Researcher Puts Gas Under Pressure for Supercritical Fluid Extraction

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On his laboratory desk, University of Arkansas researcher Jerry King has a small display with three vials. The first vial contains small chocolate candies. Another vial is three-quarters full of the cream-colored, liquid fat he extracted from the candies. The third vial contains shrunken balls of chocolate without fat.

The simple display amply illustrates King's work, in which he heats and pressurizes gas and liquids to extract substances from food and other products. King, who holds the Ansel and Virginia Condray Distinguished Professor of Chemical Engineering, is an international leader in "critical fluid technology," a phrase used to describe the process of removing agents or substances from food and other products by treating the products with pressurized fluids.

King specializes in supercritical fluid extraction, a process by which carbon-dioxide gas is pressurized and heated until it assumes the properties of a liquid. The substance is "super" in that it is heated and pressurized to a critical point, the highest temperature and pressure at which the substance can exist in equilibrium as a vapor and liquid.

By mixing the liquefied carbon dioxide with food or other products, scientists can remove substances from products. The extraction process is safe and has many applications, including removing caffeine from coffee, fat from meat, cholesterol from eggs and milk, and pesticides from fruits and vegetables. Supercritical fluid extraction also has been used to remove toxins from a wide array of industrial products, including liquids used for household cleaning.

Perhaps most importantly, supercritical fluid extraction is an environmentally safe processing method that does not harm the products from which substances are extracted. Critical fluids such as carbon dioxide, subcritical water -- water held in its liquid state above normal atmospheric boiling point by applying pressure -- and mixtures of carbon dioxide with ethanol, are environmentally benign agents. After mixing the fluids with a target product, scientists can return the fluids to a gaseous state. The carbon dioxide may then be recycled or released into the environment with no harmful effect. And, unlike toxic solvents used in traditional extraction methods, supercritical fluids do not leave solvent residues in products, so they are safer for human consumption.

"Supercritical fluid extraction is a totally 'green' processing platform," King said. "This is an interesting issue because using them to extract and refine components in foods and natural products is not a new practice. Scientists have used this method for more than 30 years. But, with the environmental movement of the past 15 years and a growing consumer interest in healthy and safe foods, supercritical fluids have become more relevant. More and more people are interested in this process because they want foods and other products that are free of toxic chemical agents."

Researchers in King's laboratory pressurize carbon dioxide up to 12,000 pounds per square inch -- by contrast, most car tires have a pressure of 35 PSI -- and heat the gas to above 31 degrees Celsius, depending on the targeted product. Specific temperature and pressure is determined for each substance to be extracted. The process of heating and pressurizing causes carbon dioxide to assume the density and some of the properties of a liquid or supercritical fluid. King then injects the fluid into food products, such as soybeans, corn germ, berries and spices. The fluid separates substances, which can then be extracted.

The process can be used on almost any food. In recent years, King has applied supercritical fluid extraction to nutraceuticals, organic substances such as ginseng, ginko biloba, black cohosh and St. John's wort that combine the nutritional requirements of food with an aspect of therapeutic protection for the human body. Nutraceuticals have become more popular as natural remedies for colds and flu, depression, certain types of cancer and even symptoms of menopause.

The expansion of King's research in this area involves the use of subcritical water and ethanol mixed with carbon dioxide to extract and enrich phytosterols, compounds found in rice bran, corn fiber or bran and soybeans. Used in margarines and spreads, phytosterols have cholesterol-reducing properties. King has pending patent on the use of subcritical water for the extraction of nutraceutical components from grapes and berry substrates. Related research investigates the use of subcritical water as a processing agent for the treatment of biomass for fuels.

King collaborates with Ed Clausen, professor of chemical engineering; Julie Carrier, associate professor of biological and agricultural engineering; and Luke Howard, professor of food sciences. Clausen and Carrier developed a water-based extraction process for milk thistle, a plant containing compounds that may have therapeutic value in treating prostate cancer and liver disease. Howard uses similar methods to recover anthocyanins and flavanoids from grapes.

A former scientist at the Los Alamos National Laboratory, King also has plans to apply critical fluid technology for fuels production.

Source: University of Arkansas