

BIG OIL

OARDC scientist's work made soybean oil king By Martha Filipic

As recently as the early 1980s, soybean oil was barely a blip on the culinary radar screen, unable to compete effectively with corn, cottonseed and sunflower oils.

Now, it's top shelf. In 2006, its value had climbed to \$141 billion worldwide, and soybean oil represented 71 percent of the world's edible oils.

OARDC's David Min is credited for the turnaround.

Soybean oil began to be produced commercially in the 1940s. In its crude form, it has a distasteful, grassy flavor that makes it inedible. Early on, industry developed a bleaching and deodorization process to remove the problematic flavor compounds, but producers soon realized their troubles weren't over: Too often, processed, packaged soybean oil developed the undesirable flavor again within days, or, sometimes, just hours. The phenomenon, known as "flavor reversion," vexed the industry for decades. As early as 1946, the chair of the Soybean Oil Processors Association called upon the nation's top food scientists to work together to find a solution.

"Many scientists worked very hard on the problem," and in doing so, put many pieces of the puzzle together, Min said. Over the years, they identified all of the compounds in soybean oil,

including phospholipids, tocopherols, oxidized polymers and chlorophyll. They determined that exposure to light was one culprit in flavor reversion. They discovered that soybean oil that had undergone flavor reversion contained peroxides, indicating that oxygen was involved. They also determined that because the flavor reversion reaction occurred so quickly, it required very little activation energy. That discovery itself was a puzzle, because the ordinary oxygen molecule—called "triplet oxygen"—requires a high amount of energy for such reactions. They also determined free radicals weren't the problem, because adding antioxidants didn't help. "No one could figure it out," Min said.

Min joined the faculty at Ohio State in 1979 and soon began tackling the issue with teams of colleagues and students. "This is a big soybean-producing state," he said. "We knew it would be worthwhile for Ohio if we could help solve this problem."

Min, an expert on lipids and oxidation, wondered if singlet oxygen molecules could be the root of the problem. Where

triplet oxygen, the most common type of oxygen in the atmosphere, has two unpaired electrons, singlet oxygen has no unpaired electrons.

"Singlet oxygen was first observed by a Hungarian scientist in 1934, but few people paid attention," Min said. It was rediscovered in the United States in 1969 and attracted more study. "People asked me, does singlet oxygen occur in foods? It had never been found before." He decided it was worth investigation.

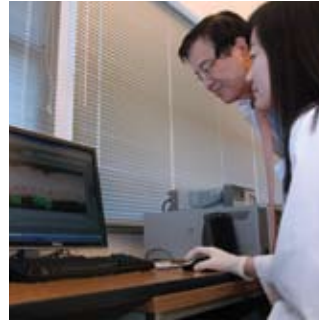
Min and colleagues found Electron Spin Resonance extremely helpful in their studies. "It's usually used to detect free radicals, but in this case we used the instrument to detect singlet oxygen in soybean oil," Min said. The find was significant: "We must have published 30 to 40 papers on this," he said.

And the more he examined singlet oxygen and soybean oil, the more he realized he was onto something. First, singlet oxygen is not a free radical. Second, singlet oxygen requires very low activation energy to react with soybean oil, allowing reactions to occur very quickly. Third, singlet oxygen can produce peroxides in

Food scientist David Min (above), known worldwide for cracking the puzzle of flavor reversion in soybean oil, has made a career of investigating the mysteries of lipids and oxidation.



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soybean oil. “Singlet oxygen explained all the reactions,” he said. But how did it form in the first place?

Min examined all of the compounds in soybean oil, carefully determined years before by scientists studying the issue. He decided to tackle the issue by removing seven types of compounds from soybean oil, and then adding them back in to see what would happen. “We purified soybean oil using chromatography until it was as clear as water. When we did that, it did not revert. So, we decided, the compounds removed from soybean oil must be associated with the oil’s reversion flavor.”

Then some trial-and-error work began.

“We added back each one, one by one, exposed the oil to light, and the oil did not produce the reversion flavor,” he said. That is, until he and his team added back chlorophyll. That’s when two compounds formed: *Trans-2* heptenal and 2-pentenylfuran—and the oil went bad.

In the end, the discovery made sense, Min said. All of the other soybean oil compounds he tested are also found in other oils. Chlorophyll is not. Min determined that when normal triplet oxygen combines with chlorophyll and is exposed to light, singlet oxygen forms, producing flavor reversion. All of a sudden, the answer was simple: All industry had to do was to remove chlorophyll during processing by passing the oil through diatomaceous earth, a natural filtration

medium, and flavor reversion became a problem of the past.

“The soybean is one of the nation’s major export products today, partly because of the success of soybean oil,” Min said.

Min has won dozens of accolades locally, nationally and internationally for his pioneering work on singlet oxygen and lipids. He received the Institute of Food Technologists’ highest research award in 1995. He was named a fellow in the International Academy of Food Science and Technology in 2006. Most recently, he received the American Oil Chemists Society Alton E. Bailey Award in 2007. And he continues to use his expertise in lipids and oxidation to study new challenges. Current projects include:

»» A \$300,000 U.S. Department of Agriculture project to reduce unhealthy trans fats in hydrogenated fat. Many food manufacturers who previously relied on hydrogenated fat have switched to oils to make their products more healthy, Min said. But hydrogenated fats remain much more economical to use in the food industry, and Min and a colleague at Miami University took the challenge to find out how to significantly reduce trans fats in hydrogenated fat. With a year to go in the three-year study, they believe they’ve found an answer by electronic hydrogenation of oil at room temperature. “Trans fatty acids form at high temperatures,” Min explained. “By conducting the electronic hydrogenation

at room temperature instead, we can’t eliminate them completely, but we can decrease them significantly.”

»» A project funded by Samsung Electronics to slow off-colors from forming on beef during refrigeration. Min said that retailers and the beef industry lose an estimated \$1 billion a year when raw beef experiences oxidation and its deep red color becomes gray or brown. The Ohio State University and Samsung Electronics are jointly studying the effects of different levels of electrons, different times and temperatures of exposure, and different polarities to improve the quality of beef including color and flavor during storage.



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