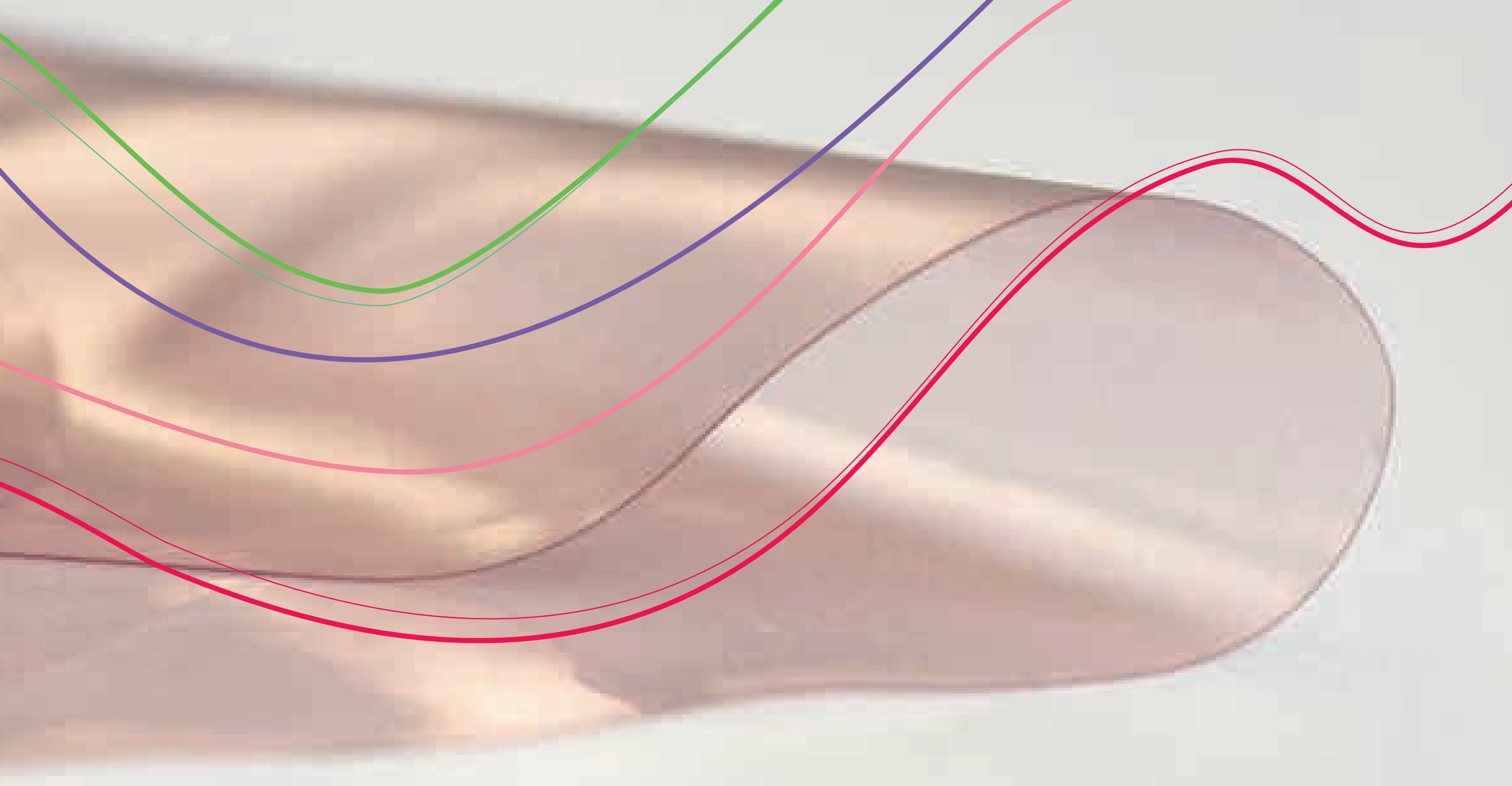
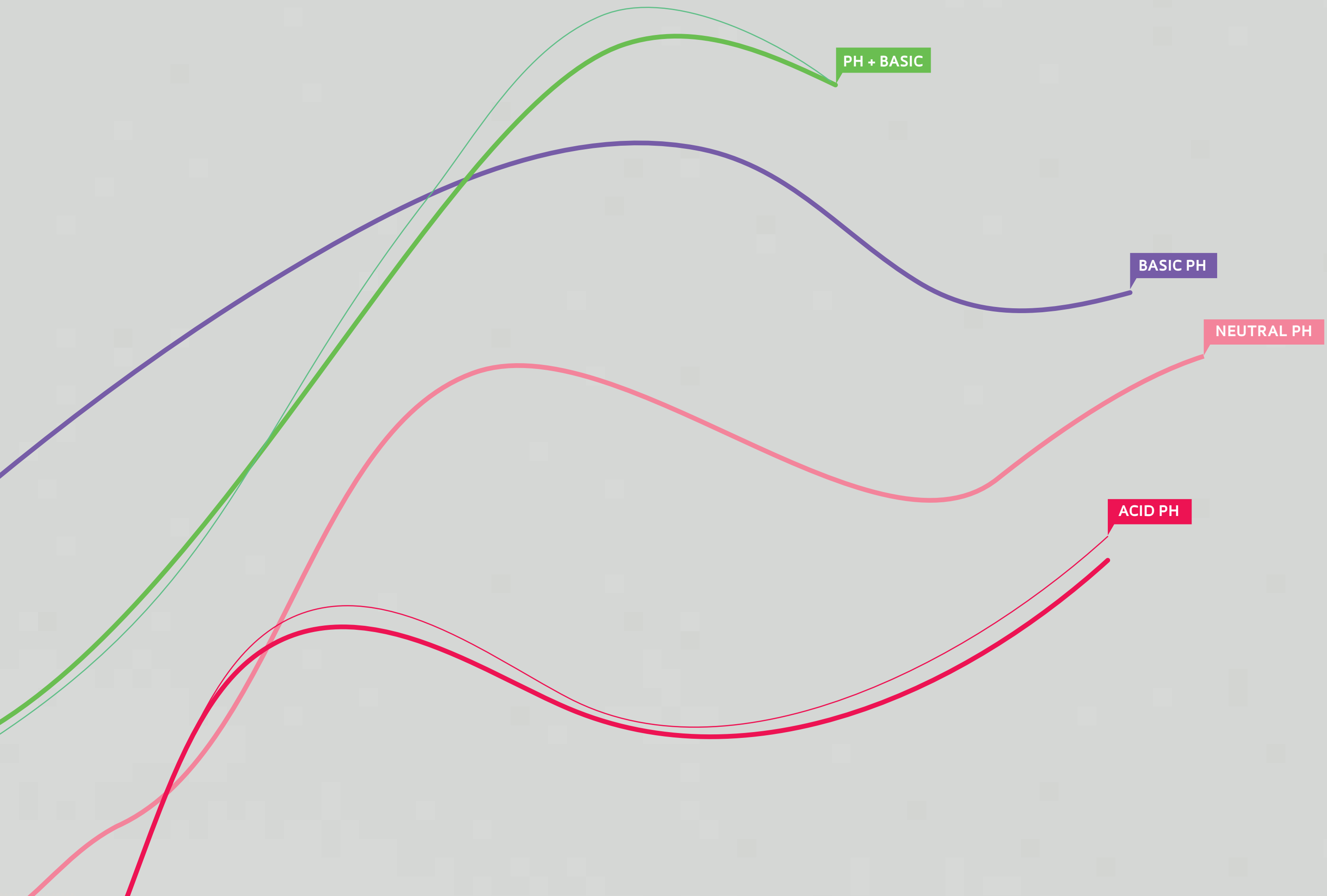
INTELLIGENT PACKAGING

Color in fungi

Sensitive film warns consumers about food deterioration

Evanildo da Silveira
PUBLISHED IN MAY 2011





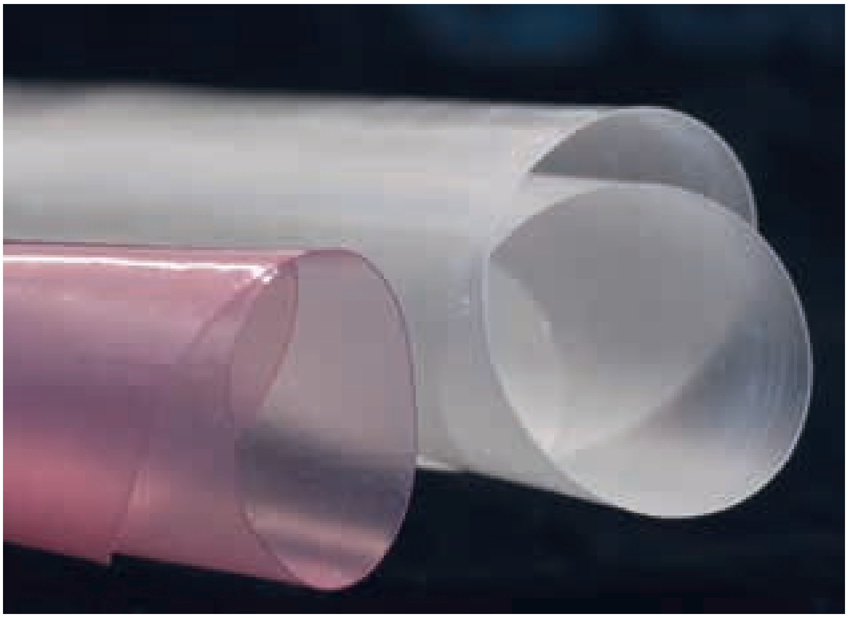
The traditional manioc (also known as cassava), a native plant from the southeast of the Amazon Region and the staple food of Brazil's indigenous people, had been used as food long before the arrival of the Portuguese explorers. Cassava now has new and advanced technological functions. Biodegradable plastic films made from the starch of this vegetable can be used to produce active packaging, capable of preventing the growth of fungi, or intelligent packaging, which changes color when the food product begins to spoil. This polymer is also being tested in heart surgery to coat venous implants and provide them with higher resistance during the initial phase or to release drugs.

The studies that resulted in the plastic films made from cassava, a polysaccharide whose main function is storing the energy produced by photosynthesis, began in 2004 at the University of São Paulo (USP). The films, developed by the research group coordinated by Professor Carmen Cecília Tadini from the Food Engineering Laboratory of the Chemical Engineering Department of USP's Polytechnic School, share a common element, which is the addition of glycerol during the composition of the film. Glycerol is a plasticizing substance, commercially referred to as glycerin. A low-cost compound, glycerol is a by-product of biodiesel.

This research group has conducted studies on three types of plastic films, each one characterized by the substances in their compositions. Two of the films contain clay nanoparticles to make them more resistant. In the case of the antimicrobial film, the substances include clove and cinnamon oils, which provide protection from microorganisms. Laboratory tests with the polymer containing these oils revealed that the polymer prevents the growth of fungi. "Nowadays, anti-fungi substances are applied to the packaged product for protection," says Carmen. "The assays we conducted on the films that we developed showed that this protection lasts for up to seven days."

One of the challenges that the researchers had to address to produce the film was to establish the specific doses of the clove and cinnamon oils. If they were too high, the characteristic scent of these spices could seep into the packaged foods; if too low, the spices would lack the necessary efficacy to prevent microbial growth. The challenge of solving this problem was handed over to doctoral student Ana Cristina de Souza, who had been an intern at the High Pressure and Supercritical Technology Laboratory at the Univer-

PHOTOS EDUARDO CESAR



The pink film contains grape extract in its composition, whereas the transparent film contains cinnamon extract

sity of Coimbra, in Portugal. While an intern in this laboratory, Ana Cristina learned how to employ carbon gas using the supercritical state technique to incorporate the said oils into the polymers. She explains that the supercritical state is achieved when the temperature and the pressure of a substance are above its critical point, which occurs when a specific pressure is achieved and the liquid-vapor balance no longer exists. A substance in this state has many applications in chemical separation and extraction processes.

The other plastic is also made from cassava starch, glycerin, and clay nanoparticles. However, unlike the first plastic, it has a fourth compound, anthocyanin, a natural component of purple or purplish fruit, such as grapes, açaí palm, jaboticabas (Brazilian grapes) and blackberries.

"Anthocyanins have the ability to change their color as their pH changes, which is the characteristic that we take advantage of in our work," Carmen explains. "As changes in the pH are one of the first signs that a food product is beginning to deteriorate, we use this component to produce a film for intelligent packaging. It changes color when the food inside the packaging starts to spoil. A palette of colors on the packaging can tell the consumer whether the product is still good or not."

The third polymer is being tested together with the team headed by Professor José Eduardo Krieger, director of the Genetics and Molecular Cardiology Department of the Heart Institute (InCor) of the School of Medicine of USP. This plastic is employed to improve the efficiency of the vein grafts used in coronary artery bypass graft surgery.

In this case, the film does not contain clay nanoparticles because it is meant to be absorbed by the patient's body. In addition to cassava starch and glycerol, the film contains a substance called carboxymethyl cellulose (CMC), a polysaccharide extracted from cellulose that improves the mechanical properties of plastic.

NATURAL RESISTANCE

In coronary bypass implants, when the saphenous vein is removed from the leg and is placed inside the heart to function as an artery, the demand for resistance is higher compared with that of the vein's natural function. Krieger explains that the speed of the flow is slower and that the pressure of the blood running in the veins is lower than in arteries, which is why the walls of veins are thinner than those of arteries. When a vein such as the saphenous vein is implanted in the heart, its function undergoes an abrupt change, and the vein has to adapt quickly to its new role. Understanding how this process works and what happens when a vein begins to act like an artery is the objective of the line of research being developed by Krieger at InCor. "We want to know which genes and proteins are involved in this process," he explains.

Once the process is understood, one can conceptualize new interventions to improve performance and to enable the coronary bypass to last longer. Krieger explains that 50% of coronary bypasses become nonfunctional after 10 years, as if "the warranty had expired in one half of all the cases." The work being conducted by the team seeks to find an alternative to increase this "warranty." To this end, the film developed by Carmen and her team is being tested for two functions. In the first, it is used to envelop (i.e., to coat) the coronary bypass externally, giving it more resistance and support during the initial stages after the surgery. Then, the vein that is now functioning as an artery acquires its own support. Therefore, the film loses its function, and its capacity for being absorbed by the body becomes an advantage.

The second function entails using the film as a platform to release drugs or other substances. "If we discover the genes or proteins involved in this process, which is different in each patient, we will be able to interfere in the process using therapeutic means," says Krieger. "Thus, if a gene is more active than it should be, we can switch it off with drugs, for example." For the film developed by Carmen to be able to perform this function, it has to be infused with drugs, just like other plastics are infused with anti-microbial or color-changing substances. For the time being, the tests conducted in Krieger's lab are in vitro

THE PROJECT

Active biodegradable packaging based on cassava starch and natural edible additives: preparation, characterization and evaluation - no. 2005/51038-1

TYPE
Regular Research Grant

COORDINATOR
Carmen Cecilia Tadini - USP

INVESTMENT
R$ 85,401.19 and US$ 58,250.00 (FAPESP)

The films developed at USP are infused with various substance types according to the function they are to perform

Intelligent packaging for grapes shows if they start spoiling

tests using vascular segments and cells and in vivo tests on experimental models using rats. The next step will be to conduct tests on rabbits and pigs.

The project for the development of the film to envelop the heart veins is more recent. It started in 2009 as a doctoral project conducted by Helena Aguiar with funding from the National Council for Scientific and Technological Development (CNPq) and with the participation of a group of researchers from USP's Chemical Institute in São Carlos, headed by Professor Douglas Franco. The most advanced project in this respect is the development of a plastic with anti-microbial properties, a project initiated in 2004. "We are already at the point of making production feasible on an industrial scale," says Carmen. This project was funded by FAPESP. The group received grants from the CNPq and the Coordinating Office for the Improvement of Higher Education Personnel (Capes).

HOMOGENEOUS AND BIODEGRADABLE

The evolution related to the integration of clay nanoparticles includes the work of doctoral student Otilia de Carvalho, who attended an internship program at France's University of Strasbourg, specifically at the Engineering and Polymers and High Technology Laboratory (the acronym in French is *Lipht*). "My main objective during the internship was to prepare a film from starch and a nanocompound with clay, plasticized with glycerol," she says. "As there is low compatibility between starch and clay, I tested two modifications and obtained a more homogeneous material."

A research study presented in April by Germany's Fraunhofer Institute also describes the use of films that change color when foods such as meat and fish have deteriorated. A study conducted by Professor Anna Hezinger used chemical sensors on plastic packaging. These sensors respond to amines, molecules found in deteriorating meats, and they change the color of the film that envelops the product. Anna's research studies were funded by the German Ministry of Education and Research. Anna is currently looking for colleagues with whom to partner to produce the chemical sensors for food packaging.

The general field of biodegradable plastics is being developed around the world. Many types of such films are being produced in countries such as Japan, the United States, Holland, and Brazil. These films are produced from various sources, such as cassava, corn, potatoes, soybeans and cellulose. In Brazil, a biodegradable plastic made from sugar cane is being produced on a pilot scale. This biodegradable plastic's properties are similar to those of propylene. This product, called Biocycle, was developed through a partnership between the Institute of Technological Research (IPT) and the Copersucar Technology Center (CTC) in the early 2000s. "Nowadays, the production technology is consolidated," says general manager Eduardo Brondi, of the PHB company that produces this bioplastic. "The company's total production is geared towards development and applications testing in conjunction with a number of partners around the world." These applications include automotive parts, toys, drinking glasses and cutlery.

According to a study conducted by European Bioplastics, a trade association established in 2006, whose members include manufacturers, processors and users of bioplastics, biodegradable polymers and by-products, the latest available data (from 2007) show that the global production capacity of bioplastics corresponds to approximately 0.3% of the world's plastics production, which is derived mostly from petrochemical sources. The forecast is that the production of bioplastics will correspond to 2.33 million tons in 2013 and 3.45 million tons in 2020. ■

Scientific articles

1. KECHICHIAN, V.; DITCHFIELD, C.; VEIGA-SANTOS, P.; TADINI, C.C. Natural antimicrobial ingredients incorporated in biodegradable films based on cassava starch. **LWT - Food Science and Technology**. v. 43, p. 1.088-94. 2010.

2. VEIGA-SANTOS, P.; DITCHFIELD, C.; TADINI, C. C. Development and evaluation of a novel pH indicator biodegradable film based on cassava starch. **Journal of Applied Polymer Science**. v. 120, p. 1.069-79. 2011.