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RESEARCH NEWS

1 Vegetarian cutlet

It looks like a cutlet, it's juicy and fibrous like a cutlet, and it even chews with the consistency of a real cutlet – but the ingredients are 100 percent vegetable. Researchers are using a new method to prepare a meat substitute that not only tastes good, but is also environmentally sustainable.

2 Implant to replace defective venous valve

If heart valves don't close properly, they are replaced. Conventional treatment of venous valve failure, however, has up to now always and exclusively been via medication. In future, an implant will assume the function of damaged valves – and a new dispensing tool means these prostheses can be made using an automated process.

3 Swarming and transporting

On its own, an ant is not particularly clever. But in a community, the insects can solve complicated tasks. Researchers intend to put this „swarm intelligence" to use in the logistics field. Lots of autonomous transport shuttles would provide an alternative to traditional materials-handling technology.

4 Environmentally-friendly cleaning and washing

More and more everyday products are based on renewable resources, with household cleaners now containing active cleaning substances (surfactants) made from plant oils and sugar. These fat and dirt removers are especially environmentally friendly and effective when produced using biotechnology, with the aid of fungi and bacteria.

5 Building lightweight trains

The less trains weigh, the more economical they are to run. A new material capable of withstanding even extreme stresses has now been developed. It is suitable for a variety of applications, not least diesel engine housings on trains – and it makes these components over 35 percent lighter than their steel and aluminum counterparts.

6 First aid for winemakers

Whether or not a wine turns out to be as outstanding as the winemaker hopes depends on the quality of the yeasts; they control the fermentation process and create the distinctive flavor. A new sensor allows winemakers to establish whether the grape must contains the right sort of microorganisms before fermentation has even begun.

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 60 Fraunhofer Institutes at over 40 different locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of around 20,000, who work with an annual research budget totaling 1,8 billion euros. Roughly two thirds of this sum is generated through contract research on behalf of industry and publicly funded research projects. Branches in the USA and Asia serve to promote international cooperation.

Editorial Notes:

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Vegetarian cutlet

Meat production is complicated, costly and not eco-friendly: fatted animals have to consume five to eight kilos of grain just to generate one kilogram of meat. It would be simpler and more sustainable if one were to make cutlets out of seed – without the detour through the animal's body. Impossible? Not entirely: there are plants that are suitable for the production of meat substitute products. Researchers in the EU-project "LikeMeat" have studied what they are, and how they can be incorporated into a product that tastes and looks like meat. "Studies have shown that many Europeans are ready to give up meat, but there have only been a handful of alternatives until now," explains Florian Wild. The researcher at the Fraunhofer Institute for Process Engineering and Packaging IVV in Freising is spearheading the project. "Our goal is to develop a vegetable surrogate for meat that is both juicy and fibrous, but that also has a pleasant flavor. The product should have a long shelf life, it should not be more expensive than meat, and be suitable for vegetarians and allergy sufferers."

In addition to the scientists at IVV, experts from the University of Natural Resources and Life Sciences, Vienna (BOKU) are also participating in the development, as are consumer researchers from the University of Wageningen, in the Netherlands, and eleven small to medium-sized corporations that manufacture or do business in food or food ingredients. The team roster also includes two Austrian and one Dutch company that have hitherto only processed meat, as well as an organic food producer from Spain. "As a group, we are seeking to engineer a simple production chain in which pure vegetable raw materials are used to produce a meat substitute that corresponds to consumer preferences," as Wild summarizes it. The ingredients originate from the land: Wheat and peas, lupins and soya are all suited for production, explains Wild: "We are intentionally not tying ourselves down to one type of plant because many people get an allergic reaction to the one or other substance. In the process, we have developed a variety of recipes. They are the basis for a product spectrum that offers a broad selection to people who suffer food intolerance or allergies."

But how do you turn a field crop into meat? "The processing technology was the biggest challenge," recalls the project manager. The previously conventional methods of mixing plant proteins with a little water, and heating them under high pressure, proved to be useless: With this hot extrusion process, the mass is heated up under high pressure. At the moment when it pushes through the die, the temperature drops dramatically, steam is released and the mass foams up. That is certainly the desired effect when making peanut flips. But not in the production of meat substitutes. Wild and his colleagues use a new process specially developed for meat substitutes: The main ingredients – water and plant proteins – are brought to a boil and slowly cooled down. Since no sudden release of pressure takes place, no steam blows out of the paste. As the temperature sinks, the protein molecules start to form chains. This gives rise to a fibrous structure that is quite similar to that of meat.

The prototype of the new vegetarian cutlet factory is currently located in the IVV laboratory. The system is no larger than two table tennis tables. On request, it can produce one endless piece of meat approximately 1-cm thick that can be shaped as desired, for example into little morsels for diced or thinly-sliced meats, or entire cutlets. The research team is currently able to produce 60 to 70 kilos of the meat substitute per hour – or 300 to 500 kilos per day. "Consistency and texture are already superb," Wild assures. There is still a little work to do on the flavor. By the end of the project term, in one year, the meat substitute from the land should be every bit as good as a genuine cutlet, and it should come directly from the machine, ready-to-eat. The experts will present their new product at the Anuga FoodTec trade fair from March 27 through March 30 in Cologne.

The ingredients in this cutlet are 100 percent vegetable. (© Fraunhofer IVV) | Picture in color and printing quality: www.fraunhofer.de/press

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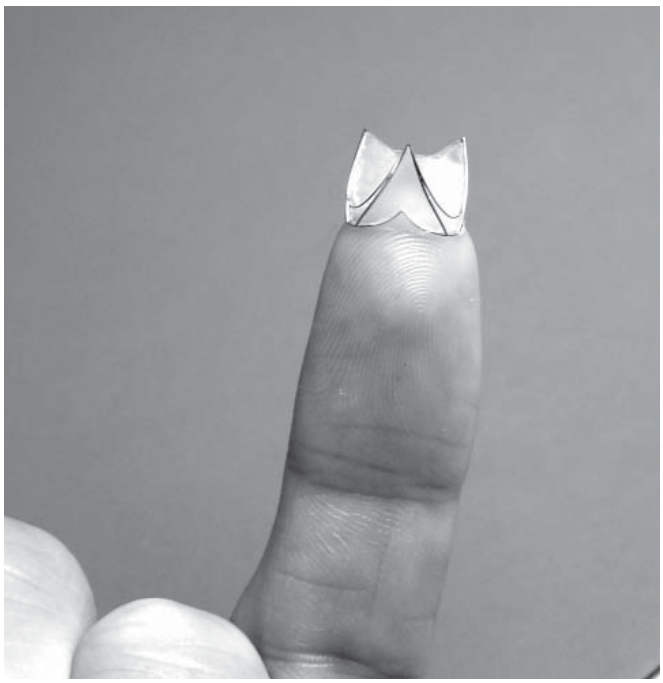
Implant to replace defective venous valve

It's one of the most commonly occurring medical conditions – chronic venous insufficiency (CVI). Almost ten million German citizens suffer from weak veins that require treatment, with twice as many women being affected as men. The cause of this widespread condition is restricted functioning of the venous valves in the legs. If the venous valve is no longer able to close properly, blood will observe the laws of gravity in between heartbeats and flow down to collect in the legs. This leads to edemas, and can cause open ulcers in particularly severe cases. CVI is usually treated with anti-inflammatory drugs and diuretics; as yet there is no globally available venous valve implant that can be used to treat the illness. This is something that researchers from the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart are setting out to change: In close collaboration with four industrial partners and Helmholtz-Institute for Biomedical Engineering of RWTH Aachen University, they have developed an automated production facility that can make venous valve prostheses from polycarbonate-urethane (PCU), a plastic. The project was sponsored by the German Federal Ministry of Economics and Technology BMWI.

The centerpiece of the facility is a 3D droplet dispensing tool which enables the researchers to precisely apply a particular polymer onto freeform surfaces and at the same time combine various grades of polymer hardness, called Shore hardnesses. "3D droplet dispensing technology is an additive procedure that allows three-dimensional geometries to be created layer by layer using a polymer", explains Dr. Oliver Schwarz, group manager at the IPA. The scientists use PCU because it is particularly strong and flexible, while another useful property of the material is that it is easy to sew into surrounding tissue. PCU structures can be made in very thin layers, which is ideal when replacing wafer-thin atrioventricular valves. "By using PCU in combination with our 3D dispensing kinematics, we can achieve seamless transitions within the material between six different grades of elasticity and hardness – without any breaking points whatsoever. This technique mirrors the design of highly stressed structures in nature. It can't be done using injection molding", says Schwarz.

But how does the PCU become a venous valve prosthesis? Initially, the polymers are dissolved in a solvent and deposited onto a venous valve prosthetic mold one droplet at a time, using the dispensing tool. The system is accurate to within 25 micrometers, and can deliver up to 100 droplets per second, each with a volume of 2 to 60 nanoliters. A six-axis kinematic system positions the piezo feeder precisely above the mold. Once it is fully coated with droplets, the mold is bathed in a warm stream of nitrogen. This causes the solvent to evaporate, leaving the polymer behind. Further layers are applied by repeating the dispensing process, and in the end the polymer prosthesis can simply be peeled from the mold. Doctors can take the finished replacement valves and implant them into the veins of the leg via a catheter passed through the skin.

The production facility comprises numerous other components besides the dispenser. The IPA experts are responsible for, amongst other things, the filling and monitoring system, the drying facilities, the entire clean-room box and the control mechanism for the six-axis kinematic system. "We have successfully managed to re-program the Beckhoff control system normally used with milling machines in such a way that it can now be used with additive processes," Schwarz is happy to report. The solution they have come up with will soon see the researcher and his team in a position to produce thin-walled, highly durable implants such as heart valves or intervertebral disks. The IPA scientists will be presenting a prototype of their 3D droplet dispenser at the MEDTEC Europe 2012 trade fair from March 13 – 15 in Stuttgart (Hall 6, Booth 6211).



The finished venous valve is highly durable. (© Helmholtz-Institute of Biomedical Engineering of RWTH Aachen) | Picture in color and printing quality: www.fraunhofer.de/press

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Swarming and transporting

The orange-colored vehicle begins moving with a quiet whirr. Soon afterwards the next shuttles begin to move, and before long there are dozens of mini-transporters rolling around in the hall. As if by magic, they head for the high-rack storage shelves or spin around their own axis. But the Multishuttle Moves® – is the name given to these driverless transport vehicles – are not performing some robots' ballet. They are moving around in the service of science. At the Fraunhofer Institute for Material Flow and Logistics IML in Dortmund, Germany, researchers are working to harness swarm intelligence as a means of improving the flow of materials and goods in the warehouse environment. In a research hall 1000 square meters in size, the scientists have replicated a small-scale distribution warehouse with storage shelves for 600 small-part carriers and eight picking stations. The heart of the testing facility is a swarm of 50 autonomous vehicles. "In the future, transport systems should be able to perform all of these tasks autonomously, from removal from storage at the shelf to delivery to a picking station. This will provide an alternative to conventional materials-handling solutions," explains Prof. Dr. Michael ten Hompel, executive director at IML.

But how do the vehicles know what they should transport, and where, and which of the 50 shuttles will take on any particular order? "The driverless transport vehicles are locally controlled. The ›intelligence‹ is in the transporters themselves," Dipl.-Ing. Thomas Albrecht, head of the Autonomous Transport Systems department explains the researchers' solution approach. "We rely on agent-based software and use ant algorithms based on the work of Marco Dorigo. These are methods of combinational optimization based on the model behavior of real ants in their search for food." When an order is received, the shuttles are informed of this through a software agent. They then coordinate with one another via WLAN to determine which shuttle can take over the load. The job goes to whichever free transport system is closest.

The shuttles are completely unimpeded as they navigate throughout the space – with no guidelines. Their integrated localization and navigation technology make this possible. The vehicles have a newly developed, hybrid sensor concept with signal-based location capability, distance and acceleration sensors and laser scanners. This way, the vehicles can compute the shortest route to any destination. The sensors also help prevent collisions.

The vehicles are based on the components of the shelf-bound Multishuttle already successfully in use for several years. The researchers at IML have worked with colleagues at Dematic to develop the system further. The special feature about the Multishuttle Move®: the transporters can navigate in the storage area and in the hall. To accomplish this, the shuttles are fitted with an additional floor running gear. But what benefits do these autonomous transporters offer compared with conventional steady materials-handling technology with roller tracks? "The system is considerably more

flexible and scalable," Albrecht points out. It can grow or contract depending on the needs at hand. This is how system performance can be adapted to seasonal and daily fluctuation. Another benefit: It considerably shortens transportation paths. In conventional storage facilities, materials-handling equipment obstructs the area between high-rack storage and picking stations. Packages must travel two to three times farther than the direct route. "It also makes shelf-control units and steady materials-handling technology," Albrecht adds. Researchers are now trying to determine how these autonomous transporters can improve intralogistics. "We want to demonstrate that cellular materials-handling technology makes sense not only technically but also economically as an alternative to classic materials-handling technology and shelf-control units," institute executive director ten Hompel observes. If this succeeds, the autonomous vehicles could soon be going into service in warehouses.

The autonomous transporters perform their work in a swarm. (© Fraunhofer IML) | Picture in color and printing quality: www.fraunhofer.de/press

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Environmentally-friendly cleaning and washing

Detergents are everywhere – in washing powders, dishwashing liquids, household cleaners, skin creams, shower gels, and shampoos. It is the detergent that loosens dirt and fat, makes hair-washing products foam up and allows creams to be absorbed quickly. Up until now, most detergents are manufactured from crude oil – a fossil fuel of which there is only a limited supply. In their search for alternatives, producers are turning increasingly to detergents made from sustainable resources, albeit that these surfactants are usually chemically produced. The problem is that the substances produced via such chemical processes are only suitable for a small number of applications, since they display only limited structural diversity – which is to say that their molecular structure is not very complex. Now researchers at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB are taking a different approach: they are manufacturing surfactants using biotechnological methods, with the assistance of fungi and bacteria. "We produce biosurfactants microbially, based on sustainable resources such as sugar and plant oil," says Suzanne Zibek, a technical biologist and engineer at the IGB in Stuttgart. The scientist and her team use cellobiose lipids (CL) and mannosylerythritol lipids (MEL) because testing has shown these to be promising for industrial application. They are produced in large quantities by certain types of smut fungus, of the kind that can affect corn plants. What is more, CL also has antibacterial properties.

What marks biological surfactants out from their synthetic competitors is their increased structural diversity. In addition, they are biodegradable, are less toxic and are just as good at loosening fats. But despite all this, to date they are used in only a few household products and cosmetics. The reason is that they are costly and difficult to produce, with low yields. One substance that has been successfully brought to market is the sophorose lipid made by Candida bombicola, which is used by a number of manufacturers as an additive in household cleaning products. This biosurfactant is produced by a yeast that is harvested from bumble-bee nectar.

"If we want natural surfactants to conquer the mass market, we need to increase fermentation yields," says Zibek. To this end, the scientists are optimizing the production process in order to bring down manufacturing costs. They cultivate the microorganisms in a bioreactor, where they grow in a continuously stirred culture medium containing sugar, oil, vitamins and minerals salts. The goal is to achieve high concentrations in as short a time as possible, so they need to encourage as many microorganisms as possible to grow. There are numerous factors with a bearing on the outcome, including the oxygen supply, the pH value, the condition of the cells, and the temperature. The composition of the culture medium itself is also crucial. It is not just a question of how much sugar and oil go into the mix, but also the speed at which they are added. "We have already achieved concentrations of 16 grams per liter for CL and as high as 100 grams per liter for MEL – with a high production rate, too," the group manager is happy to report.

The next step is to separate the biosurfactants from the fermentation medium and to characterize them with the help of industrial partners, determining which surfactants are suitable for use in dishwashing liquids, which are more suited to oven cleaning products, and which are ideal for use in cosmetics. The substances can finally be mo dified or improved at the enzymatic level. "For instance, we managed to increase wa-ter solubility. After all, the biosurfactant shouldn't form an oily film over the surface of the dishwashing liquid," explains Zibek. The experts have even managed to produce biological surfactants using waste products, by obtaining the sugar needed for the culture medium from straw. The researchers will be presenting biosurfactants they have produced themselves at HANNOVER MESSE from April 23 to 27, 2012 (Hall 2, Booth D22).

The researcher takes samples from the bioreactor. (© Fraunhofer IGB/Frank Kleinbach) | Picture in color and printing quality: www.fraunhofer.de/press

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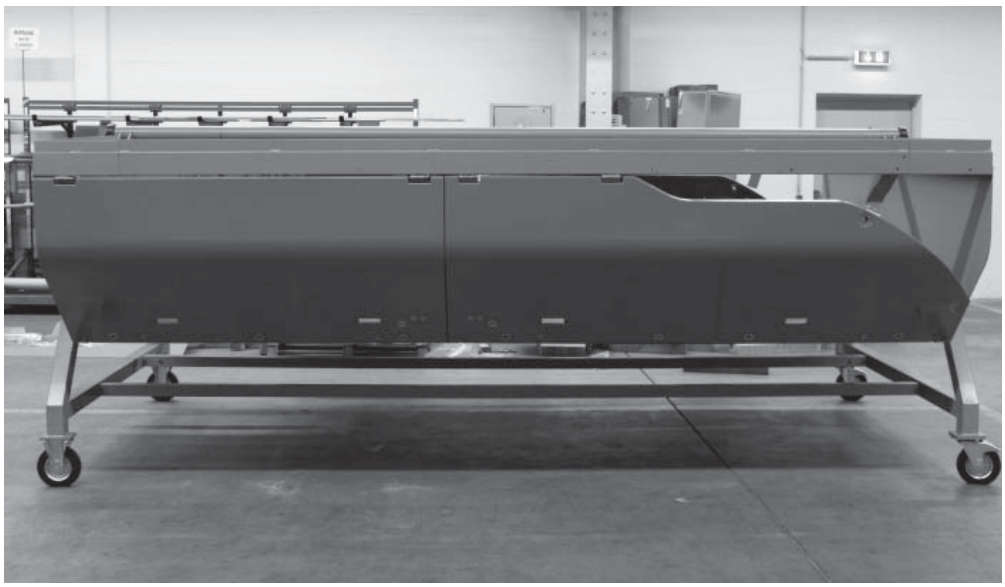
Building lightweight trains

In their efforts to render cars and trains more economical, manufacturers are trying to find lighter materials to replace those currently used. But there is a problem: Lighter materials tend not to be as tough as steel or aluminum, so they cannot simply be used in place of these metals. Rather, it is a question of manufacturers deciding which components can really afford to have weight shaved off and how to integrate them into the overall systems.

Working together with Bombardier GmbH, KraussMaffei Kunststofftechnik GmbH, Bayer MaterialScience AG, DECS GmbH, the DLR's Institute for Vehicle Concepts, the University of Stuttgart and the Karlsruhe Institute for Technology, researchers at the Fraunhofer Institute for Chemical Technology ICT in Pfinztal have now developed a polyurethane-based sandwich material that is extremely resilient. "To demonstrate the material, we manufactured a component that is subject to significant stresses and which has to fulfill a number of requirements – the diesel engine housing for a train," says Jan Kuppinger, a scientist at the ICT. This housing is located beneath the passenger compartment, i.e. between the car and the tracks. Not only does it shield the engine against flying stones and protect the environment from any oil that might escape, but in the event of a fire, it also stops the flames from spreading, thus meeting the flame retardant and fire safety standards for railway vehicles. Kuppinger adds: "By using this new material, we can reduce the component's weight by over 35 percent – and cut costs by 30 percent."

The researchers opted for a sandwich construction to ensure component stability: Glass fiber reinforced polyurethane layers form the outer facings, while the core is made of paper honeycomb. Polyurethane is a bulk plastic combining two substances. Since it can be adapted to fulfill various requirements, it is referred to as a 'customizable material'. In foamed form it is soft, and can be used for example as a material for mattresses; in compact form it is strong and hard. The researchers began by incorporating various additives into their polyurethane, altering it in such a way as to ensure it would meet fire safety standards. Then, the partners optimized the standard manufacturing process, fiber spraying, by developing a mixing chamber which allows even more complex structures to be produced in any required size. The diesel engine housing they made is approximately 4.5 meters long and more than 2 meters wide. "This is the first time it has proved possible to use this process to manufacture such a large and complex component that also satisfies the structural requirements," states Kuppinger. Previously, one problem encountered with fiber spraying was that it was impossible to determine the precise thickness of the polyurethane top layers. But now the researchers have found a way to do this, using computer tomography to inspect the manufactured layers and then applying a specially-adapted evaluation routine to establish their exact thickness. This information helps to simulate the strength of the component, as well as its ability to withstand stresses.

The scientists produced their diesel engine housing demonstrator as part of the PUR-train project, which is funded by the German Federal Ministry of Education and Research (BMBF). The demonstrator passed its first strength test – in which the scientists placed it in a test rig and then applied forces to it at various locations, measuring the extent to which it deformed – with flying colors. In the next stage, the researchers want to trial the component in a proper field test. If that, too, proves successful, it will then be possible to use the material to make roof segments, side flaps and wind deflectors for the automobile and commercial vehicle industry, and to ramp up the manufacturing process to produce medium volumes of between 250 and 30,000 units.



Although this diesel engine housing for trains is made of a light polyurethane-based material, it is nonetheless capable of withstanding extreme stresses. (© Fraunhofer ICT) | Picture in color and printing quality: www.fraunhofer.de/press

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First aid for winemakers

A good wine is unmistakable. It has its own particular taste, its own characteristic and singular aroma. None of this happens by accident: the production of quality wines is an art form in its own right. The vintner has to plant the right variety of grape, harvest and press it at just the right moment and store the grape juice properly for fermentation. "Even if you get everything right in the preparations, there's still an element of risk," explains Dr. Mark Bücking of the Fraunhofer Institute for Molecular Biology and Applied Ecology IME. It is not just location, type of grape and degree of ripeness that give a wine 'that special something'; the yeasts that are active during the fermentation process are just as important. These yeasts are microorganisms that occur naturally in areas where wine is produced. Each vineyard has a characteristic yeast population of its very own, and it is this that lends the wine its own distinctive flavor. Only those winemakers who use these wild yeasts for spontaneous fermentation are in with a chance of producing a truly top-class wine that will garner the praise and approval of connoisseurs.

Spontaneous fermentation is not without its risks, though, since not all wild yeasts have a positive effect on the development of a wine. There are some "bad guys" that can generate unpleasant flavors or even impede the fermentation process. Ex-perienced winemakers always keep a very close eye on the process so that they can add cultured yeasts if necessary. "Supplementing the wine in such a way has a detrimental effect on its quality, however, and the resulting wine is destined for mediocrity," says Bücking. The research scientist is not only a wine lover and connoisseur, but also an analytical specialist. He and his team have developed a prototype piece of equipment that winemakers can use to check whether the yeasts present in their wine must are indeed the right ones. The experts will be presenting their work at the Anuga FoodTec trade fair in Cologne from March 27 to 30, 2012.

The detector is no bigger than a cell phone, and fits into any trouser pocket. It contains ten little Plexiglas tubes, each coated with antibodies. The winemaker takes a pipette and fills the tubes with wine must, upon which any yeast that encounters a matching antibody on the walls of the tubes sticks to the sides. The ensuing biochemical reaction produces an easily recognizable color change: the little tube turns blue. "We can already detect half a dozen different types of yeast in a short space of time just using this prototype," explains Bücking. "Depending on what the winemaker wants, it's possible to analyze the 'good', sought-after yeasts or the 'bad', undesirable ones. The technology is very flexible; all you have to do is make the antibodies."

Apart from identifying "bad guys", the analytical technology can also be used to detect fungi, bacteria and viruses that cause diseases in plants, for example. Until now it was only big labs that could carry out such microbiological analyses. Sending them the samples and having to wait for these to be analyzed cost a lot of time. As Mark

Bücking states: "Everything's much quicker with the new antibody testing kit. It's possible to carry out the test in situ and so save precious time."

Each vineyard has a characteristic yeast population. A newly developed sensor means it is now possible to establish if the yeasts contained within the wine must are up to the job of producing a top-class wine. (© Albert Mathier et Fils) | Picture in color and printing quality: www.fraunhofer.de/press

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