ceramic membrane of 5 kDa pore size provides the necessary rejection of phospholipids. There is some oil retention, that might require a downstream recovery step. The best results were obtained with cymene, suggesting this is a good target for industrial use.

Vegetable oils derived from rapeseed and its genetic variant canola, are conventionally extracted from oilseeds by means of an organic solvent, typically hexane. Concerns regarding the toxicity of hexane have meant safer and more environmentally friendly solvents, such as terpenes, are becoming attractive. In this research, the degumming of canola oil/terpene mixtures using ultrafiltration is considered as a critical step in such an extraction process. Polysulfone (PSF) and polyethersulfone (PES) membranes were found to be ineffective in this application, as the oil appeared to cause swelling of the membrane structure. This meant that the original flux could not be restored after cleaning. Conversely, a ceramic membrane (MWCO 5 kDa) provided stable behavior over several cycles of operation when cleaned with pure solvent at high cross-flow velocity at 40°C. This membrane showed high phospholipid retention (95 ± 2%), although some oil was also retained (16 ± 3%). Cymene emerged as the most attractive of the three terpenes tested, with higher permeate flux and phospholipid rejection than limonene or pinene.

Perspective

ANA Identifying fraudulent natural products: a perspective on the application of carbon-14 analysis

Gershon, H., *et al.*, *J. Agric. Food Chem. 67*: 13393–13399, 2019, https://doi.org/10.1021/acs.jafc.9b01821.

Carbon-14 analysis is a standard method used to determine naturalness of any organic material. It is based on carbon isotope C-14, which is detected in natural sources of carbon as compared to fossil sources of carbon, such as petroleum and its byproducts. It is helpful if applied in addition to more easily accessible methods, such as quantitatively tracing of standard metabolite(s).

This perspective highlights the application of carbon-14 analysis to screen for potential adulteration of natural ingredients, such as garlic oil. Carbon-14 testing determines if a product is comprised of solely plant- or animal-based ingredients by measuring the percentage of biomass versus petrochemical-derived sources. Through comparison to other analytical techniques used for quality control, carbon-14 testing stands out as being able to detect petrochemical-derived nature-identical compounds.

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