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Preserving emulsions with plant-based antioxidants

Rebecca Guenard

Saturated fats were once the preferred lipids for baked goods and other packaged foods. They are not easily oxidized, and their chemical stability means foods stay fresh longer. However, saturated fats have been linked to cardiovascular disease, diabetes, and certain cancers, and physicians recommend that we minimize our intake of saturated fats. Current dietary guidelines recommend substituting polyunsaturated fatty acids (PUFAs), particularly omega-3s.

- Food manufacturers are eager to develop functional foods by adding healthy polyunsaturated fatty acids to new products, but they must first develop a natural antioxidant capable of protecting the lipids in an emulsion.
- Researchers are using AI to help them more quickly identify protein peptides that can act as antioxidants.
- Synergistic phospholipids and phenolic compounds from plant extracts are other natural antioxidants researchers are exploring.

Consequently, formulators are eager to incorporate omega-3s into more food products, especially since studies show that western consumers do not get enough seafood in their diets. But unlike saturated fats, PUFAs are easily oxidized. The accumulation of harmful oxidation by-products, such as aldehydes and ketones, deteriorate the foods' taste, color, smell, or texture, leading to a shorter shelf life and increased waste. After decades of studying lipid oxidation, food chemists still face the challenge of protecting unsaturated lipids. With changing consumer preferences, the need for a solution grows particularly important.

"For many years, EDTA has been used as the preservative for emulsions," says Eric Decker, food science professor at the University of Massachusetts in Amherst, Massachusetts. "EDTA works great, but everyone is trying to get away from it."

Consumer demand for clean labels and a growing interest in functional foods are motivating experts to identify natural preservatives for emulsified systems to incorporate healthy lipids into everyday food products without increasing the risk of spoilage. A lipid emulsion represents a unique antioxidation challenge since the increased surface area of the droplets provides more sites to initiate decomposition. Researchers have made progress toward developing naturally sourced compounds that act as preservatives for emulsified lipids, but these compounds have physical and financial limitations. This article describes the latest approaches for preserving lipids in emulsified systems.

LIPID OXIDATION IN EMULSIFIED SYSTEMS

The fatty acid composition of an oil determines how susceptible the lipids are to oxidation. Lipids that are rich in polyunsaturated fatty acids, like omega-3s, are beneficial for health, but they are more prone to oxidation because of their unsaturated bonds. By preventing light, oxygen, or metals from initiating the reaction cascade that leads to the eventual breakdown of the fatty acid molecules, scientists can protect the vulnerable lipids from decomposition.

Lipid oxidation actually occurs faster in an emulsion than in a bulk oil. A lipid droplet surrounded by water-based solution, as in salad dressing and mayonnaise, is routinely under attack from dissolved oxygen and metals in the continuous phase. At the same time, hydroperoxides from inside the droplet also pose a threat. The trace amount of hydroperoxides that exists in the oils after refining migrate to the droplet interface and react to produce lipid radicals which initiate and propagate oxidation. This surface reactivity quickly leads to a breakdown of the lipids in the emulsion.

Scientists are eager to develop a means of protecting vulnerable PUFAs while still incorporating them into food. “Most people will agree the chemistry of oxidation of emulsions happens mostly at the water-oil droplet interface,” says Decker. “If you can change that interface in certain ways, you can slow down the oxidation.” A range of techniques have been attempted to engineer oil droplet surfaces and limit oxidation.

Casein and whey protein are popular oil-in-water emulsifiers due to their antioxidant properties, but they cannot be used in animal-free foods and researchers continue to search for plant-based options. (https://doi.org/10.1021/acs.jafc.8b02871). Lecithins are a complex mixture of polar lipids—such as phospholipids, glycolipids, and sphingolipids—and residual triacylglycerols produced as a by-product of oil refining. There is growing interest in using these polar lipids as emulsifiers given their natural source and antioxidant activity. Amphiphilic biopolymers extracted from botanicals are another natural ingredient used to stabilize oil-in-water emulsions. The size of these compounds allows room for both hydrophobic and hydrophilic regions that arrange at the inter-

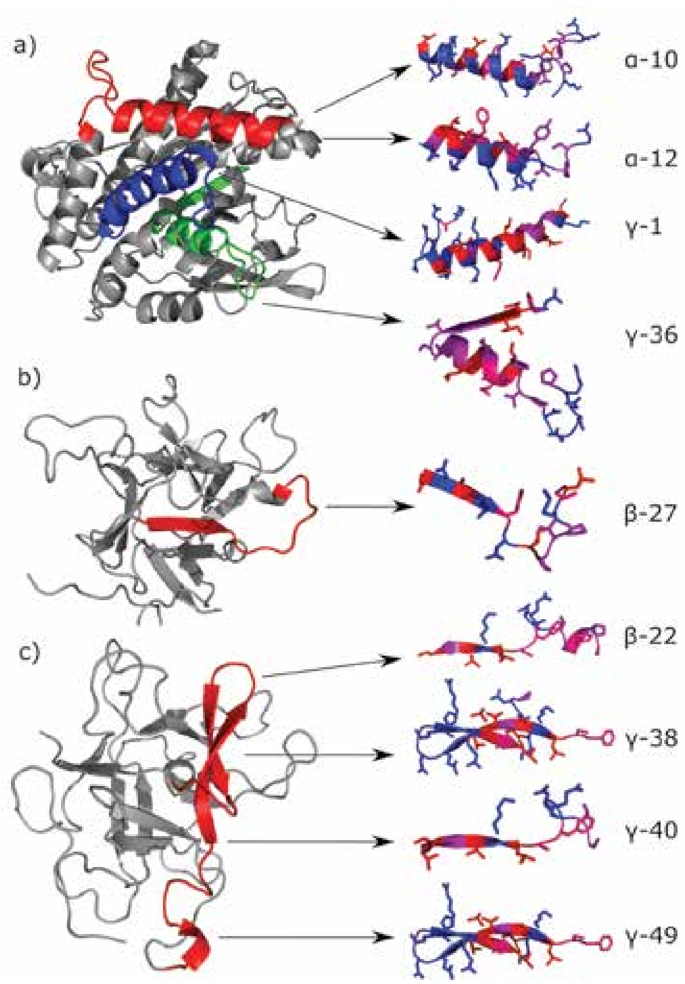

FIG. 1. Predicted emulsifier peptide-based models from the original potato juice proteins. A Danish research team is using the predictions from computer algorithms to quickly identify peptides that would function as antioxidizing emulsifiers.
Source: García-Moreno, P.J., *et al.*, S*ci. Rep., 10*, 690, 2020.

face and stabilize the mixture. Researchers are still searching for the right kind of molecules that will serve double duty to preserve the lipid by shielding it from oxidation.

HYDROLYZED PROTEINS

Corn gluten meal, sorghum, potato rapeseed, and canola have all been reported as good sources of enzymatically hydrolyzed proteins that possess antioxidant activity. The proteins are reduced to smaller amino acid chains when cut at peptide bonds. The bond cleavage unfolds the protein, improving its solubility and emulsifying capacity. Since the resulting peptides are less prone to conformational folding, reactive groups are available for scavenging free radicals and chelating iron.

Statistical modelling has determined that the effectiveness of the peptides resulting from the enzymatic hydrolysis of proteins depends on multiple factors: protein source, hydrolysis conditions, enzyme type, and emulsion pH. The trial and error associated with finding the optimal condition for an appropriate protein can be costly and time consuming. A research group from the Technical University of Denmark in Kongens Lyngby, Denmark, is developing machine learning algorithms to understand and then predict patterns of antioxidant activity in a peptide, by evaluating its amino acid sequence (https://doi.org/10.1038/s41598-020-78319-w).

Using similar technology, the research group first identified antioxidant active peptide sequences in proteins found in potato juice. By combining proteomics and bioinformatics, the team could quickly reveal the peptides with the molecular functionality needed to serve as a preservative and an emulsifier (https://doi.org/10.1038/s41598-019-57229-6). The computer algorithm highlighted 40 peptides that were likely candidates. Of those, the group tested the most active examples in a fish oil-in-water emulsion to see how well they protected its fatty acids. After successfully identifying functional peptides (Fig. 1), particularly in a food-processing waste stream like potato juice, the research team developed the machine-learning software that will hunt down useful peptides in a myriad of untapped sources.

If the tool is successful, finding proteins to use as antioxidants in emulsified systems will get easier. However, thus far protein hydrolysates work best at a neutral to high pH, while emulsified foods are typically acidic. So, scientists continue to search for other options.

POLYPHENOLS

A perennial succulent plant native to tropical areas of the world and used in the traditional medicine of several different cultures has recently shown promise as a possible antioxidant for fish oil-in-water emulsions. The polyphenolic compounds contained in the plants are known to exhibit pharmacological activity, such as inhibiting tumor development, bacteria growth, and inflammation. Phenolic compounds are known to scavenge free radicals and chelate metal ions, in addition to participating in other types of antioxidant reactions.

Last year, Pascual García-Pérez, a recent doctoral recipient at the University of Vigo, in Vigo, Spain, along with a team of collaborators, developed a plant extract from the genus *Bryophyllum* to test its antioxidant capabilities in a fish oil-in-water emulsion (https://doi.org/10.3390/plants9081012). "The methodology is working quite well," says García-Pérez.

Polyphenols are synthesized by plants as a result of secondary metabolism. Such compounds are not typically involved in the plant's growth and often function as a way for the plant to defend itself against stress. As such, they do not exist in large concentrations in the plant. García-Pérez used a biotechnology technique, known as plant tissue culture, to grow *Bryophyllum* extracts obtained from the plant (Fig. 2).

After acquiring a sufficient amount of plant extract, the group analyzed its effectiveness for minimizing oxidation within the emulsion. Using a simple binary system of fish oil and water, they first determined that the phenolic compounds would partition as necessary between the two phases. García-Pérez says they were surprised by how well the extract dissolved in both phases, giving them confidence it would reside at the interface of an emulsion. After adding a surfactant and producing an emulsion, they found that the oxidative stability of the emulsion increased with greater *Bryophyllum* extract

FIG. 2. A Bryophyllum plant. Researchers in Spain have cultured tissue from the plant and studied its potential as a natural preservative.
Source: Wikimedia Commons

concentration. Finally, they evaluated a range of emulsion compositions, pHs, and temperatures to determine conditions where the extract worked most effectively.

"We saw that the application of the antioxidants caused a delay in the accumulation of conjugate dienes which are a by-product formed after omega-3 oxidation." García-Pérez says.

García-Pérez acknowledges that although they are encouraging, the experiments his team performed are preliminary. The researchers plan to identify the particular polyphenols within the plant extract that act as antioxidants in the emulsion, as well as their distribution between lipid and aqueous regions. The team will also determine if there are any compounds in the extracts that create synergistic activity—in other words, compounds that restore an antioxidant's reactivity after it has been depleted.

"It is essential to develop several strategies to prevent oxidation while also taking into account the current consumer demand on food naturalness," says García-Pérez.

TOCOPHEROLS

Another strategy under development is amplifying the lipid's own natural protection system. The antioxidant compounds, tocopherols, occur naturally in vegetable oils. Their protective ability is limited, however, and the Decker group is investigating ways to extend it by combining the tocopherols with other antioxidants. The researchers have proved that phosphatidylethanolamine (PE) and phosphatidylserine (PS), phospholipids found in lecithin, regenerate tocopherol's oxidizing potential (https://doi.org/10.1021/acs.jafc.8b00677).

Tocopherols are amphipathic molecules with hydrophobic side chains extending from aromatic rings. They exist in different forms depending on the number and position of methyl groups in the ring. A molecule's form determines its surface activity and thus its effectiveness at acting as an antioxidant in an emulsion. Earlier research showed that the delta-tocopherol is more surface active than alpha-tocopherol. The team combined these two forms with the two phospholipids in different combinations and evaluated whether synergistic antioxidant activity resulted.

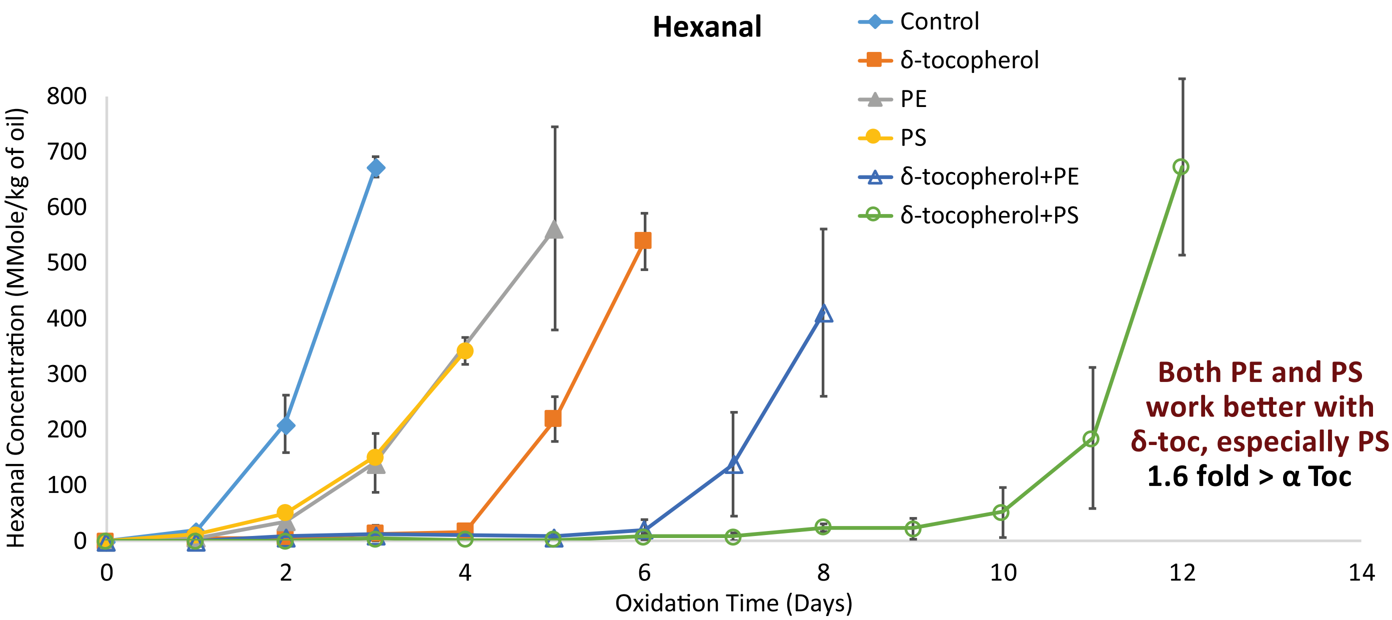

FIG. 3. Stripped soybean oil-in-water emulsions mixed with different combinations of the delta-tocopherol and phospholipids. A synergistic activity is observed with delays formation of lipid oxidation products. Source: Samdani, G. K., *et al., J. Agric. Food Chem., 66*, 3939, 2018.

"We found that these phospholipids are effective when combined with tocopherols and can sometimes triple the shelf life compared to tocopherol alone," says Decker. The formation of lipid oxidation products, hydroperoxide and hexanal, was delayed by nearly a week when the tocopherols were mixed with phosphatidylserine. Since it is more polar, the delta-tocopherol form combined with PS was especially effective at preserving lipids in an emulsion (Fig. 3), but alpha- and mixed tocopherols also worked well.

Though these results are encouraging, PE and PS are currently too expensive to use as food additives, and commercial lecithin contains a low quantity of the two phospholipids. The research team is working on enzymatically modifying lecithin to increase its PE and PS content. Preliminary experiments show that lecithin modified to have higher PE concentration can synergistically interact with naturally occurring tocopherols in refined oils and increase oxidative stability.

Cost continues to be the greatest challenge for developing natural antioxidants for a variety of food systems. Decker says he regularly preaches to companies that they should view natural preservatives in an emulsion as a set of hurdles. "If you add one barrier you get a certain amount of oxidative protection and when you add a second, distinct barrier the lipids get even more stable. And then you add a third mechanism and so on," he says. Putting all those hurdles in place can increase the guarantee on freshness, but it comes at a cost. In addition, more additives are counter to consumer demand and complicate manufacturing the food at the plant.

Until researchers can find one natural preservative that can do the job of many, food manufactures will have to continue relying on EDTA. Decker says it is still the prominent preservative for most commercial emulsions. "It has no flavor. It is super cheap and super effective," he says. "It is really hard to replace."

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

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Developments in green surfactants for enhanced oil recovery

Raj Shah and John Caledron

- Scientists are developing improved surfactants for enhanced oil extraction that have superior capabilities while being environmentally friendly and capable of strong operational tolerances to pH, salinity, and temperature.
- In laboratory tests, numerous green surfactants synthesized from vegetable oils and other plant-based materials matched or exceeded the capabilities of conventional synthetic surfactants.
- Plant-based zwitterionic surfactants are reported to have strong interfacial reduction values and operational tolerances.

MORE INFORMED

POSTER SUMMARY

A poster summary of this topic with additional figures and graphics is available at bit.ly/green-surfactants-poster.

Despite the continuing development of sustainable sources of energy, crude oil and natural gas resources remain crucial elements of the international economy. The oil and natural gas exploration industry alone is worth $86 trillion and represents 3.8% of the global economy [1]. With global petroleum and liquid fuel demand continually increasing and production set to reach 99.71 million barrels per day by 2021, improving the efficiency of extraction from existing natural reserves of petroleum is of utmost importance as the world gradually transitions away from fossil fuels to more sustainable sources [2]. Toward that end, enhanced oil recovery (EOR) techniques have been developed and are used to minimize the amount of crude oil and petroleum that is left behind in underground reservoirs from conventional drilling extraction methods.

EOR, also known as tertiary oil recovery, follows the primary and secondary production stages of conventional oil extraction. These first two stages use the initial pressure energy stored in the reservoir to extract the oil (primary), then water or specialized gases to maintain pressure for a secondary extraction (secondary), ultimately yielding a total oil recovery of 40–60% [3]. A significant amount of remaining oil is trapped within the reservoir due to capillary forces that can vary depending on the type of rock structure, porosity, temperature, and other factors. EOR is used to overcome these capillary forces and increase recovery yields through a multitude of methods which can generally be classified into thermal, non-thermal, and microbial techniques [3,4]. The most commonly used and well understood EOR technique is thermal EOR (TEOR). This typically involves the injection of steam within the reservoir to increase the temperature of the well, subsequently reducing the viscosity of the oil and improving the flow of oil toward extraction sites. TEOR techniques account for approximately 40% of EOR wells in the United States. They are most commonly used in the extraction of heavy oil reservoirs but are not suitable for reservoirs involving the great depths and thin pay zones found in more mature reservoirs [4,5]. For these situations, non-TEOR techniques such as chemical EOR are more economical.

Chemical EOR (CEOR) techniques, used since the 1980s, are non-thermal EOR techniques that use the injection of water-soluble chemical agents, such as polymers, surfactants, alkalis, or a mixture of all three (Fig. 1). These agents can be mixed with water used during the secondary stage of extraction or as an addi-

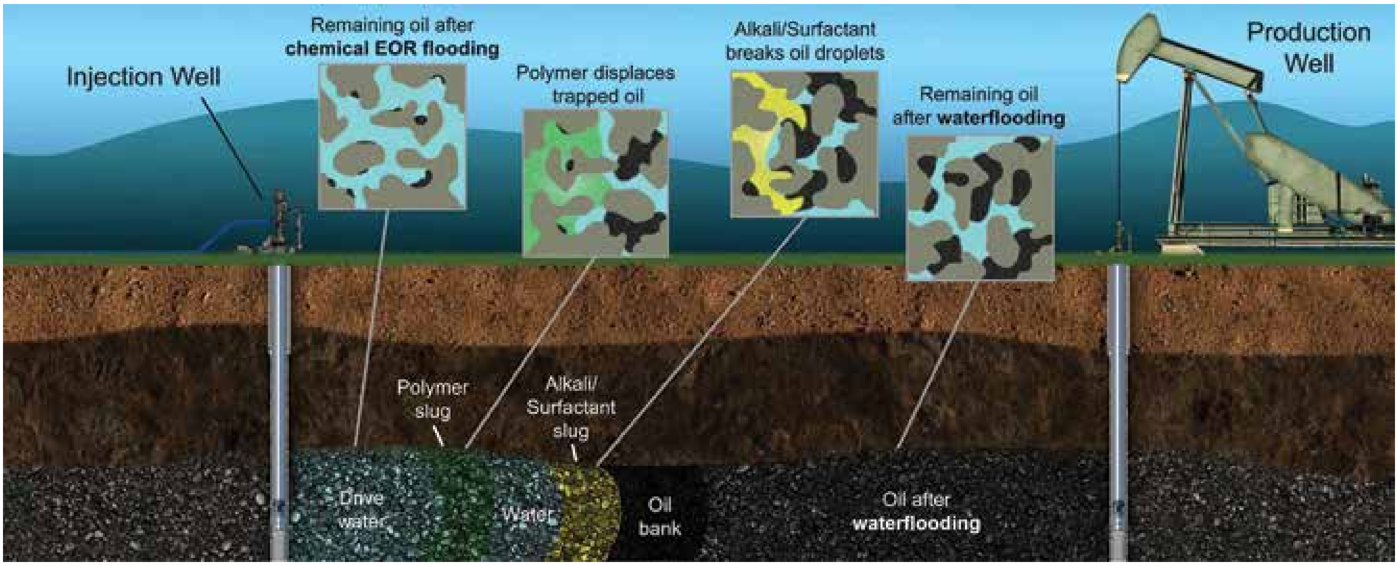


FIG.1. Schematic of chemical enhanced oil extraction (CEOR). Republished with permission from Chemical enhanced oil recovery and the role of chemical product design, P. Druetta, *et al.*, *Applied Energy 252*: 15 October 2019, 113480.

tional tertiary stage, with each type of chemical agent improving net oil recovery through different mechanisms. Polymers increase the viscosity of the aqueous phase, thereby improving the ability of the solution to push oil out of pores on a macroscopic scale. Surfactants reduce the interfacial tension (IFT) between the oil and water solution, allowing greater microscopic displacement of oil through the formation of oil-water emulsions. Finally, alkalis react with acidic components in crude oil to form natural surfactants that reduce IFT in the same manner as synthetic surfactants [7,8]. These agents can be used individually or in combination, depending on geological and economic factors. Multiple CEOR projects have been successfully established internationally, but today CEOR is limited by high upfront capital and material costs, loss of surfactant/polymer due to adhesion to reservoir rock beds, and significant concern over the environmental impact of the chemicals that are used.

In the United States, EOR well operations are monitored and regulated by the US Environmental Protection Agency (EPA) through the Underground Injection Control Program (UIC), established in 1980 as a way to safeguard underground drinking water sources protected under the Federal Safe Drinking Water Act passed in 1974. All EOR operations fall under class II well designations for oil and gas recovery under the UIC and must meet minimum requirements to obtain and keep permits for well operation [4]. With oil demand continuing to rise and oil reservoirs maturing over time, the use of CEOR is expected to expand, and with it, the importance of using effective surfactants that are as environmentally friendly as possible.

HOW CEOR SURFACTANTS WORK

CEOR surfactants reduce interfacial tension (IFT) between the oil and water solution to enable greater mobility. This interaction arises from the amphiphilic nature of surfactants, which allows them to be soluble in both water and organic solvents [7]. Surfactants have a hydrophilic head and hydrophobic tail that work together to adsorb onto the oil/water interface. This reduces IFT and weakens the capillary forces trapping the oil within rock pores. A separate interaction known as wettability alteration can occur simultaneously and further improve oil recovery. Wettability alteration alters the contact angle of oil on the rock surface from an “oil-wet” state (contact angle > 90°) to a “water-wet” state (< 90°) through desorption caused by the surfactant. The end result is a similar weakening of the capillary forces holding the oil in place and a corresponding increase in oil recovery. A visual representation of both mechanisms on an oil reservoir is depicted in Figure 2 [10].

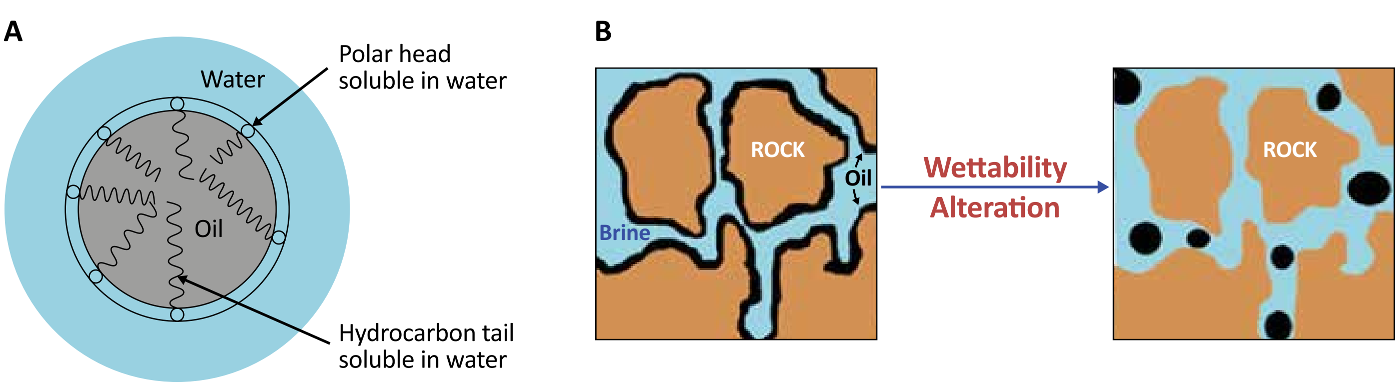


FIG. 2. a) Visual depiction of IFT reduction through adsorption of surfactant on oil-water interface. b) Effect of wettability alteration on oil [10]

The surfactants used to activate these mechanisms can be classified into four major classes: anionic, cationic, non-ionic, and zwitterionic. These classes refer to the charge on the hydrophilic head, with anionic surfactants having a negative charge, cationic having a positive charge, non-ionic having no charge, and zwitterionic having both a negative and positive charge. Each type of surfactant has its own advantages and disadvantages. Anionic surfactants are the most commonly used due to their effective wettability alteration and IFT reduction. Cationic surfactants are particularly effective for carbonate rocks and clays but are more expensive than anionic surfactants. They are also unsuitable for sandstone due to strong adsorption onto the rock surface caused by the opposite charge of the rock. Non-ionic surfactants exhibit high tolerance to salinity and hardness but are less effective for IFT reduction. Zwitterionic surfactants, which are relatively new and less explored, combine the useful properties of anionic and cationic surfactants with high temperature, salt, and pH tolerance [7,10].

As a result of these inherent advantages and disadvantages, the operational conditions of the reservoir (rock type, salinity, temperature, etc.) have a significant impact on the type of surfactant used and, thus, the chemical structure of the surfactant. In general, carboxylates, sulphates, or sulphonates produce the surface-active negatively charged head in anionic surfactants, while non-ionic surfactants tend to utilize alcohols, such as the NEODOL compound and its derivatives developed by Shell researchers [11]. Cationic surfactants include bromide and chloride derivatives, while past investigations have used betaines to create the less-explored zwitterionic surfactants [10,11]. Choosing specific chemical groups can further alter properties, such as salinity and temperature resistance as well as compatibility with other chemicals, as occurs in Surfactant-Polymer (SP) or Alkali-Surfactant-Polymer (ASP) wells. Several examples of surfactants that have been investigated/used of each type alongside their chemical structures are shown in Table 1 [10].

GREEN SURFACTANTS

Although current synthetic surfactants provide an excellent range of capabilities for IFT reduction, wettability alteration, and operational tolerances, the cost-to-performance scalability for oil well operations is still too small for practical applications outside of mature and/or thin pay zone oil reservoirs. Adsorption of the surfactant onto the rock material results in loss of active surfactant and increases costs. These challenges, along with growing environmental concerns, signal the need to develop surfactants with superior IFT reduction and wettability alteration that are also environmentally friendly and non-toxic. Early investigations by Saeed Majidaeie, *et al.*, in 2011, found that Methyl Ester Sulfonates (MES) synthesized using *Jatropha curcas* oil as feedstock were capable of reducing the IFT of a solution of itself and oil from the Dulang oilfield to 0.078 mN/m with a concentration of 0.25% by weight. This is an acceptable concentration for surfactant CEOR operations and illustrates the potential of using vegetable oils as alternative feedstocks [12]. Since then, numerous investigations of

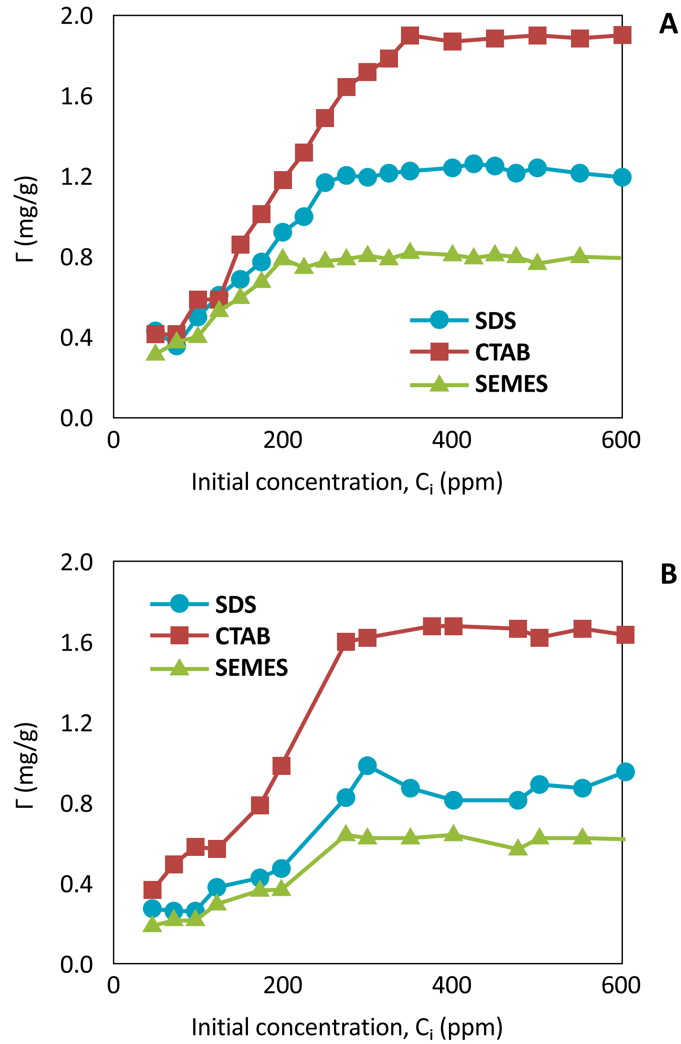
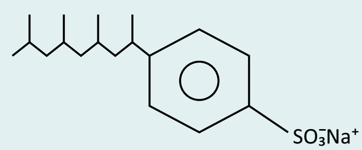


FIG. 3. Adsorption densities of SDS, CTAB, and SEMES surfactants on (a) kaolin clay absorbent and (b) ilmenite adsorbent [13]

green surfactants developed from vegetable oils and other natural sources have observed strong IFT reduction, wettability alteration, and operational tolerance performances.

In nearly every case, these investigations take advantage of the unsaturated fatty acids or lignin that constitute many vegetables and plant sources to synthesize an effective surfactant for CEOR. With regard to surfactant adsorption, in 2016, Ademola M. Rabiu, Samya Elias and Oluwaseun Oyekola synthesized a sodium epoxidized methyl ester sulfonate (SEMES) from waste vegetable oil and compared its performance to common commercially used synthetic surfactants like sodium dodecylsulfate (SDS) and cetyltrimethyl-ammonium bromide (CTAB) across several rock types: kaolin clay, ilmenite, silica, and alumina. Adsorption measurements in terms of adsorption density (mg of surfactant/g of adsorbent) found that SEMES showed lower adsorption density compared to SDS (an anionic surfactant) and CTAB (a cationic surfactant) on kaolin clay and ilmenite absorbents, shows the adsorption densities across a range of initial concentrations (Fig. 3), indicating the strong oil recovery efficiency of the SEMES surfactant and subsequent potential for lower costs [13].

TABLE 1. Examples of previously investigated surfactants and their corresponding chemical structure for each type of surfactant [10]

Surfactant type	Examples	Structures
Anionic	Sodium dodecylbenzene sulfonate	$CH_3(CH_2)_{11}C_6H_4SO_3^-Na^+$
	Sodium dodecyl sulphate (SDS)	$CH_3(CH_2)_{11}SO_4^-Na^+$
	Sodium stearate	$CH_3(CH_2)_{16}COO^-Na^+$
	N-Ethoxy sulfonate	$H(OCH_2CH_2)_n\text{–}O\text{–}SO_2\text{–}R$
	Alcohol propoxy sulphate (APS)	$ROH\text{–}[CH_2\text{–}CHO\text{–}CH_3]_x\text{–}SO_3^-Na^+$ $R = 16\text{–}17$, $x = 7$
	Alpha-Olefin sulfonate (AOS)	$R\text{–}CH{=}CH\text{–}(CH_2)_n\text{–}SO_3Na$ $R = C_{10}\text{–}C_{20}$ $n = 10\text{–}20$
	Alkyl polyalkoxy alkyl sulfonate or alkyl aryl polyalkoxy alkyl sulfonate	$RO(R'O)_nR''SO_3^-\ M^+$ $R = C_8\text{–}C_{24}$ R' = ethyl or a mixture of ethyl and propyl R'' = Ethyl, propyl, hydroxypropyl, or butyl n = integer from 1 to 20, preferably from 2 to 8 M^+ = monovalent cation such as NH4$^+$, Na^+, K^+
	Branched alkyl benzene sulfonate	
	Docusate sodium	$C_{20}H_{37}NaO_7S$
	Guerbet alkoxy sulphate	$C_nH_{2n+1}O\text{–}PO_x\text{–}EO_y\text{–}SO_3^{o-}$ n = is an integer between 12 and 44 x = is an integer between 0 and 50 y = is an integer between 0 and 100
	Sulfonated, ethoxylated alcohol or alkyl phenol	$RO(CH_2)(CH_2)_xCH_2CH_2SO_3^-M^+$ M^+ = monovalent cation such as NH4$^+$, Na^+, and K^+
	Alkyl alcohol propoxylated sulphate	$R\text{–}(OHCH_2CH_2CH_2)_nO\ SO_3^{o-}M^+$ M^+ = monovalent cation such as NH4$^+$, Na^+, and K^+
Nonionic	Polyoxyethylene alcohol	$C_nH_{2n+1}(OCH_2CH_2)_m\ OH$, where $n = 8\text{–}18$; $m = 3\text{–}15$
	Alkylphenol ethoxylate	$C_{19}H_{19}C_6H_4\text{–}(OCH_2CH_2)_n\ OH$ $n = 5\text{–}10$
	NEODOL	$RO(CH_2CH_2O)_x\ CH_2COO^-M^+$ $R = C_8\text{–}C_{18}$ $x = 1\text{–}15$ M = alkali or alkaline earth metal
	NEODOL ethoxylate 91-8	$RO\text{–}(CH_2CH_2O)_n\text{–}H$ R = blend of C9, C10, and C11 alcohol n = integer from 1 to 20, an average number of 8
	NEODOL 67 propoxylated sulphate (N67-7POS)	$RO\text{–}(OHCH_2CH_2CH_2)_n\text{–}O\text{–}SO_3^{o-}M^+$, where R = blend of C16 and C17 alcohols n = integer from 1 to 20 with an average number of 7
	Synperonic PE/F68	$HO\text{–}(C_2H_4O)_m\text{–}(C_3H_6O)_n\text{–}H$, where n = integer from 1 to 20 and preferably 2 to 8 M^+ = monovalent cation such as NH4$^+$, Na^+, and K^+
Cationic	Cetyl trimethyl ammonium bromide (CTAB)	$CH_3(CH_2)_{15}N^+(CH_3)_3Br^-$
	Laurylamine hydrochloride	$CH_3(CH_2)_{11}NH_3^+Cl^-$
	Dodecyl trimethyl ammonium bromide (DTAB)	$C_{12}H_{25}N^+(CH_3)_3Br^-$
Zwitterionic	Dodecyl betaine	$C_{12}H_{25}N^+(CH_3)_2CH_2COO^-$
	Lauramidopropyl betaine	$C_{11}H_{25}CONH(CH_2)_3N^+(CH_3)_2CH_2COO^-$
	Cocoamido-2-hydroxypropyl sulfo betaine	$C_nH_{2n+1}CONH(CH_2)_3N^+(CH_3)_2CH_2CH(OH)CH_2SO_3^-$

Investigations into other plant-based sources have yielded similar promising results in a multitude of other areas as well. A surfactant synthesized from oil palm empty fruit bunches showed sufficiently low IFT of 0.204 mN/M with 1% concentration and strong thermal stability across 3 months. IFT values ranged between 0.204 mN/M and 0.125 mN/M with clear froth formation for oil separation [14]. An oil recovery study performed by Kevin Woe, *et al.*, using a non-ionic surfactant also derived from palm oil found oil recovery values of up to 78.07% and IFT values as low as 2.08 x 10^{-3} dyne/cm; a spontaneous imbibition test at a reservoir temperature of 60°C and a concentration of 0.3% showed strong oil recovery potential at optimal conditions [15]. Perhaps one of the most promising endeavors comes from a zwitterionic surfactant dubbed CPDB synthesized from castor oil by Zhang, *et al.*, in 2015 [16]. IFT measurements were performed against crude oil derived from the Daqing oil field at a range of pH (3–12) and salinity (5,318–12,223 mg/L) conditions to simulate performance against Shengli, Xinjiang, and Huabei crude oils. The synthesized surfactant achieved an extremely low interfacial tension of 5.3 x 10^{-3} mN/m against Daqing crude oil without any extra alkali at a concentration of 0.010 g/L while maintaining strong thermal stability and salinity/pH resistance [16]. Such strong performance merits further exploration of the capability of naturally derived zwitterionic surfactants and other castor oil surfactants.

As demand for oil continues to grow alongside energy demands, many maturing oil fields will require enhanced oil recovery techniques like CEOR to adequately provide stable supply. Countries with mature oil fields, such as the United States and Singapore, have invested efforts into developing improved surfactants. Continued development of green surfactants for CEOR will achieve greater yields with minimal environmental harm to support the world economy as it transitions to alternative energy sources for a more sustainable future.

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John Caledron is a chemical engineering student from Stony Brook University, where Shah is the Chair of the external advisory board of directors. John is also part of a thriving internship program at Koehler instrument Company.

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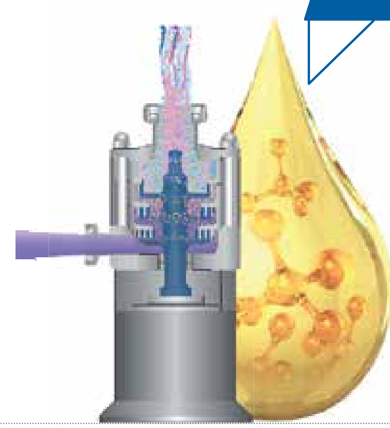

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Lauric fats from the Brazilian Amazon: babassu and murumuru

Larissa Magalhães Grimaldi, Kamila Ramponi Rodrigues de Godoi, Fernanda Luisa Lüdtke, Thais Jordânia Silva, Mayanny Gomes da Silva, Renato Grimaldi, and Ana Paula Badan Ribeiro

The babassu palm (*Orbignya phalerata*), which originated in Brazil, is found in the Amazon and Atlantic Forest regions. Its growth is spontaneous: Each palm can produce up to 2,000 fruits annually. Figure 1 shows the babassu fruit (Rosa, 1986; Bezerra, 1999).

- **Babassu and murumuru palms are both sources of lauric acid.**
- **Due to their high oxidative stability and well-defined melting points, fats from both plants are widely used in the cosmetic industry and in the preparation of specialty fats for confectionery, ice cream, margarines, and cocoa butter substitutes.**
- **This article reviews the compositions and physicochemical properties of these exotic fats.**

The murumuru palm is found throughout the Amazon rainforest, mainly in humid and temporarily flooded areas, close to lakes and rivers, and sometimes in numerous forms. Its fruits have a high economic value. Murumuru fruit is shown in Figure 2 (Altman, 1958; Queiroz, *et al*., 2007).

Babassu and murumuru fats are sources of lauric acid and important to industry since they are resistant to oxidation and, unlike other saturated fats, have a low and well-defined melting point. Both are widely used in the cosmetic industry and due to their specific physical properties and high oxidative stability, used in the preparation of special fats for confectionery, ice cream, margarines, and cocoa butter substitutes (Soares, Franco, 1990; Robinson, 1991; Haumann, 1992; Lawson, 1995). Table 1 shows the fatty acid composition of babassu and murumuru fats.

Babassu fat is mainly comprised of lauric acid (44.63%), myristic acid (16.53%), and oleic acids (13.27%). Murumuru is primarily comprised by the same fatty acids, but in different percentages: 47.69%, 28.46%, and 7.38% respectively, indicating a fat with low melting point and, consequently, rapid metabolic absorption.

The triacylglycerol composition of babassu includes groups C26 to C60, with groups C36 and C38 being the majority. Murumuru fat includes groups from C32 to C54, with the majority also in groups C36 and C38.

The fat solids profile is an important characteristic for evaluating possible applications. Figure 3 shows the solid profile of babassu and murumuru fats.

FIG. 1. Babassu fruit

FIG. 2. Murumuru fruit

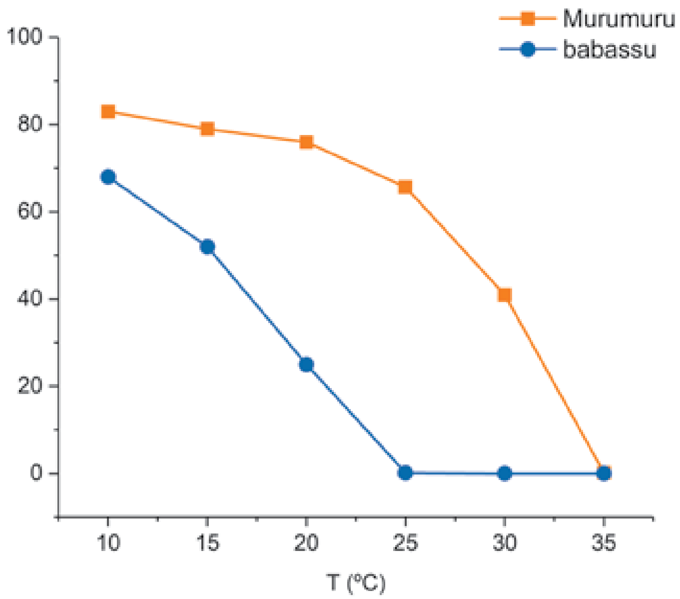

FIG. 3. Solid profiles of babassu and murumuru fats

Ramli, *et al.* (2005), analyzed the solid fat content (SFC) of fully hydrogenated palm kernel oil, also from a lauric source, which showed that the SFC started to decrease at 15°C. According to Timms (1979), this profile could be explained by the existence of a wide range of triacylglycerols. Despite their high saturated fatty acid content, babassu and murumuru fats, while rich in medium-chain fatty acids, do not induce crystallization at room temperature. In this study, babassu fat had an induction time of 60 minutes at 15°C, with a maximum solids content of

TABLE 1. Fatty acid compositions of babassu and murumuru fats

Fatty acid (%)	Babassu	Murumuru
Caproic acid (C6:0)	0.31	0.11
Caprylic acid (C8:0)	4.93	1.30
Capric acid (C10: 0)	5.22	1.36
Lauric acid (C12: 0)	44.60	47.69
Myristic acid (C14: 0)	16.52	28.46
Palmitic acid (C16: 0)	8.99	6.99
Stearic acid (C18: 0)	3.83	3.02
Oleic acid (C18: 1)	13.26	7.38
Linoleic acid (C18: 2)	2.19	3.44
Arachidic acid (C20: 0)	0.05	0.13
Gadoleic acid (C20: 1)	0.05	0.05
Behenic acid (C22: 0)	0.06	0.07
Σ saturated	84.50	89.13
Σ unsaturated	15.50	10.87

7.2%; while murumuru fat had an induction time of 16 minutes with a maximum solids content of 67.8%. While babassu has a melting point of around 24°C, murumuru becomes liquid around 35°C, considering 4% SFC (Karabulut, *et al.*, 2004).

With respect to thermal behavior, babassu fat showed low initial crystallization (5.28°C) and melting temperatures (4.55°C). The parameters for murumuru were 16.5°C and 17.57°C, respectively. These differences can be explained by each fat's major chain fatty acid compositions.

As shown by X-ray diffraction analysis, the beta polymorphic form—which is known for its high thermal stability, high melting point and hardness, and suitability for use with cocoa butter and in chocolates—is predominant in both babassu fat and fully hydrogenated palm kernel oil. In contrast, the beta' polymorphic form, which is characterized by less rigid crystals, was predominant in murumuru fat.

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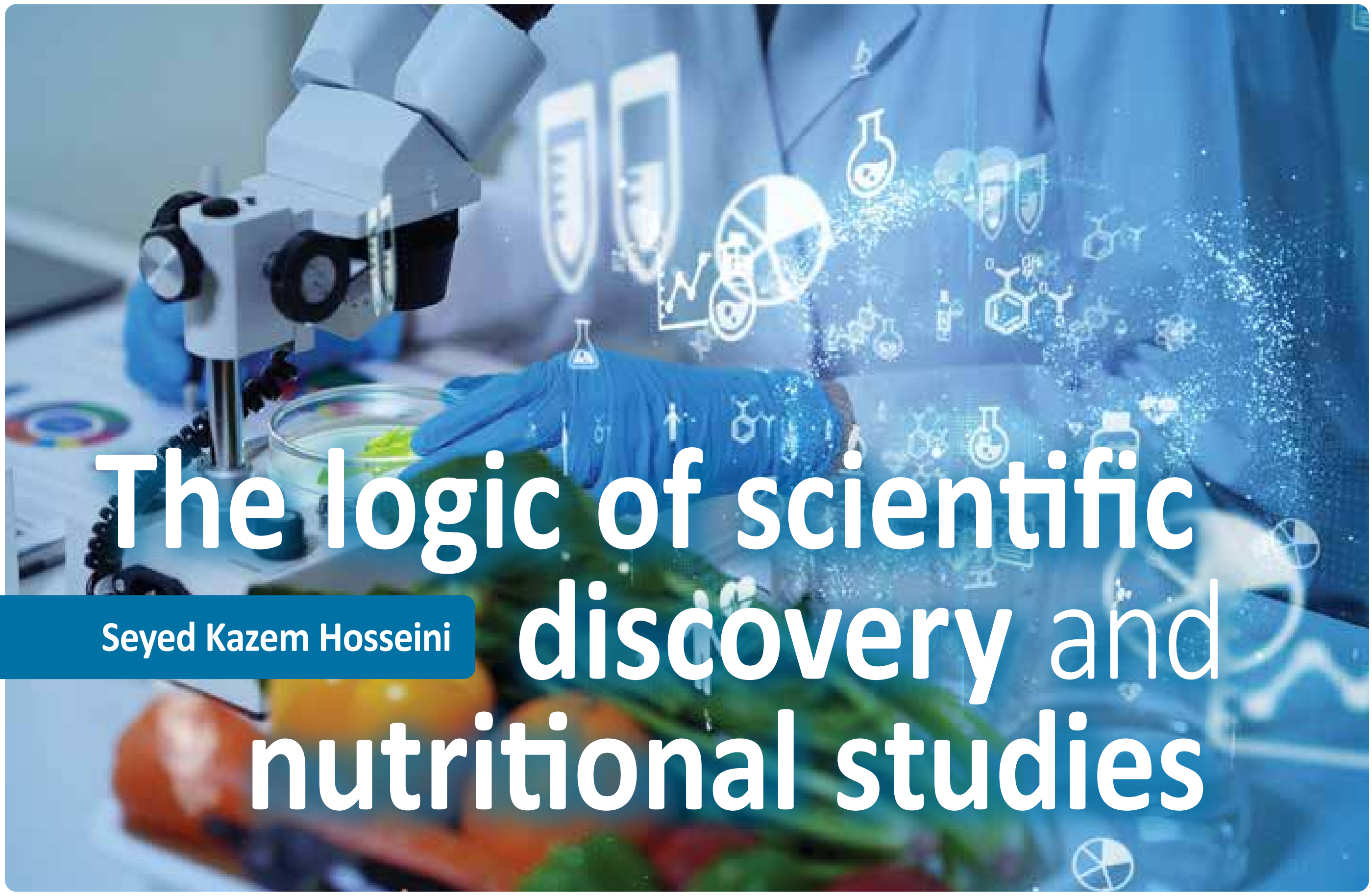

The logic of scientific discovery and nutritional studies

Seyed Kazem Hosseini

- **Contradictions and even opposing theories are not that unusual in science, but the increasing number of disagreements with respect to nutrition is confusing even for specialists and experts, let alone the general public.**
- **Without clear and consistent conclusions and recommendations from experts, the general public is more likely to fall for unscientific or exteme "nutrition" advice from less scrupulous sources.**
- **This article examines the reasons why nutrition studies result in so many contradictory conclusions.**

It is not that unusual in different fields of science to find contradictions or opposing viewpoints, but when it comes to nutrition studies, the increasing number of disagreements is enough to make one wonder why. Many articles have been written about the causes for these contradictions, the main ones being:

- The conditions under which a study is carried out are highly specific. Participants in the experiments must follow highly controlled diets and strictly adhere to predetermined plans, while what happens in the real world is vastly different than the restricted conditions of these study designs (1).
- Most nutrition theories and advice is derived from reports of dietary trials which neglect the documentations and disease records of the participants and medications they take. Such reports are often based on inaccurate information provided by the study participants and lack the painstaking attention that is needed (2).
- Contradictions arise from genetic characteristics of individuals. Accordingly, genetic differences can justify the variety of effects a single diet can have on different people (3).
- Most studies, opinions, and advice in the field of nutrition are not placed in the framework of the logic of scientific discoveries.

THE LOGIC OF SCIENTIFIC DISCOVERY

In *The Logic of Scientific Discovery*, first published in 1959, Karl Popper, one of the most influential philosophers of science in the 20th Century, outlined a procedure for distinguishing scientific theory from unscientific opinion. Although other scholars have since proposed specific criteria, Popper's procedure for differentiating scientific from unscientific comments is still considered to be the most reliable reference. In his book, Popper proposed that a scientific theory should contain four main characteristics (4).

- *It is always trustworthy*. Scientific theories and laws are widely applicable and use words such as "always", "every", "all", "none", and so on. Well-known examples of trustworthy scientific statements include the law of reflection in which the angle of incidence is equal to the angle of reflection, and Boyle's law, which states that for any ideal gas at constant temperature, pressure multiplied by volume is always a constant value. Even statistical laws have such a logical generality. For instance, saying that "cholera vaccine is effective in 75% of cases" implies that under normal conditions, whenever and wherever the vaccine is used, 75% of the people who are vaccinated will not get cholera.
- *It can predict events that will consequently happen*. The law of reflection states that when a ray of light hits a surface at a particular angle, it will be reflected at the same angle. If you mix 39.99 gm of sodium hydroxide with 36.46 gm of hydrochloric acid, they will form 58.44 gm of sodium chloride and 18 gm of water. Similarly, if there is not enough insulin in a your body, your blood sugars will be elevated, and a calcium deficiency will result in osteoporosis.
- *It can be disproved*. It is always possible to reject scientific theories based on new evidence. Statements which cannot be validated are not scientific. The more falsifiable a rule is, the more easily it can be disproved or validated through experiment (5).
- *It explains only one aspect of phenomena*. Just as there are different scientific explanations for the solubility, hydrogen bonds, and boiling and freezing points of water, there should be different scientific explanations for the fatty acids, melting point, hydrolysis, and energy production of lipids.

APPLYING THE LOGIC OF SCIENTIFIC DISCOVERY TO NUTRITION

If you apply Popper's logic of scientific discovery to nutrition studies, you will find that many are not that scientific.

Trustworthiness

Nutritional studies based on chemical and biochemical studies of well-known mechanisms in the human body are highly trustworthy and leave little doubt about the accuracy of the research, reliability of the results, and predictability of their effects. The interrelation between Vitamin C deficiency and scurvy that was first revealed by a study conducted in 1747, has been verified many times over and is highly trustworthy, as have the consequences of vitamin A deficiency and the link between calcium deficiency and osteoporosis (6).

However, another group of studies in the nutrition field are more in number but lack the accuracy and predictability of the first group. They are the main source of contradictions and doubts in the field of nutrition.

For instance, one of the first studies on fats and oils (7) explored the interrelation between saturated fatty acids (SFA) and increased level of low-density lipoprotein (LDL) cholesterol. Even at the time, the results were not definite enough to be broadly applicable, yet the study became the basis for the assumption that saturated fatty acids increase LDL—even though decreasing SFA intake reduced LDL levels in only 55% of the male participants. Decreasing SFA actually elevated LDL levels in 3% of the male participants, and no changes in LDL levels were observed in the rest of the male participants. The results were even less conclusive for females: LDL levels decreased in 39% and increased in 13% of the female participants, while no changes in LDL levels were observed in the rest.

Nevertheless, such inconclusive results did not stop researchers from taking next steps and even led to mathematical equations by Hegsted(8), Ketan(9), Yu(10), Clarke(11), Muller(12). Eventually, the conclusion derived from these studies led to the World Health Organization report in 2016, which recommended that SFA intake should be less than 10% of a person's total energy consumption per day.

For the sake of argument, let's compare the theories arising from studies related to the effects on human health of eating or not eating certain foods to the Theory of Relativity, which states that if an object moves at different speeds, its mass will change. This principle is true from the moment the object starts to move. In other words, change in mass of an object totally depends on its speed and the quantity of the change and speed. Can we say the same about consuming linoleic acid and increasing the level of high-density lipoprotein (HDL)?

Comparing a nutrition theory to physics may be a stretch, but why is it so impossible? Is the degree of certainty for Einstein's theory too high, or is the nutrition theory about the effect of linoleic acid on HDL not certain enough? The certainty of Einstein's theory is undeniable but why is this not the case with nutrition theory? The answer is that Einstein's theory explains a quantitative relationship between the speed of an object and its mass change, while the nutrition theory depends on many variables—the level of linoleic acid, the intake of other fatty acids, the gender and age of the individual, his/her physical activity and level of stress, among other factors—for it to be true. That is why the terms such as "each", "every" and "always" do not apply.

The power to predict

For the statement, "Using more than 10% of total energy of saturated fatty acids will increase the amount of total cholesterol and LDL," to be predictive, it should quantitatively come true for all individuals.

The theory appears to be more scientific when stated through statistics, e.g., "always for 75% of people, using x amount of saturated fatty acids will increase their total cholesterol up to y," but when a general sentence is used in place of a specific number or certain statistics, the theory cannot be regarded as scientific. There is a difference between prediction and incidence. Prediction is based on two factors: a general theory and initial conditions, while incidence lacks both.

In the case of physics, we can reach predictions for a specific case by combining general principles and initial conditions. Consider the following as an example:

- If we hang a weight to a rope which weighs more than the tensile strength of the rope, the rope will be torn apart (universal proposition).
- The tensile strength of a rope is 1 Newton, and the weight weighs 2 Newtons (initial conditions).
- The rope will be torn apart (singular proposition).

Now, let's apply the same quantitative causal relationship to make a prediction based on the effectiveness of using saturated fatty acids on the level of LDL.

- Using more than 10% of energy will increase total cholesterol (TCl) (universal proposition).
- A person uses more than 10% of total energy of saturated fatty acids (initial conditions)
- TCl level of this person will be increased (singular proposition).

The question is: How certain are the theorists of the aforementioned statement about their prediction? A nutrition specialist may answer that increasing the use of SFA is only one way to increase of this person's TCl, and it is alright to talk about probabilities regarding numerous studies conducted on this issue. However, such approaches will reduce the degree of certainty of the general principle mentioned above.

The ability to be disproved

Falsifiability is a significant characteristic of science in which claimants pave the way for others to experiment and falsify a hypothesis, put its protentional mistakes into action, and confirm its reliability if it is not rejected. The more empirical and testable a hypothesis is, the more falsifiable, objective, and scientific it is. A statement lacking the capability of being confirmed through tests and experiments cannot be considered as scientific even if it has the most obvious axiom in mind. Falsifiability goes hand-in-hand with prediction to determine how scientific a theory is. Scientific laws are both empirical (falsifiable) and predictive.

Falsifiability of scientific hypotheses means that the person making the hypothesis should clarify that under what condition he/she will take his/her word back. More precisely, if a scientific hypothesis is incorrect, it should be capable of being proven wrong by the means of experiment. A statement can be unfalsifiable and unscientific for many reasons such as it:

- addresses an indefinite future. For instance: A radioactive material will eventually reduce to half. Such a statement is unscientific and unfalsifiable since if after a few years the bulk reduces to half, the claimants will announce that their statement was proven correct; otherwise, they will claim that the time is yet to come. But the statement, "a radioactive bulk will always reduce to its half after a certain period of time (half-life)," is considered as a falsifiable scientific theory; if the radioactive bulk does not reduce to half at its determined time (half-life), there will be no way for the claimants to justify their statements.
- states positive minor propositions. For instance, the claim, "some objects expand on heating," is unfalsifiable and unscientific since if we find objects which either expand on heating or otherwise, the claim will still be proven right. In contrast, if a theory states that "objects will expand on heating," it can be disproved if we find only one object that does not expand on heating, and the statement.
- talks about essentialities and requisites; for instance, "two plus two equals four" or "salt is saline by nature".

No scientific rule can explain all aspects of a phenomena.

Scientific laws do not deal with generalization. They deal with specifics, such as weight, specific weight, freezing, expanding, melting point, boiling point, osmotic pressure, solubility, ionization, crystallization, surface tension, degree of saturation, oxidation, and so on. They describe the quantitative and qualitative relationships among different aspects of a phenom-

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ena, such as the relation between boiling point of water and its impurities, or how specific weight will change by changing the heat degree.

Now, consider how this applies to nutrition studies that look at the “effects of saturated fatty acids on lipolipids of blood.” To start with, empirical laws governing molecular weight melting point, density, thermal expansion, latent heat of melting, viscosity, freezing point, boiling point, specific heat, smoke point, fire point, oxidation, hydrolyze, crystallization, and so on also apply to lipids and fats—and that the quantitative and qualitative relations and effects are measurable and scientific. However, lipids and fats have exclusive aspects of their own, such as saturation and unsaturation—and the quantitative and qualitative relations and effects for all these aspects are measurable and scientific as well (eg., the effect different types of fatty acids have on melting point, latent heat, viscosity, etc.) .

No quantitative and qualitative relation can be found in which these exclusive characteristics forget to play their fundamental roles. Therefore, all saturated fatty acids have characteristics in common regarding their general definition: “They are fatty acids with only one Pi bond between their carbon-carbon”, but when it comes to diversity in types, each plays its one and only role. Well-known saturated fatty acids such as butyric acid (C4:0), caproic acid (C6:0), caprylic acid (C8:), capric acid (C10:), lauric acid (C12:0), meristic acid (C14:0), palmitic acid (C16:0), stearic acid (C18:) are all have exclusive independent aspects. Recent categorization of triacylglycerol into short chain (SCT), medium chain (MCT), and long chain (LCT) is based on such qualitative differences (13).

A systematic review of studies (14)) on fatty acids and their effect on lipids and serum lipids by Mesnik in 2016, “Effects of saturated fatty acids on lipids and lipolipids of serum,” considered the quantitative effect of a mixture of saturated fatty acids on total cholesterol, LDL, HDL, triacylglycerol (triglyceride), the proportion of total cholesterol to HDL, the proportion of LDL to HDL, and the proportion of triglyceride to HDL.

The review did not consider saturated acids with less than 12 carbons or those with more than 18, but it found noticeable differences. When a mixture of saturated fatty acids, equivalent to 1% of energy consumption, substituted carbohydrates, the amount of TCl , LDL, HDL, triacylglycerol (TG) rose to 0.045, 0.036, 0.011, and 0.02 mmol/L. However, if it was substituted by lauric fatty acid, the numbers changes to 0.014, 0.017, 0.019, and 0.015 mmol/L. The difference is meaningful. In case of the three proportions of TCl to HDL, LDL to HDL, and TC to HDL, when 1% of energy consumption of a mixture of saturated fatty acids was substituted for the equivalent of carbohydrates, the numbers respectively decreased to 0.002, increased to 0.007, and decreased to 0.16. But, when the same amount of carbohydrates were substituted with lauric acid, the numbers increased respectively to 0.035, 0.024, and 0.024, indicating that lauric acid is a healthier fatty acid. Results for myristic and palmitic were different from those of the mixture of saturated fatty acids, while stearic acid had no effect on increase or decrease of lipids or lipolipids of serum. The point is that three different SFAs demonstrated different effects, but the biggest problem with such studies, which the report mentioned, is that the individuals participating in the experiment have diets which are obviously different from those in the real world.

Such contradictions are problematic even for specialists and experts in nutrition fields, let alone for members of the public who become so confused by the opposing theories that they gradually lose their trust in science. In the absence of consistent, reliable statements from the experts, it seems inevitable that people will start to seek nutrition advice from non-scientists. Nutrition may never be an exact science like physics or chemistry, and it is likely that contradictions will continue to arise. However, knowledge in this field would be considerably more reliable if the majority of nutrition studies kept the principles of the logic of scientific discovery in mind.

Seyed Kazem Hosseini earned a B.S in Food Science and Industry from the Faculty of Food Science and Industry, Tehran, and an M.S. in Food Engineering from Tehran University in Iran. He worked for 16 years as Manager of Research for Pars Vegetable Oil Co., where he introduced the GRCLS System (dietary guidelines, recommendations, claims, labelling, and standards) and formulated and produced Iran’s first table margarine, vegetable oil suitable for frying, cocoa butter substitute, and ghee oil with low trans,low saturated and high SFC. He has been a research consultant for several edible oil companies sinc 2006, and can be contacted at sk1hosseini@gmail.com.

AOCS MEETING WATCH

May 3–14, 2021. AOCS Annual Meeting & Expo, annualmeeting.aocs.org.

October 5–7, 2021. Plant Protein Science and Technology Forum, Millennium Knickerbocker, Chicago, Illinois, USA.

May 1–4, 2022. AOCS Annual Meeting & Expo, Hyatt Regency Atlanta, Atlanta, Georgia, USA.

April 30–May 3, 2023. AOCS Annual Meeting & Expo, Colorado Convention Center, Denver, Colorado, USA.

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Measuring protein quality in food

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

Rebecca Guenard

Food and beverage manufacturers continue to focus on creating new high-protein products from plant sources to satisfy an enduring consumer trend. Protein provides the body with energy, in addition to building muscle mass and maintaining cell function to prevent disease. It is an essential nutrient in any diet, but food companies are particularly interested in animal-free protein to satisfy the growing number of consumers concerned about the humaneness and sustainability of raising livestock.

With so many new sources of protein, producers and consumers are faced with determining which is best. Milk has always had a reputation as a good source of protein, but how do we know whether pea is a better source than soy? The US Food and Drug Administration (FDA) requires a protein digestibility corrected amino acid score (PDCAAS) for all protein claims on foods sold in the United States. However, the score is not ideal for distinguishing between two similar protein sources, according to food science professor Hans H. Stein, at the University of Illinois in Urbana-Champaign, Illinois, USA.

Stein is one of many scientists worldwide who are using the latest measurement techniques to build a new database of protein quality. He says, researchers have updated protein quality evaluation methods several times over the last hundred years. The PDCAAS method was established in 1991 and since then new technology has made it possible to measure the individual amino acids in a protein, he says. The Food and Agricultural Organization (FAO) recently decided to adjust protein scores again to take advantage of this new technology.

The FAO is an agency of the United Nations intent on defeating world hunger. Its goal is food security for all through unhindered access to high-quality foods. According to the FAO, protein quality depends on the amino acid composition and bioavailability of the protein source which should be determined through standardized analytical methods. "In 2011, the FAO called experts together in a meeting that resulted in a report that went public in 2013," says Stein. "The experts agreed to introduce a system that was better than the PDCAAS system." The report recommended that the digestible indispensable amino acid score (DIAAS) be adopted.

The human body requires 20 amino acids to function, but can only produce about half of them. The remainder must be acquired from our diet. The proteins we eat are broken down into amino acids during digestion. Decades ago, scientists realized that instead of just measuring the total crude protein in a food, it is important to measure the individual amino acids the body takes in from a protein. Since then, the challenge has been how to measure them. Proteins are fully digested into essential amino acids in the small intestine and then released into the bloodstream. Any nondietary amino acids that remain proceed to the large intestine where gut microbes ferment them in preparation for excretion. In addition, certain anti-nutritional compounds in foods can inhibit the digestibility of amino acids. These multiple processes make it difficult to analyze protein digestibility through excrement.

PDCAAS samples come from the feces and are analyzed for crude protein. The score is calculated by measuring the total crude protein remaining in the digestive tract and assumes that all amino acids have the same digestibility as their crude proteins.

"The amino acids in the feces are different from the amino acids that come out of the small intestine," says Stein. "If you want to know what amino acids were absorbed during digestion, you really need to know what a person consumed and then what left their small intestine." The amino acids absorbed by the small intestine are known as digestible amino acids. The DIAAS is the ratio (mg/g of protein) of digestible amino acids in a protein source to an indispensable amino acid requirement. Stein and others are currently collecting data based on the requirements of healthy adults.

The ideal way to determine the quality of a protein is by evaluating the amino acid content at the end of the small intestine, the ilium, after a food product is eaten. To determine DIAAS, samples are taken from the ilium and analyzed for amino acids. Hence, the DIAAS sample from the ilium is a more accurate representation of amino acid digestion and absorption.

There is no easy way to measure this digestibility score directly for human food. The process would be too invasive to be done routinely. However, researchers have developed an animal model using an adolescent pig. Pigs are not as selective about what they eat as other laboratory animals and typically consume anything that humans consume. This allowed the researchers to develop a protocol for measuring amino acid digestibility values in a myriad of foods prepared in the same way humans would consume them. By understanding how the digestibility values for a pig are proportional to those of humans, research groups around the world have built a robust method for "predicted human" amino acid digestion. Stein believes that in two years the database will be extensive enough, containing data for foods from around the world, to replace the PDCAAS with the DIAAS.

The DIAAS label should be particularly helpful for those interested in a plant-based diet. It is more straightforward for animal product consumers to assess if they have fulfilled their protein requirements than for strictly plant-based eaters. Meat, fish, eggs, and dairy products are known as whole or complete proteins. They contain all nine of the essential amino acids. Other protein sources, such as nuts, beans, and seeds, only contain some essential amino acids. Because of their limitations, plant protein sources need to be combined to create a complete protein at a meal or within the course of a day.

"This new system allows us to measure the protein quality in individual ingredients and then calculate what we will get when we combine several ingredients," says Stein. For example, with a DIAAS he can measure the protein quality in corn flakes and in milk. Then he can calculate how much milk a person would need to add to the corn flakes to obtain the necessary amino acids. "That is an advantage of the new system," he says. Another advantage with DIAAS, is that it will help consumers distinguish between high-quality and low-quality proteins and more easily determine which proteins complement each other. That is not possible with the PDCAAS system.

As the data collection comes to completion, Stein predicts it will become the new standard for regulatory agencies like the FDA. Once that happens, researchers may turn their attention to how protein requirements change at various stages of life. "There is a growing understanding that if you are 65 or older than you may have different amino acid requirements," he says. "We do not know a lot about that." He mentions lactating mothers as another demographic that needs more research. Scientists cannot currently quantify how much amino acids a nursing woman needs to produce an adequate, nutritious milk supply. Protein requirements is an area of research that needs more attention, he says.

"There is lots of stuff to work on," says Stein. "That is what makes nutrition so exciting."

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

Information

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Opportunities and key challenges for soap noodles industry through COVID-19 pandemic

Markets in Motion covers market trends, opportunities, developments, and future prospects in AOCS-related industries.

Hrishikesh Kadam

Soap noodles are a consumer product in many countries and serve as a ubiquitous intermediate in the production of bar soaps. The current pandemic response has caused many changes in personal habits, and near the top of any listing is the importance of hygiene, especially hand washing. Changes to improve the performance of noodles and bars offer growth opportunities for producers, and potentially significantly better health for individual users.

Soap noodles contain fatty acids derived from vegetable or animal oils. Soap manufacturers include colorants, fragrances, essential oils, and other additives as required. Over the years, bar soaps have emerged from a purely cleansing product to a personal care item that offers multiple benefits and functionality. Manufacturers are using innovative technologies to offer new soap variants to compete with liquid shower gels and similar products.

Two key challenges for soap noodle manufacturers include the need to improve the active ingredients (both effectiveness and economics), without adverse effect on the production line. An overview of projected improvements is available: (https://www.gminsights.com/industry-analysis/soap-noodles-market). The market value is estimated to grow to USD 1.1 billion by 2025.

BIOBASED SOAP NOODLES TO WITNESS SUBSTANTIAL DEMAND THROUGH 2025

Personal care products with natural and organic ingredients are becoming increasingly popular as consumers become more aware of ingredient sources.

The past few years have witnessed a notable increase in the demand for soaps with aromatic oils, such as tea tree oil, honey oil, palm oil, and chamomile oil. Such ingredients offer excellent skincare properties such as mildness and moisturizing.

These vegetable oils enhance consumer appeal, without inhibiting the cleaning necessary for improved hygiene.

EMERGING OPPORTUNITIES FOR MANUFACTURES AMID COVID-19 PANDEMIC

Mounting concerns in wake of the COVID-19 public health emergency led to an increase in hand soap demand early in 2020. This upward trend in demand has persisted because of increased awareness of the importance of hand hygiene.

While hand sanitizers have been an indispensable tool in the fight against the virus, their use in combination with hand soap and warm water is especially effective.

The sustained nature of the pandemic and its resurgence in several parts of the world will continue to drive the demand for hand soaps, thereby bolstering the global soap noodles industry outlook. It is anticipated by some that after the pandemic subsides, personal and family hygiene will have been established as improved regular habits.

COVID-19-ASSOCIATED SUPPLY CHAIN CHALLENGES TO BE A MAJOR ROAD BLOCK

Although the coronavirus pandemic disrupted many regular business activities, it has emphasized the importance of improving production of personal care products. To enhance supply chains, companies qualified local suppliers for raw materials.

All of the challenges resulting from the pandemic are particularly urgent in the emerging economies of the Middle East and Africa. In Ethiopia, Africa's second most populated nation, nearly 40% of the population lack access to adequate hygiene facilities.

Enhancing distribution and access to affordable hand washing solutions is a top priority. In June 2020, the United States Agency for International Development (USAID) launched the Transform Water, Sanitation and Hygiene (T/WASH) project to improve the supply chain for raw materials, including soap noodles (https://www.psi.org/2020/06/covid19-ethiopia-supply-chain/).

Under the project, the T/WASH team is constantly working to improve the quality, range, and affordability of hand hygiene products for households and public institutions. The team is also leveraging its network of local distributors and retail business partners to further strengthen the supply chain for these products. This and other similar initiatives will certainly provide the regional soap noodle suppliers with tremendous opportunities.

HOW WILL THE GLOBAL SOAP NOODLES INDUSTRY FARE OVER THE NEXT FEW YEARS?

Changing preferences and increasing consumer expectations will remain the key factors influencing future developments in personal care products and formulations. The demand for effective products with natural and organic ingredients is expected to remain a key trend in the industry. Meanwhile, the need to improve hand hygiene product manufacturing should substantially boost soap noodles consumption.

Wilmar International, Levant soap, KLK Oleo, Raj Industries, Sari Utama, Timur Oleochemicals Malaysia, M Bedforth & Sons, John Drury & Co Ltd., Jocil Limited, Musim Mas Hodling Pte, and IoI Oleochemicals are among the top soap noodle vendors in the global market.

Hrishikesh Kadam is a graduate in electronics and telecommunication engineering who has always found writing fascinating. Driven by a never-ending passion for content creation and experience in writing personal blogs, Hrishikesh blends his technical knowledge and expertise to write articles across various domains.

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2-/3-MCPD Fatty Acid Esters and Glycidyl Fatty Acid Esters in Edible Oils and Fats by Enzymatic Hydrolysis

Joint JOCS/AOCS Recommended Practice Cd 29e-19
2-/3-MCPD Fatty Acid Esters and Glycidyl Fatty Acid Esters in Fish Oils by Enzymatic Hydrolysis

Joint JOCS/AOCS Official Method Ch 3a-19
Determination of the Composition of Fatty Acids at the 2-Position of Oils and Fats-Enzymatic Transesterification Method using *Candida antarctica* Lipase

REVISIONS

AOCS Standard Procedure Ba 6a-05
Crude Fiber in Feed by Filter Bag Technique

AOCS Official Method Cc 7-25
Refractive Index of Fats and Oils

AOCS Official Method Cd 26-96
Stigmastadienes in Vegetable Oils

AOCS Official Method Cd 27-96
Steroidal Hydrocarbons in Vegetable Oils

AOCS Official Method Cd 3d-63
Acid Value of Fats and Oils

AOCS Official Method Cd 29c-13
2- and 3-MCPD Fatty Acid Esters and Glycidol Fatty Acid Esters in Edible Oils and Fats by GC/MS (Difference Method)

AOCS Official Method Ce 8-89
Tocopherols and Tocotrienols in Vegetable Oils and Fats by HPLC

AOCS Official Method Ch 3-91
Fatty Acids in the 2-Position in the Triglycerides of Oils and Fats

AOCS Official Method Ch 5-91
Specific Extinction of Oils and Fats, Ultraviolet Absorption

AOCS Analytical Guidelines Ch 7-09
International Trade Standard Applying to Olive and Olive-Pomace Oils

AOCS Official Method Ch 8-02
Wax Content by Capillary Column Gas-Liquid Chromatography

AOCS Procedure M 1-92
Determination of Precision of Analytical Methods

AOCS Procedure M 3-82
Surplus Status of Methods

AOCS Criteria M 5-09
Approved Chemists (Criteria)

AOCS Criteria M 6-09
Certified Laboratories (Criteria)

New and revised methods included in the 2020 Additions and Revisions may also be purchased individually as PDF downloads.

EFSA update: edible insects and front-of-package nutrition labeling

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

The European Food Safety Authority (EFSA) announced two new developments in early 2021: its first completed assessment of a proposed insect-derived food product and the supportive role EFSA will play in developing a future EU-wide system for front-of-pack nutrition labelling.

GREEN LIGHT FOR DRIED YELLOW MEALWORM

Following a request from the European Commission, the EFSA Panel on Nutrition, Novel Foods and Food Allergens (NDA) was asked to deliver an opinion on dried yellow mealworm as a novel food (NF) pursuant to Regulation (EU) 2015/2283. The term yellow mealworm refers to the larval form of the insect species *Tenebrio molitor*, and the novel food is the thermally dried yellow mealworm, either as whole dried insect or in the form of powder. The NF's main components are protein, fat, and fiber (chitin), and the applicant proposed to use the NF as whole, dried insect in the form of snacks, as well as a food ingredient in several food products marketed to the general population.

The Panel noted in its published scientific opinion (https://doi.org/10.2903/j.efsa.2021.6343) that the levels of contaminants in the NF depend on the occurrence levels of these substances in the insect feed, but that there are no safety concerns regarding the stability of the NF if the NF complies with the proposed specification limits during its entire shelf life.

Although the NF has a high protein content, the panel pointed out that true protein levels are overestimated when using the nitrogen-to-protein conversion factor of 6.25, due to the presence of non-protein nitrogen from chitin. Even so, "considering the composition of the NF and the proposed conditions of use, the consumption of the NF is not nutritionally disadvantageous."

The submitted toxicity studies from the literature did not raise safety concerns, although the Panel did consider that the consumption of the NF may induce primary sensitization and allergic reactions to yellow mealworm proteins or cause allergic reactions in subjects with allergy to crustaceans and dust mites. It was also noted that allergens from the feed may end up in the NF. Nevertheless, the conclusion was that the NF is safe under the proposed uses and use levels.

Ermolaos Ververis, a chemist and food scientist at EFSA who coordinated the first adopted opinion on insects as novel food, said: "Insects are complex organisms, which makes characterizing the composition of insect-derived food products a challenge. Understanding their microbiology is paramount, considering also that the entire insect is consumed."

Various insect-derived foodstuffs are often heralded as a source of protein for the diet. According to Ververis, "Formulations from insects may be high in protein, although the true protein levels can be overestimated when the substance chitin, a major component of insects' exoskeleton, is present. Critically, many food allergies are linked to proteins, so we assess whether the consumption of insects could trigger any allergic reactions. These can be caused by an individual's sensitivity to insect proteins, cross-reactivity with other allergens or residual allergens from insect feed, such as gluten," Ververis said.

"It's challenging work because the quality and availability of data varies, and there is a lot of diversity among insect species."

The novelty of using insects in food has led to high interest from the public and the media, so EFSA's scientific assessments are essential for the policymakers who will decide whether or not to authorize these products before they can be put on the EU market.

Giovanni Sogari, a social and consumer researcher at the University of Parma, stated: "There are cognitive reasons derived from our social and cultural experiences, the so-called 'yuck factor' that make the thought of eating insects repellent to many Europeans. With time and exposure such attitudes can change."

Mario Mazzocchi, an economic statistician and professor at the University of Bologna, said: "There are clear environmental and economic benefits if you substitute traditional sources of animal proteins with those that require less feed, produce less waste, and result in fewer greenhouse gas emissions. Lower costs and prices could enhance food security and new demand will open economic opportunities too, but these could also affect existing sectors."

FRONT-OF-PACK NUTRITION LABELLING

In February 2021, EFSA reported that its nutrition scientists will provide scientific advice to support the development of a future EU-wide system for front-of-pack nutrition labelling. They will also inform the setting of conditions for using nutrition and health claims on foods.

According to the action plan for the EU's *Farm to Fork Strategy*, the European Commission intends to submit, by the end of 2022, a proposal for harmonized mandatory front-of-pack nutrition labelling and for the setting of nutrient profiles to restrict the promotion of food high in, for example, salt, sugars, and/or fat.

The European Commission has asked EFSA to provide scientific advice on:

- Nutrients of public health importance for European populations, including non-nutrient components of food (e.g. energy, dietary fiber);
- Food groups which have important roles in the diets of European populations and subgroups; and
- Criteria to guide the choice of nutrients and other non-nutrient components of food for nutrient profiling.

EFSA's experts will assess recent scientific information, including such sources as published reviews on dietary recommendations for healthy diets based on evidence from studies on humans, and EFSA's own work on dietary reference values (https://www.efsa.europa.eu/en/topics/topic/dietary-reference-values) provided by the European Commission.

EFSA is required to deliver its scientific opinion by March 2022. It will consult publicly on the draft by the end of 2021. The "Request for a scientific opinion on development of harmonized mandatory front-of-pack nutrition labelling and the setting of nutrient profiles for restricting nutrition and health claims on foods can be accessed at https://www.efsa.europa.eu/sites/default/files/EFSA-Q-2021-00026_M-2021-0007.pdf.

Notice of Annual Business Meeting

ONLINE

AOCS members will convene for the AOCS annual business meeting on Friday, May 14, 2021, 4–5 p.m. CDT (Chicago USA; UTC-5) online at annualmeeting.aocs.org/watch-the-livestream. In addition to conducting routine business of the Society, attending members will receive an update on the state of the Society, meet the 2021-2022 Governing Board, and gain insight on our future plans. The Governing Board will be present to answer questions from members.

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Meet Chris Dayton

Member Spotlight is a slice of life that helps AOCS members get to know each other on a more personal level.

Chris Dayton, on a dive about six miles off the Atlantic coast, near his home in Palm Beach County, Florida, USA.

Fast facts

Name	Chris Dayton
Joined AOCS	1986
Education	BS in chemistry, Purdue University (West Lafayette, Indiana, USA)
Job title	Manager Oils Technology BLC
Employer	Bunge
Current AOCS involvement	Senior associate editor of *JAOCS*; Uniform Methods Committee Chairman; Examination Board Chairman; and member of the Hans Kaunitz Award Committee and of the Processing, Analytical, and Biotechnology Divisions

PROFESSIONAL

What's a typical day like for you?

My day all depends on the type of work that needs to be completed that day. I may spend the entire day in the laboratory troubleshooting a process with the people in Channahon, Illinois, or developing a process that does not currently exist with the scientists in Chesterfield, Missouri or Wormerveer, Netherlands. I may spend the day going through invention disclosures, United States Patent and Trademark Office actions, or review existing patents with the researchers in Budapest, Hungry; or I may be spending my day teaching others more about the chemistry involved in fats and oils processing in Xiamen, China. After hours, I review articles submitted to the *Journal of the American Oil Chemists' Society* that are geared toward analytical techniques or processing as a senior associate editor of the journal.

Is there an achievement or contribution that you are most proud of? Why?

The patented enzymatic degumming and enzymatic interesterification (EIE) processing technology that I have been able to develop and implement around the globe, which has enabled the dramatic reduction of *trans* fatty acids and the elimination of partially hydrogenated vegetable oils from the food market.

What event, person, or life experience has had the most influence on the direction of your life?

I had two very good mentors during my first few years at Central Soya. The first was Irme Balazs, who stressed the importance of working on projects that enable the company to either reduce costs or to develop new technologies that are implementable in the process. The second was Jerry Fawbush. Jerry believed in the work Kerry Staller and I were doing and pushed for its implementation. The result of that work was the enzymatic degumming/physical refining plant in Morristown, Indiana, USA, which was the first successful physical refining plant of soybean oil in the world. Up until then, physical refining of soybean oil had been impossible.

PERSONAL

What is the most impressive thing you know how to do?

I can breathe under water. Yes, I am an avid SCUBA diver with multiple technical certifications and have had the opportunity to dive all around the world. I am waiting for an end of the pandemic and travel again becomes possible without long periods of quarantine. I have had a trip to the Chuuk Lagoon in Micronesia postponed twice and two other dive trips threatened thus far.

What skill would you like to master?

I would like to master underwater photography. It is very difficult because the light is always wrong. Typically, the subject (fish) is always moving, and I am also always moving due to the current. I am lucky if I am able to get one or two pictures out of 100 taken on a dive. Some of the pictures others take are absolutely phenomenal.

PATENTS

Reactive resins made from renewable sources

Messana, A.D., *et al.*, Henkel IP & Holding GmbH, US10822444, November 3, 2020

The invention provides reactive resins compounds and compositions made from renewable materials, such as plant and animal oils. The reactive resins, compounds, and compositions may include an accelerator as part of their structure and are made from renewable materials containing a variety of functional groups. The compositions provide excellent adhesion and sealing capability.

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Particulate composition

Simonsen; O., *et al.*, Novozymes A/S, US10829721, November 10, 2020

Enzymes tend to be inactivated during wash by a bleach catalyst in combination with a source of organic peroxyacids. The risk of enzyme inactivation by active bleach catalyst is reduced when the release of the enzyme into the wash solution is delayed. The enzyme stability during washing together with a bleach catalyst can be improved by applying a delayed-release coating to cores which comprise the enzyme.

Cacao-based food products

Petyaev, I., IP Science Ltd., US10849336, December 1, 2020

The invention is concerned with food products comprising one or more cacao bean products and a carotenoid compound, particularly with food products which are, or comprise, chocolate. The products of the invention may be used in reducing elevated total cholesterol, triglycerides, and inflammatory damage, as well as improving tissue microcirculation and tissue oxygenation.

Method of making lipids with improved cold flow properties

Sun, Z., *et al.*, MARA Renewables Corp., , US20201201, December 1, 2020

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.

Preparing method of tightly sealed 3D lipid structure and tightly sealed 3D lipid structure prepared thereby

Kim, T.S., *et al.*, Korea Institute of Science and Technology, US20201124, November 24, 2020

A method for preparing a tightly sealed 3D lipid structure and a tightly sealed 3D lipid structure prepared thereby is disclosed. The method allows for simpler and more convenient preparation of an artificial biomembrane structure on a substrate using a lipid material, by using a plurality of transparent microwells formed on the substrate, and observation inside the microwells. In addition, a spherical 3D artificial single bilayer structure may be sealed very tightly through a simple method of changing the frequency of an electric field applied vertically to the microwells having a lipid layer formed. Through this, a biomimetic 3D structure having the structural and/or functional characteristics of a cell membrane constituting a cell can be provided more effectively.

Methods of refining a grain oil composition feedstock, and related systems, compositions and uses

Urban, Shannon S., *et al.*, POET Research, Inc., US10851327, December 1, 2020

The present disclosure relates methods and systems for refining grain oil compositions using water, and related compositions produced therefrom. The present disclosure also relates to methods of using said compositions. The present disclosure also relates to methods of using grain oil derived from a fermentation product in an anti-foam composition.

Process for the preparation and stabilization of emulsions with omega-3 by means of isometric crystalline networks of cellulose derivatives

Moreno Egea, F., Solutex NA, LCC, US10856564, December 8, 2020

The present invention relates to a novel emulsion structured in an isometric crystalline network of cellulose derivatives where the emulsion comprises omega-3 fatty acids homogeneously distributed in the same. The emulsion of the invention has been designed to have greater stability, bioavailability, and gastro-resistance and may be used in special medical foods, nutritional supplements, sports nutrition, enteral nutrition, or child nutrition, amongst others.

Process for preparing mixtures of epoxidized fatty acid esters

Verraes, A., *et al.*, Proviron Holding N.V., US10858611, December 8, 2020

The present invention relates to a process for preparing two mixtures of epoxidized fatty acid esters, comprising in the order given a transesterification of an epoxidized vegetable oil, followed by a reduction of the volatile saturated non-epoxidized fraction by short-path distillation of the transesterified epoxidized vegetable oil, followed by a selection on the one hand of the non-vaporized fraction (residue) of the previous process step as the first mixture of epoxidized fatty acid esters and a selection on the other hand of the vaporized fraction (distillate) as the second mixture of epoxidized fatty acid esters. The first mixture is in particular suitable as plasticizer in halogenated polymers, the second mixture being particularly suitable as plasticizer in non-halogenated polymers.

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High-solubility pea protein composition and method of preparing same

Zhang, Y., *et al.*, Cargill, Inc., 10863755, December 15, 2020

The present invention relates to the field of processing pea protein compositions. The present invention particularly relates to a method for preparing a high solubility pea protein composition and a product prepared thereby. The method of the present invention includes a step of subjecting a pea protein composition to high pressure homogenization. The method of the present invention significantly improves the solubility of pea protein compositions. The present invention further provides a pea protein composition prepared by the method, the pea protein composition having better solubility.

Lipid compositions

Myhren, F., *et al.*, Aker BioMarine Antarctic AS, US10864223, December 15, 2020

The present invention provides improved processes for extracting and preparing lipids from biological sources for use in pharmaceuticals, nutraceuticals, and functional foods.

Foamable skin composition

Hedren, M., *et al.*, Paragon Nordic AB, US10869818, December 22, 2020

A foamable skin composition comprises, in % by weight of the foamable skin composition, at least one C12-C22 fatty acid at a concentration of 1–3%, at least one C12-C22 fatty alcohol at a concentration of 1–5%, at least one ester and/or vegetable oil at a concentration of 1–40%, at least one non-ionic surfactant at a concentration of 1–15%, at least one emollient at a concentration of 0.5–10% and water. The foamable skin composition has an acidic pH but still forms a stable form following dispensing.

Fortified jelly confectionery

Chamberlin, N., BASF SE, US10874116, December 29, 2020

The present application relates to the field of confectionery jellies fortified with high concentrations of hydrophobic actives such as phytosterol esters, omega-3 fatty acids (i.e. combinations of DHA and EPA) and/or conjugated linoleic acid (CLA). The ingestible hydrophobic actives are incorporated at high levels by using two types of pectin; an emulsifying pectin and a gelling pectin, wherein the weight ratio of the hydrophobic active to emulsifying pectin ranges from about 5:1 to about 35:1.

Fatty acid composition and method for fortifying nutritional products with fatty acids

Gleason; J., *et al.*, Jost Chemical Co., US10888104, January 12, 2021

A fatty acid composition is provided which can be used to make fatty acid fortified nutritional products. In one embodiment, the fatty acid composition comprises a fatty acid component, inorganic salts (which can include a phosphate salt), vitamins, and optionally a protein source and optionally a carbohydrate source. The composition can further include additional nutrients and combinations thereof. In another embodiment, the fatty acid composition is only the fatty acid (i.e., consists of a sodium or potassium fatty acid) which is spray dried. In both embodiments, the fatty acid composition is not microencapsulated in a waxy or carbohydrate substrate, yet the powdered composition is flowable and is easily dispersible in a liquid to form a stable dispersion in the liquid by stirring or shaking the powder in the liquid for only a short period of time.

PUFA salt formulations (I)

Funda, E., *et al.*, DSM IP Assets B.V., US10888538, January 12, 2021

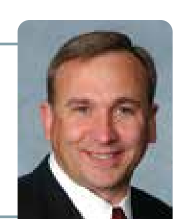
The present patent application relates to novel polyunsaturated fatty acid salt (PUFA salts) solid formulations.

Lipid sterilization method

Kvale; S., *et al.*, GE Healthcare AS, US10888631, January 12, 2021

The present invention relates to a method for sterilization of phospholipid suspensions, useful in the preparation of ultrasound contrast agent precursors comprising phospholipid-stabilized perfluorobutane microbubbles. The method provides sterility assurance, without undue thermal degradation of the phospholipid. The method is also amenable to commercial scale manufacture. Also provided are methods of preparing kits and ultrasound contrast agents incorporating the sterilization method of the invention.

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,~~ May 3–14, 2021, https://annualmeeting.aocs.org/), 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.

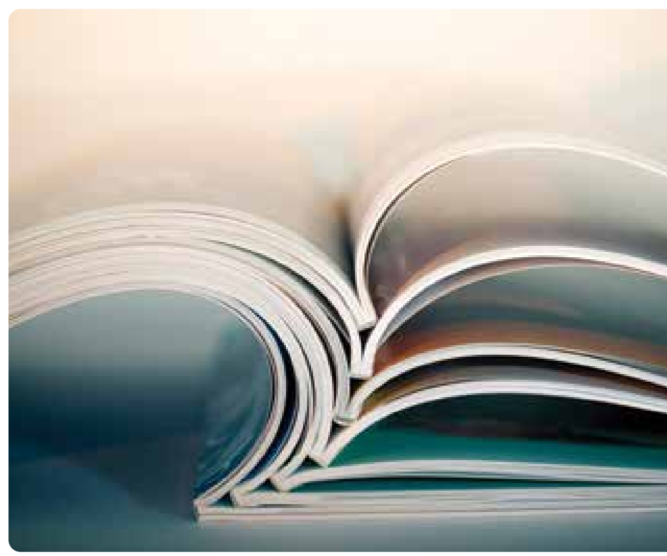
All best papers are for papers published the year before the Annual Meeting, so if your paper is published in 2020, you might be eligible for a best paper award in 2021. To learn more, check out this brief summary of the four awards.

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.

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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.

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 advance-

AOCS remembers winner of the 2007 Edwin N. Frankel Award

In January 2021, colleagues were heartbroken to learn of the sudden illness and death of Usha Thiyam, a beloved member of AOCS and Lipid Oxidation and Quality Division, as well as a recipient of the 2007 Edwin N. Frankel Award for Best Paper in Lipid Oxidation and Quality, "Antioxidant Activity of Rapeseed Phenolics and Their Interactions with Tocopherols During Lipid Oxidation," U. Thiyam, H. Stöckmann, and K. Schwarz (*JAOCS 83*(6):523–528).

Usha joined AOCS as a student member in 2003 while completing her Ph.D. in Nutritional Sciences at the University of Kiel, Germany. She continued as an individual member and after earning a position at the University of Manitoba, Canada, she became involved with the Lipid Oxidation and Quality Division, serving many years as the Vice Chair, where she helped develop the annual meeting programming. In the past two years, Usha took on the Vice Chair position within the Processing Division and up until her last days, she had AOCS activities on her mind.

Usha built a large and broad group of friends and colleagues from around the world. She will be missed by so many.

ment 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 1999, first presented in 1998

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.

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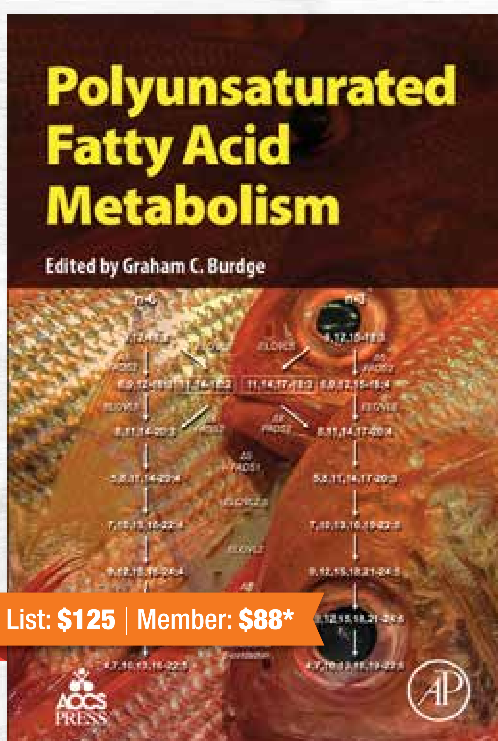

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Polyunsaturated Fatty Acid Metabolism

Edited by Graham C. Burdge
May 2018 | 272 pages | ISBN: 9780128112304
Available in softcover and eBook

Polyunsaturated Fatty Acid Metabolism explores major roles of PUFA in the body, including its role as a component of cell membranes where it provides substrates for the synthesis of lipid second messengers. Recent studies are unraveling the effect of interactions between diet and endocrine factors and genetic and epigenetic variation on the regulation of PUFA biosynthesis in animals. Together, these recent findings provide novel insight into the impact differences in PUFA supply have on health. This book captures these findings in a state-of-the-art manner that places them in the wider context of PUFA metabolism and nutritional science.

Users will find a comprehensive discussion on the topic that presents the contributions of leading researchers whose combined knowledge creates a cohesive academic resource for researchers, those involved in production of PUFA, and health policy makers.

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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

Perspective

H&N Bioactive lipids in antiviral immunity

Theken, K.N. and G.A. FitzGerald, *Science 37*: 237–278, 2021, https://doi.org/10.1126/science.abf3192.

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has brought focus to attempts to limit viral replication and manage the immunological response to infection. Lipids modulate host receptor binding, facilitate viral fusion, and fuel viral replication; thus, modulation of viral-host lipid interactions may have therapeutic utility (1). Indeed, the spike (S) glycoprotein on the surface of SARS-CoV-2 tightly binds the free fatty acid linoleic acid, stabilizing it and reducing its interaction with the host angiotensin-converting enzyme 2 (ACE2) receptor that facilitates viral cell entry (2). However, in the case of many viral infections, including COVID-19, it is the overexuberant host immune response that results in life-threatening consequences of infection. Therefore, therapies that modulate bioactive lipids that regulate the host immune response to respiratory viral infections may be beneficial.

Review Articles

ANA IOP LOQ Emerging trends in olive oil fraud and possible countermeasures

Casadei, E., *et al.*, *Food Control 124*: 107902, 2021, https://doi.org/10.1016/j.foodcont.2021.107902.

A review of most common types of fraud in the olive oil sector was conducted. The work was supplemented by the results of an international on-line survey of EU and non-EU stakeholders in the olive oil sector. The review confirms that most common infringements (fraud or non-compliance) are the marketing of virgin olive oil as extra virgin, and blends of other vegetable oils (sunflower, corn, palm, rapeseed, etc.) with olive oil being marketing as olive oil. The on-line survey focused on current and future issues facing a range of stakeholders, e.g. exporters, importers, control laboratories. Of seemingly high priority to industry were emerging issues with regards to fraud arising from the addition of deodorized oil and from mixing with oil obtained by a second centrifugation of the olive paste (remolido). On the same line, a questionnaire, addressed to the EU Food Fraud Network National Contact Points, highlighted that the most frequent fraudulent practice is mixing with lower quality olive oils and that EU, non-EU and mix of EU and non-EU oils are the cases which need more control activities in relation to false designations of origin.

EAT LOQ The power of microsystem technology in the food industry—Going small makes it better.

Tusek, A.J., *Innov. Food Sci. Emerg. Technol. 68*: 102613, 2021, https://doi.org/10.1016/j.ifset.2021.102613.

Microfluidic devices show significant potential of application in the food industry. They decrease the costs associated with analysis, reduce the amount of waste, enhance mass and heat transfer, increase and improve analytical performances, and allow process parallelization and on-site analysis. However, there is still a gap in standardization of materials, channel geometries, and process conditions to achieve maximum process efficiency. This review looks at micro and nano- particle formation for protection of bioactive compounds, monitoring of microorganisms and contaminants, and extraction of bioactive compounds and analysis of antimicrobial substances for applications in the food industry. A discussion of the specific properties of used microfluidic devices is included.

H&N Role of dietary polyphenols on gut microbiota, their metabolites and health benefits

Mithul Aravind, S., *et al.*, *Food Res. Int. 142*: 110189, 2021, https://doi.org/10.1016/j.foodres.2021.110189.

This review focused on the role of different types and sources of dietary polyphenols on the modulation of the gut microbiota, their metabolites, and how they impact on host health benefits. Inter-dependence between the gut microbiota and polyphenol metabolites and the vital balance between the two in maintaining the host gut homeostasis were discussed with reference to different types and sources of dietary polyphenols. Similarly, the mechanisms behind the health benefits by various polyphenolic metabolites bio-transformed by gut microbiota were also explained. Further research should focus on the importance of human trials and profound links of polyphenols-gut microbiota-nerve-brain as they provide the key to unlock the mechanisms behind the observed benefits of dietary polyphenols found *in vitro* and *in vivo* studies.


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PRO PCP IOP Biorefining of seed oil cakes as industrial co-streams for production of innovative bioplastics. A review

Mirpoor, S.F., *et al.*, *Trends Food Sci. Technol. 109*: 259–270, 2021, https://doi.org/10.1016/j.tifs.2021.01.014.

This review, resulting from a collection of experimental results by databases, as well as by topic and keyword search, summarizes the current use of most seed oil cakes so far utilized, as well as that of additional four seed cakes obtained from plants having an economically significant relevance due to their food, nutraceutical or pharmaceutical properties: sesame (*Sesamum indicum* L.), hemp (*Cannabis sativa*), cardoon (*Cynara cardunculus*), and black cumin (*Nigella sativa*). Various attempts have been done to convert their protein content into a renewable source for producing biodegradable and edible plastics, potentially attractive mainly for food and agricultural industries, as substitutes of the highly polluting petroleum-based plastics. Seed oil cakes are generally used as animal feed supplementation, plant fertilizer or soil compost due to their high protein, carbohydrate, and nitrogen contents. More recently, novel exploitations of the seed oil cakes are under study, such as the production of biofuels and bioplastics. Therefore, seed oil cakes may represent an attractive feedstock for the development of biorefineries through the edible or not edible oil production.

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IOP PRO Biolubricant production from several oleaginous feedstocks using lipases as catalysts: current scenario and future perspectives

Bolina, I.C.A., *et al.*, *Bioenerg. Res.*, January 2021, https://doi.org/10.1007/s12155-020-10242-4.

This review describes different aspects of biolubricants by detailing their main applications, properties, uses, and potential feedstocks, such as vegetable oils. Chemical modification of their structures using different routes has been highlighted to overcome a few limitations for direct application of oleaginous feedstocks as biolubricants. It also traces the progress of enzymatic catalysis and immobilization protocols for preparing heterogenous biocatalysts (immobilized lipases a promising route to obtain a variety of biolubricants based on recent studies described in available literature. Future prospects and challenges for enzymatic biolubricant production on an industrial scale are also reviewed.

Original Articles

ANA EAT Comprehensive triacylglycerol characterization of oils and butters of 15 Amazonian oleaginous species by esi-hrms/ms and comparison with common edible oils and fats

Fasciotti, M., *et al.*, *Eur. J. Lipid Sci. Technol. 122*: 2000019, 2020, https://doi.org/10.1002/ejlt.202000019.

The main composition of fifteen Amazonian oils and butters were investigated via gas chromatography-mass spectrometry (GC-MS) and electrospray ionization high resolution mass spectrometry (ESI-HRMS). Triacylglycerols (TAG) were characterized by their fragmentation spectra and comparison with the LIPID MAPS database, resulting in a detailed compendium of TAG composition of these samples. Over 70 different TAG were putatively annotated per sample and the occurrence of isomers was remarkable, showing that TAG complexity in these samples is considerably higher than ever reported. The TAG composition of the Amazonian samples were also statistically evaluated using principal component analysis (PCA) for comparison to common edible oils such as soybean, corn, coconut, and olive oil. Some tendencies of grouping were observed: butters with medium chain fatty acids (FA); butters with high oleic FA; and oils with high oleic and high linoleic FA contents. This study provided profiles that ensure Amazonian oils and butters authenticity, quality, and also aids in understanding their properties and the best applications for each.

BIO PCP Recombinant production of poly-(3-hydroxybutyrate) by *Bacillus megaterium* utilizing millet bran and rapeseed meal hydrolysates

Tadi, S.R.R., *et al.*, *Bioresour. Technol. 326*: 124800, 2021, https://doi.org/10.1016/j.biortech.2021.124800

Fermentative poly-3-hydroxybutyrate (PHB) production is mainly limited by the cost of raw material. In this study, low-cost feedstock *viz.,* millet bran residue (MBRH) and rapeseed meal hydrolysates were successfully used for PHB production. Metabolic engineering of *Bacillus megaterium* by co-expression of both precursor (*phbRBC*) and NADPH cofactor regeneration (*zwf*) genes resulted in 2.67-fold enhancement in PHB accumulation compared to wild strain. Modified logistic model characterized *B. megaterium* growth and PHB production effectively. The kinetic analysis proved that maximum cell concentration (15.01 $g.L^{-1}$) and growth-associated constant (0.22 $g.g^{-1}$) were found to be higher for initial MBRH concentration (S_0 = 20 $g.L^{-1}$). PHB production kinetics elucidated its expression in *B. megaterium* was growth-associated. PHB synthesized by *B. megaterium* was characterized using FTIR, NMR, XRD, DSC/TGA, FESEM, and the physio-chemical properties enumerated its as a potential biodegradable plastic for industrial application.

BIO PCP IOP Enhancement of biomass yield and lipid accumulation of freshwater microalga *Euglena gracilis* by phenolic compounds from basic structures of lignin

Zhu, J., et al., *Bioresour. Technol. 321*: 124441, 2020, https://doi.org/10.1016/j.biortech.2020.124441.

Introducing biomass-derived additives into microalgae cultivation to increase its yield has been regarded as a more cost-effective and environment-friendly method compared with gene-editing and nutrients supplementation. In this research, feasibility of three major phenolic compounds from lignin's basic structures (guaiacyl-, hydroxyphenyl- and syringyl- types) for freshwater microalga *Euglena gracilis* cultivation was evaluated. The results indicated that *trans*-4-hydroxy-3-methoxycinnamic acid (HMA), 4-hydroxybenzaldehyde (HBA), and syringaldehyde (SRA) could all promote microalgae growth in a phytohormone-like role, and the highest promotion effect was achieved under HMA treatment. HMA at 0.5 $g{\cdot}L^{-1}$ enhanced the cell biomass yield by 2.30 times, while HBA and SRA at the concentration of 0.1 $g{\cdot}L^{-1}$ increased the yield by 1.30 and 1.21 times, respectively. In addition, increased carotenoids and lipid biosynthesis were also observed under the treatments of phenolic compounds, which would contribute to the microalgae biofuel production, since the growth and lipid accumulation of *E. gracilis* were simultaneously enhanced.

BIO PCP IOP Lipid production from non-sugar compounds in pretreated lignocellulose hydrolysates by *Rhodococcus jostii* RHA1

Li, X., *et al.*, *Biomass Bioenerg. 145*: 105970, 2021, https://doi.org/10.1016/j.biombioe.2021.105970.

The non-sugar compounds such as lignin derived phenolic compounds, furans, and organic acids generated from biomass pretreatment are often inhibitors to microbial growth and function, leading to lower ethanol yield in cellulosic ethanol biorefinery. In this study, phenols (vanillin, vanillate), furans (furfural, 5-hydroxymethylfurfural), and organic acids (acetate), which mimic the complex components of the non-sugar compounds in pretreated biomass hydrolysate, were either mixed with benzoate or used individually as carbon sources to investigate their effects on the growth and lipid accumulation of *Rhodococcus jostii* RHA1. Higher consumption rates of benzoate than that of vanillate, as well as different lipid yields from them, suggested that the strain preferred to employ the catechol branch of the beta-ketoadipate pathway to catabolize benzoate and plausibly distinctly routed carbon to lipid biosynthesis when fed on different aromatics. Compared to benzoate, acetate was less favorable by *R. jostii* RHA1 for lipid synthesis, again emphasizing that carbon contribution to either lipid synthesis or cell biomass was selective, using different compounds as carbon sources. Among the five selected non-sugar compounds, the presence of 5-hydroxymethylfurfural (5-HMF) promoted the highest lipid yield at 0.46 g lipid g^{-1} CDW by using benzoate as the main carbon source. Furthermore, the oxidation pathway of furfural and 5-HMF was predicted for the first time in *R. jostii* RHA1 based on the characterization of the products by NMR.

BIO PCP Enhancement of polyhydroxyalkanoate production by co-feeding lignin derivatives with glycerol in *Pseudomonas putida* KT2440

Xu, Z., *et al.*, *Biotechnol. Biofuel. 14*: 11, 2021, https://doi.org/10.1186/s13068-020-01861-2.

Efficient utilization of all available carbons from lignocellulosic biomass is critical for economic efficiency of a bioconversion process to produce renewable bioproducts. However, the metabolic responses that enable *Pseudomonas putida* to utilize mixed carbon sources to generate reducing power and polyhydroxyalkanoate (PHA) remain unclear. Previous research has mainly focused on different fermentation strategies, including the sequential feeding of xylose as the growth stage substrate and octanoic acid as the PHA-producing substrate, feeding glycerol as the sole carbon substrate, and co-feeding of lignin and glucose. This study developed a new strategy—co-feeding glycerol and lignin derivatives such as benzoate, vanillin, and vanillic acid in *Pseudomonas putida* KT2440—for the first time, which simultaneously improved both cell biomass and PHA production.

H&N LOQ Potential of green and roasted coffee beans and spent coffee grounds to provide bioactive peptides

Ribeiro, E., *et al.*, *Food Chem. 348*: 129061, 2021, https://doi.org/10.1016/j.foodchem.2021.129061.

Protein extracts from green and roasted coffee beans and from spent coffee grounds (SCG) were evaluated as bioactive peptides sources. The *in-silico* approach revealed a high frequency of the occurrence (A) of dipeptidyl peptidase-IV (DPP-IV) (0.62) and angiotensin I-converting enzyme (ACE) inhibitor peptides (0.44) in the 11S coffee globulin, which could be released after digestion. After *in vitro* digestion of the protein, the green bean and SCG proteins were more susceptible to proteolysis, releasing smaller polypeptides (3.4 kDa), which showed higher anti-hypertensive potentials (IC_{50} = 0.30 and 0.27 mg soluble protein/mL). However, the antioxidant capacity only increased for the roasted coffee and SCG extracts due to antioxidant groups formed during roasting. The heat treatment applied during coffee brewing increased the sensitivity of the SCG extract to proteolysis, leading to their high anti-hypertensive and antioxidant potentials. Therefore, the 11S coffee globulin is a precursor of a series of bioactive peptides.

H&N LOQ Selective recovery of terpenes, polyphenols, and cannabinoids from *Cannabis sativa* L. inflorescences under microwaves

Gunjevic, V., *et al.*, *Ind. Crop. Prod. 162*: 113247, 2021, https://doi.org/10.1016/j.indcrop.2021.113247.

This work aims to design a fast and cost-efficient MW-assisted cascade protocol for bioactive *Cannabis* compounds recovery in a pilot-scale reactor. Microwave-assisted hydrodistillation (MAHD) can provide a volatile hydrodistillate that is rich in monoterpenes, sesquiterpenes, and a small amount of phytocannabinoids. Using non-canonical protocol of hydrodistillation, the definition of "volatile fraction" is generally considered more appropriate than "essential oil". The optimized MAHD procedure yielded 0.35 ± 0.02 % w/w of hydrodistillate, while conventional hydrodistillation gave only 0.12 ± 0.01 %, w/w (in relation to dry inflorescence mass). The water resulting in the vessel after MAHD showed a high total polyphenolic content (5.35 ± 0.23 %, w/w). Two flavones known for their beneficial effects to health, namely luteolin-7-O-glucoside and apigenin-7-O-glucoside, were detected and quantified. An attempt to recover phytocannabinoid using the MW-assisted hydrodiffusion and gravity method (MAHG) was also carried out. Cannabinoids (CBD and THC) content was determined in fresh *Cannabis* and in production streams. During MAHD, phytocannabinoid decarboxylation inside the residual matrix was around 70 % (69.01 ± 0.98 % and 74.32 ± 1.02 % for THC and CBD respectively). Furthermore, the overall content of these metabolites was not affected by the hydrodistillation, preserving the processed plant material for subsequent ethanolic extraction.

EAT LOQ Proximate composition, physical, sensory, and microbial properties of wheat hog plum bagasse composite cookies

Oladunjoye, A.O, *et al.*, *LWT 141*: 111038, 2021, https://doi.org/10.1016/j.lwt.2021.111038.

Hog plum bagasse (HPB) incorporated into wheat flour at 5, 10, and 15% was used to formulate composite cookies with 100% wheat cookies as control. The cookies were evaluated for proximate, physical, antioxidant, microbial, and sensory characteristics. The composite cookies significantly ($p < 0.05$) showed increased ash and fiber content but decreased protein, fat, and caloric contents compared to the control. Addition of bagasse comparatively improved textural hardness, spread ratio, and baking yield of composite cookies. The color (L^*) decreased, while the total phenolic content and antioxidant properties of cookies increased with bagasse addition. The microbial population reduced with the addition of treated bagasse after 28 d. Sensory scores reduced with bagasse addition but compare favorably with control. Overall acceptability was mostly preferred with bagasse at a 5% inclusion level. The use of agro-waste such as treated hog plum bagasse as a source of dietary fiber in cookies formulation is technically feasible.

IOP PRO Semi-refined *Crambe abyssinica* (Hochst. EX R.E.Fr.) oil as a biobased hydraulic fluid for agricultural applications

Fanigliulo, R., *et al.*, *Biomass Conv. Bioref.*, January 2021, https://doi.org/10.1007/s13399-020-01213-y.

Vegetable oils are well known for their potential applications in green chemistry, including use as hydraulic fluids. *Crambe abyssinica* Hochst. EX R.E.Fr. has low-input requirements during cultivation, and the properties of its oil are characterized by a high erucic acid content. In this study, it was tested as a hydraulic fluid for sustainable agricultural applications. Crambe oil was partially refined through phospholipid removal and added with a food-grade antioxidant (*tert*-butylhydroquinone) at two different concentrations. The fluid efficiency tests were carried out using an experimental test rig, able to simulate a real hydraulic device, performing heavy work cycles at 40-MPa pressure and at 100°C temperature, with the aim of strongly accelerating the aging of the tested fluid. At a lower antioxidant concentration, 0.25 g kg^{-1}, the oil underwent a very quick degradation process. However, increasing the additive dose to 2.0 g kg^{-1}, the fluid maintained stable performances. Indeed, all parameters, referred to oil chemical-physical stability and technical performance, were constant along the entire work cycle, up to 290 h. Finally, the present work showed how crambe seed cultivation, oil extraction, and exploitation in the hydraulic circuit of farm machinery could be developed applying green chemistry approaches aiming at small-scale biorefineries linked to the local supply.

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PRO BIO Techno-economic assessment of heterotrophic microalgae biodiesel production integrated with a sugarcane bio-refinery

Coelho, R.S., *et al.*, *Biofuel. Bioprod. Biorefin*, December 30, 2020, https://doi.org/10.1002/bbb.2174.

The use of diesel fuel in crop and transportation operations is responsible for one third of the carbon emissions in sugarcane biorefineries. A possible solution is to replace it with biodiesel from lipids, directly produced from sugarcane by highly productive heterotrophic microalgae. In this study, a heterotrophic microalgae biodiesel plant, integrated with a typical Brazilian sugarcane biorefinery, was designed and evaluated. Molasses, steam, and electricity from sugarcane processing were used as inputs for microalgae production. For a non-integrated plant, the production cost of the microalgae biodiesel was estimated at \$2.51 and \$2.27/liter for fed-batch and continuous processes, respectively. Equipment for cultivation and carbon sources was the highest cost affecting the financial feasibility of the proposed design. For the integrated plant, at present ethanol and biodiesel selling prices, the profitability would be lower than a first-generation sugarcane bio-refinery using fossil diesel fuel for its operations. However, the CO_2 emissions would be reduced by up to $50\,000 \times 10^3$ kg per year at a cost of \$83 10^{-3} kg^{-1} CO_2-eq. If carbon credits are considered, the process becomes economically profitable even at present fuel prices.

PRO EAT PCP HPP improves the emulsion properties of reduced fat and salt meat batters by promoting the adsorption of proteins at fat droplets/water interface

Yang, H.-J., *et al.*, *LWT 13*: 110394, 2021, https://doi.org/10.1016/j.lwt.2020.110394.

The aim of this study was to explore whether the state of the formation of interfacial protein film (IPF) could be used to increase the emulsion ability modified by high-pressure processing (HPP). The meat emulsion was obtained from the meat batters with reduced fat and reduced salt (RFRS). The results revealed the highest stability and activity of meat emulsion were obtained as 68.12% and 76.89% at 200 MPa, respectively, and the minimized diameter of emulsion particles was D3,2 2.29 micrometer. Also, after obtaining the interfacial proteins (IPs) and the fat droplets individually, the diameter of fat droplets and proportion of ionic bonds first decreased then rose along with increasing pressure, and the lowest values were exhibited at 200 MPa. In contrast, the adsorbed IPs content (0.657 mg/m2), zeta potential (– 0.27), hydrophobic interactions (63.57%), hydrogen bonds (83.29%), and disulfide bonds (75.69%) presented the opposite trends, with the highest value also exhibited at 200 MPa. In conclusion, 200 MPa helped proteins adsorbed at the interface, corresponding with the unfolding conformational rearrangement and reorientation of IPs at the interface with the dispersed fat droplets.

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Biobased Surfactants
Synthesis, Properties, and Applications
Second Edition

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Biobased Surfactants: Synthesis, Properties, and Applications, Second Edition, covers biosurfactant synthesis and applications and demonstrates how to reduce manufacturing and purification costs, impurities and by-products. Fully updated, this book covers surfactants in biomedical applications, detergents, personal care, food, pharmaceuticals, cosmetics and nanotechnology. It reflects on the latest developments in biobased surfactant science and provides case scenarios to guide readers in efficient and effective biobased surfactant application, along with strategies for research into new applications. This book is written from a biorefinery-based perspective by an international team of experts and acts as a key text for researchers and practitioners involved in the synthesis, utilization and development of biobased surfactants.

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