NEW MATERIALS

A fiber for all handiwork

Dry leaves of an Amazonian plant have wide use, from car parts to clothes and medicines

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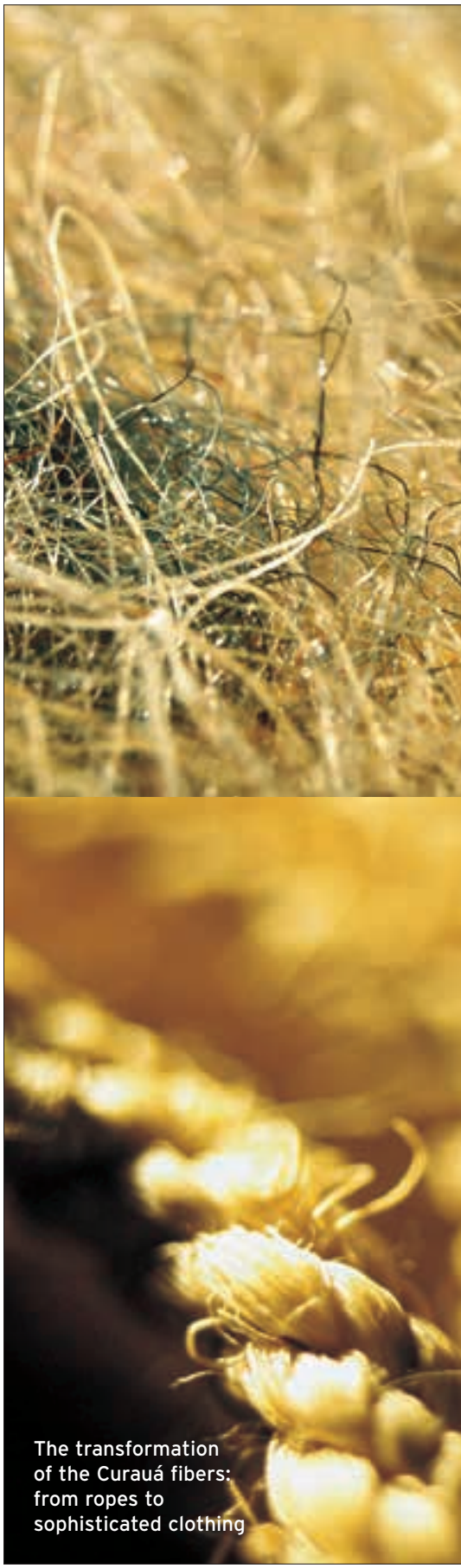
The dry Curauá fiber, an Amazonian plant that belongs the same family as the pineapple, looks just like sisal. But the similarity stops right there. Very soft to the touch, it has as its main characteristic a very high mechanical resistance which gives it, even at reduced width, the capacity to support high tensions. This property makes it a natural substitute for glass fiber. When mixed with other materials that have polypropylene as their base, such as the scraps of blankets and carpets dumped by the textile industry, it turns itself into a composite that is already in use by the automobile industry. "Some cars are already on the road, such as Volkswagen's Fox and Polo models, which use the new material in their roofing, in the internal part of the doors and in the cover of the luggage compartment", says professor Alcides Lopes Leão, from the Agronomy Sciences School of the São Paulo State University (Unesp) at Botucatu, who has been studying the application of plants for some eight years.

The interest in Curauá (*Ananas erectifolius*) originated from the observation of the use of this material by native when manufacturing ropes, hammocks and fishing nets, products that can testify to its resistance and lightness. For now, the new materials resulting from vegetal fiber just revolve around a few items because the available raw material has not caught up with demand. "Just to attend to Volkswagen's demand, 100 tons of the fiber will be needed per day. Today the production is 10 tons per month", Lopes figures out.

In order to get the Curauá fibers onto the market, Unesp has teamed up with he company Pematec-Triangel, from São Bernardo do Campo, which manufactures the structural car parts in the form of a composite. The partnership began in 2000 when the company was sought out by Volkswagen in order to develop parts from new fibers. The car manufacturer's interest is increasing more and more towards substituting certain parts so that they will not be an environmental problem at the end of the car's useful life when it is broken up, as well as lowering its weight and making the vehicle lighter.



The transformation of the Curauá fibers: from ropes to sophisticated clothing

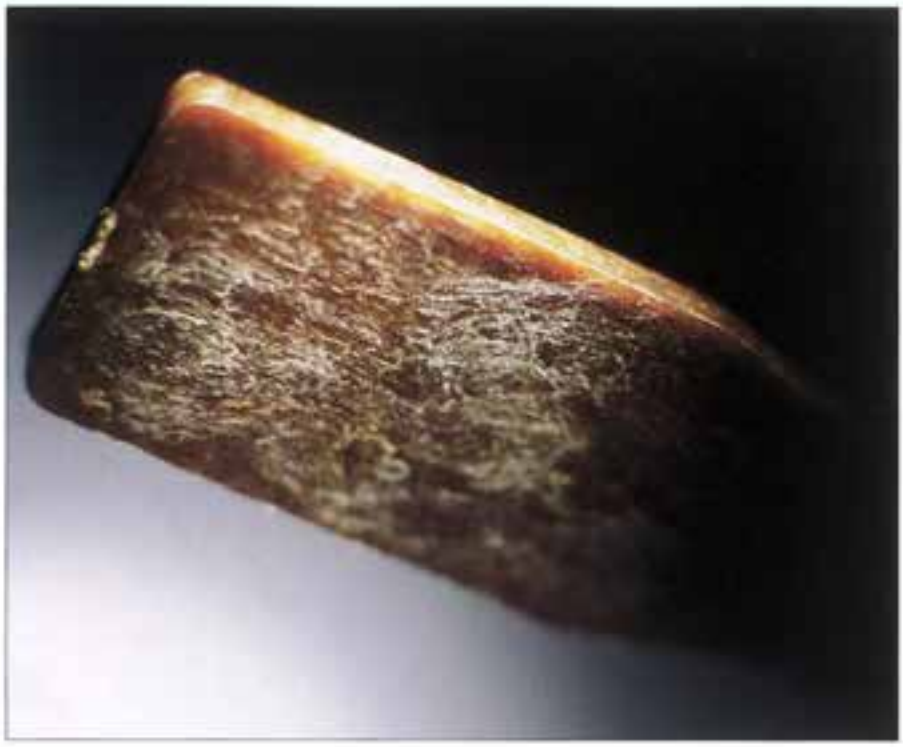
PHOTOGRAPHS BY MIGUEL BOYAYAN

Initially Pematec began its research using jute, which had been heavily used in Europe for applications of this type. But on a visit to Germany, Gilson Romanato, one of the company's directors, received advise from the Germans themselves that a vegetal fiber better than jute exists in Brazil. On his return the entrepreneur searched for references concerning the fiber and approached professor Lopes Leão, who had already had some scientific papers published on the question.

In one of them the professor tested various fibers, both native and imported, in order to make a comparison of the mechanical properties of each one. Curauá proved to be unbeatable on the resistance issue when compared with wadding, banana, sugarcane bagasse, hemp (marijuana), ramie, sisal, jute, mallow and wood. The other was a research project funded through FAPESP, within the Partnership for Technological Innovation Program (PITE), coordinated by Lopes Leão, which had as its theme the production of composites based on vegetal fibers, such as Curauá, for use in the auto industry. At that time the project's partner company, named Toro, from the town of Diadema, after having faced serious financial problems, quit its plans to invest in the development of composites. The agreement between Unesp and Toro was wound up and Pematec came in as the hired company to produce parts in accordance with the proposal made by the car manufacturing company.

Initially the project developed by the university for the company suggested the Ribeira Valley as one of the possible locations for the cultivation of the plant, but there was still the lack of studies that would evaluate the plant's adaptation to the region. Shortly afterwards, Pematec purchased a farm in the town of Santarém, in the State of Pará, and began to encourage the local farmers to increase their plantation. "When we arrived there, between 150 and 200 families were involved in the growing the fiber but we believe that by the end of 2005 there will be 400 families involved", says Romanato. The farm is considered to be a safe supply. "If there is a lack of fibers or a rainy season that makes drying difficult, we can make use of the fibers from our plantation." Since July of this year a fiber processing factory, still experimental, has been in operation in Santarém. For now there are some 50 employees, managed by Gilmar Lazarini, an ex-student of Unesp. There the vegetal fibers, around 1.20 meters in length, are cut up into pieces between 5 to 7 centimeters, and mixed in the proportion of 50% with polypropylene textile fibers.

Injection mold parts - After the formation of the composite, sheets are made that are sent to the company's headquarters in São Bernardo where the plastic parts are manufactured in a process named thermal configuring. Placed in a mold, the layered material is heated until it obtains the final form and cooled within the same environment. Another technique used is injection molding. The cut up fiber, mixed with granulated plastic, is passed through a process called extrusion in which the two materials are synthesized. Afterwards the mixture passes through an injection machine for the molding of the part. Various plastic resins have been tested since 1995 in order to be used in the final product, among them polypropylene, polyethylene, high and low densities, among others. The injection process allows for the partial substitution of the plastic resins. General Motors of Brazil, for example, has a research contract with Unesp to develop injection mold parts that are reinforced with natural fibers. A third process, which is not in use yet due to a lack of the raw material, called BMC (Bulk Molding Compound), has already been tested at the university. In this process the fiber is used in its pure form, without polypropylene, and is cut



The Curauá: fibrous leaves and a fruit smaller than the pineapple. Above, part of a composite used in the roofing of cars

up into small grains for the manufacture of the vehicle's external parts. There are grills and car bumpers made with an epoxy or polyester matrix (synthetic resins) as a substitute for the glass fibers currently in use, a material that is difficult to throw away and recycle.

The flexibility and the softness of the Amazonian fiber has also led the researchers to think about its use as a raw material for clothing. In this manner, according to the size of the fiber, they could be used both by the textile industry and for injection molding. In the Philippines, fibers from the pineapple plant, extracted from the leaves that are discarded by the juice industry, are transformed, for example, into fine smocks used during wedding ceremonies. The lack of machines with the appropriate technology for the formation of thread made Unesp turn to the Natural Fibers Institute of Poznan, in Poland, an entity which since 1994 has maintained a partnership with the university. Nothing short of 500 kilograms of fiber have been taken to the Polish city in professor Lopes Leão's luggage. A mixture of Curauá with polyester and wool, in open and closed weaves, has resulted in blouses, skirts, sweaters, socks and even curtains. In order to be certain that the fiber will not cause an allergy when in contact with the skin, various tests were carried out with sensors coupled to the body of volunteers during various periods of the day and night, even to evaluate the peacefulness of the people during their sleep.

The versatility of the plant even points towards the exploration of bromelain, an enzyme used in the production of medicines that help in the digestive processes, such as anti-acids, in the food industry for softening meat and in the production of biscuits and dehydrated eggs, as well as also being used in the treatment of leather. Bromelain is mainly found in the pineapple. However, the quantity produced is still small in relation to the market needs, which gives the product a high commercial value. The study of the activity of the enzyme in Curauá plants suggests that, though the leaves show activity that is significantly less than the fruit (which look like very small pineapples), the major part of the green pulp (mucilage) removed in order to get at the fibers, and dispensed with by the industry, could be economically made use of for its extraction.

Pematec's goal, which is to process 100 tons per day of fiber, indicates a huge quantity of residue at the end of the process. In order to avoid a future environmental problem, Unesp has developed a project that makes use of the energy embodied within the mucilage to produce bio-gas that makes the machinery destined to drying the fibers work. Another potential application for this residue, which is also being studied at the university, lies in cattle feeding. "Because of its high protein and vitamin content, we have realized that it is possible to make use of it as an enrichment of animal feed", says Lopes Leão.

Cultivation in the Southeast - In order to supply all of the possible uses of Curauá production will need to be boosted and probably out of the Amazon basin, mainly in the Southeast, closer to the consumer market. Since 2000, as part of the project developed by for Pematec, Unesp has been studying the adaptation of the plant to the region's climate and soil. Various plant off-shoots were brought from Pará and planted on the campus at Lajeado and on a Unesp farm at São Manuel, a town close to Botucatu. The off-shoots were of two varieties: purple and white. "We believe that for the São Paulo region the purple variety adapts itself better to the climate", said Lopes Leão. The crop has already passed through three winters, the last one with temperatures of -3.5ºC. And the plant survived without problems. Thus the fear that it would not adapt itself to the Southeast has not been confirmed. "We know that it does not die off easily, that it is resistant, does not have pestilence and responds well to soil fertilizing."

The multiplication of the off-shoots is carried out by the cloning of the buds that sprout in the region between the base of the plant and the leaf. The buds go into a culture medium with the texture of gelatin in which all of the necessary mineral salts can be found as well as the macro and micro nutrients that the plant needs, including vitamins and phytohormones (regulators of vegetable growth). From one single bud it is

possible to generate another four in 45 days, the period of each sub-growth. These four result in sixteen and so on successively in a geometrical progression. "From a single plant matrix that I managed to extract ten buds, I was able to obtain more than 10,000 identical plants in only four sub-growths", says Isaac Stringueta Machado, from the environmental biotechnology area of the Agronomy Sciences School of Unesp, who is also participating in the project. Two to three months later the first plants are being sent to the hot-house and then in a further four months they will be around 20 centimeters, ready for planting in the field.

Afterwards one only has to wait for a year, the period necessary for the leaves to reach around 1.20 meters, the ideal phase for the first cropping to be done. Six months later, when the leaves are once again at the same length, a new cropping is carried out. There are around four of these sequences until the cycle of planting is restarted, which can be accomplished both through offspring produced by the mother-plant and by the transplanting of clones. The second option is more interesting because, as well as the reduction in time and space in multiplication, there are two other positive aspects in micro-propagation in vitro underlined by the researcher. One of them is clonal cleaning. Since the clone is made starting from a young portion of the plant (meristem) which as yet does not have the conducting tubes defined (xylem and phloem), any phytopathogen, bacterium or fungus that it has can be eliminated. The other is genetic fidelity, which allows for exact copies of the selected plants for the best adaptation of the field conditions in the Southeast region.

"We have observed that the cloned plants have a potential to multiply in the field which is greater than the wild plants. The induction that we give with these growth regulators in some manner stays registered in the plant's memory (genotype), because they continue multiplying themselves at a higher level to that verified by conventional planting", says Machado. In the evaluation of professor Lopes Leão, the increase in the production in order to account for the demand of the automobile industry will be through cloning. "For this reason at Unesp we are setting up a reproduction structure of 5 to 8 million plants per year in order to attend to the growing demand for Curauá off-shoots, that will be transported by road to the State of Pará, ready to be placed in the field."

Curauá's potential has caught the attention of Europeans who have already made a proposal to the research

THE PROJECTS

The production of composites based on natural fibers for use in the automobile industry

MODALITY
Partnership for Technological Innovation Program (PITE)

COORDINATOR
Alcides Lopes Leão – Unesp

INVESTMENT
R$ 728,350.00 (Toro) and R$ 145,750.00 (FAPESP)

The production of reinforced composites using Curauá fibers

MODALITY
Green-Yellow Fund – MCT/Finep

COORDINATOR
Alcides Lopes Leão – Unesp

INVESTMENT
R$ 799,616.00 (R$ 371,600.00 – Finep and R$ 428,016.00 – Pematec)

Various clothes produced from Curauá fibers mixed in with other materials

group to take off-shoots to Ceylon, Malaysia and Indonesia. To prevent the Amazonian fiber from suffering the same fate as the rubber tree, which at the end of the nineteenth century and in the first decades of the twentieth century was the major source of income for Brazil, when British colonists in Asia began cultivating the plant with success and made the Brazilian exports drop drastically, Lopes Leão's recipe is to invest in technology so that the Brazilian product will always be ahead of its competitors. As well as the recognized competence of the Unesp team, in which there is also participation from researchers from the Agronomy Sciences College, the work with Curauá is in truth the fruit of a multidisciplinary work group, which can further count on Elisabete Frollini, from the Chemical Institute of São Carlos, University of São Paulo (USP), and Luiz Mattoso, from the Embrapa Agricultural Instrumentation, also at São Carlos. For example, at Embrapa the trials for the evaluation of the interaction of the fiber with plastic are being carried out. At the IQSC the composite matrixes are tested. "Our work has to be highly technical since industry is very demanding", explained professor Lopes Leão. "We know how the parts behave both if they were to be used in Siberia at a temperature of -50ºC, and in the heat of Teresina in the State of Piauí."

In order to make the project viable at all of its stages, which began with the study of the plant in the field, its adaptation to the Southeast region, to cloning and the transportation of the off-shoots, as well as the steps involved in the application of the fiber within the car industry, and closing the circle with the utilization of leftovers, the Financier of Studies and Projects (Finep), by way of the Green-Yellow Fund, a stimulation program between a university and company that supports innovation, signed an agreement with Pematec and Unesp during 2002 to the value of approximately R$ 800,000.00 of risk capital, valid for two years. The Finep part, half of the total value, was used for grants, equipment and testing. The agreement ends in December, but will be renewed for a further year. Pematec, which contributed with the other half of the project's total budget, can write-off its investment as research incentive.

In the current phase, the research group is beginning to rethink some of the concepts adopted at the start of the project. One of them is with respect to the number of plants cultivated per hectare. The number was 10,000 at the start of the study and currently there are 60,00 per hectare. Another is the utilization of bromelain, previously considered only as a by-product. Today the enzyme, whose value on the market is higher than that of the fiber, is considered to be a co-product in the exploration of Curauá. This is without taking into account that the researchers now know that it can be cultivated in any place in the State of São Paulo and that it is a cash crop. Currently a dry kilogram costs up to R$ 3, whilst two years ago it was valued at R$ 1. However, the most visible change is in the use of all of the resources that the plant offers both for the car industry and for the pharmaceutical and textile industries. •