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june **2024**

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Property
@ Colab ForestWISE

Address
Quinta de Prados, Campus da UTAD
5001-801 Vila Real, Portugal

Contacts
geral@rn21.pt

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EDITORIAL

We are pleased to present the third edition of Resinae magazine, a publication specialized in the promotion and valorization of Natural Resin, as well as the revitalization of the resin production sector in Portugal.

Natural Resin, a biomaterial with growing and multiple applicability, has experienced a global increase in demand. This phenomenon has boosted its real value and reaffirmed resin tapping as a viable and profitable economic activity. This scenario highlights the need to revitalize the Natural Resin sector, which plays a crucial role in the Portuguese economy, in forest fire prevention, in the profitability and sustainability of pine forests, promoting employability, and generating revenue, which is so important in rural areas.

In addition to its economic value, the production of Natural Resin plays a fundamental role in the sustainable management of forest ecosystems. Resin-producing trees, particularly the maritime pine, are an essential component of biodiversity. Resin tapping promotes management practices that help ensure the conservation of forest areas, contributing to the sustainability of forest ecosystems and the prevention of fires by reducing the available fuel load and, consequently, the risk of major fires.

The implementation of support measures for resin tapping and the management of maritime pine stands aims to increase the area available for future resin production, strengthening the production of this bioproduct in the European Union, contributing to the achievement of the sustainability goals assumed by Portugal. Actions that promote the increase of resin tapping areas include the utilization of natural regeneration and the management of stands, with the goal of optimizing the growth and profitability of these areas, ensuring the continuous production of Natural Resin and other ecosystem services.

In the context of enhancing and differentiating Portuguese Resin, certification emerges as a strategic and essential tool. This process not only guarantees the quality and traceability of Natural Resin but also increases its competitiveness, facilitating entry into new markets and strengthening consumer and investor confidence.

Carlos Fonseca
CTO CoLAB ForestWISE

Thus, this edition of Resinae not only celebrates the richness of Natural Resin as an integral element of the bioeconomy but also highlights the innovations and ongoing efforts for the necessary development of this sector. The RN21 consortium is effectively contributing significantly to the promotion of a modern value chain, enriched with knowledge and innovation, positioning the Natural Resin sector at a prominent level in the environmental, social, and economic sustainability of our country.

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MARIA EMÍLIA SILVA | INTERVIEW

“(...) A PROJECT THAT COULD LEAD TO THE CREATION OF A RESIN CLUSTER (...)”

Maria Emilia Silva is an Assistant Professor at the University of Trás-os-Montes and Alto Douro (UTAD) and a researcher at CITAB - Center for Research and Agro-environmental and Biological Technologies, in the field of forest products technology. She has over twenty years' experience in scientific research and is a leading expert in the field of resin tapping.

What motivated UTAD to take part in RN21?

RN21 is an integrated project that aims to boost an activity in the primary sector, resin tapping, which has a strong tradition in the region of Trás-os-Montes, where UTAD is located, and is significant to the social and economic development of the region's rural territories. UTAD, through the School of Agricultural and Veterinary Sciences, has always carried out research in the agricultural sector, integrating projects that contribute to the development of this sector, with special emphasis on those projects that can help increase the income of the sector's agents, create jobs, technologically develop more archaic production systems and also those projects that contribute to the transition to a sustainable bioeconomy and respond to the United Nations 2030 Sustainable Development Goals. UTAD identified RN21 as one of these projects and so, right from the start, it showed willingness, commitment, and engagement in building the Consortium that gave rise to RN21.

UTAD carries out research in the agricultural sector, integrating projects that contribute to the development of this sector, with special relevance to those projects that can help increase the income of agents in the sector, create more jobs, technological development and those that contribute to the transition to a sustainable bioeconomy and that respond to the United Nations 2030 SDGs.

How do you characterize the research carried out in Portugal in the field of resin production?

Before we tackle the question, it's crucial to distinguish between research into the activity of resin tapping and research into the resin itself. Although both concern the same product, the former is related to the extraction of resin from the pine forest and the latter to the use of resin to the production of different compounds, and subsequently a huge and varied range of end products with high added value. The latter area has undergone considerable development in Portugal, with regular applied research, resulting in an internationally recognized national 1st and 2nd processing industry.

Regarding resin extraction, although Portugal was one of the world's largest resin producers, its production fell significantly from the 1990s onwards, making resin tapping an activity that many thought would disappear. This led to little interest from researchers in the sector and, as a result, a residual investment in the development of the resin tapping business. Despite this, several projects have emerged, some of them in partnership with Spanish colleagues, and there has also been research as part of doctoral theses which, by reintroducing the focus on this activity, have led to the amendment of existing legislation which had remained practically unchanged since the 50s.

However little research that has been carried out, it has led to an increased knowledge about resin tapping, its techniques, and the physiological processes governing resin production in the tree. Although the increased knowledge, there has been little practical impact on the ground, i.e. on the resin tapping workers and on the resin tapping process.

The measure led by UTAD provides for innovation in resin tapping techniques. What are the main results expected from this measure?

In this measure we are studying various aspects that we believe are crucial for the advancement of resin tapping activity. To this end, we are developing new stimulants that are more effective and better adapted to the specific environmental and climatic conditions of each region where resin tapping is significant. These stimulants will be of biological origin, aiming for a more sustainable approach.
We are also studying new techniques and new resin collection containers with the aim of ensuring that the resin reaches the industry cleaner and with a higher terpene content and therefore, with greater commercial value. We are also studying ways to reduce the amount of waste generated by the activity, namely the use of non-recyclable plastics and waste from the first processing industry.

Finally, we are developing technology that will make the activity less physically demanding, less dependent on labor and consequently more profitable and attractive to young entrepreneurs.

What is the expected impact of this research for the resin tapping worker (social and economic impact)?

The main goal of all the actions planned in the research led by UTAD is to make the resin tapping activity more profitable and sustainable.
The aim is to increase resin production from each tree and thus the amount of resin harvested per campaign. Ando also reducing operating costs by using new technologies and reducing the need for manual labor. In addition, by supplying the industry with a cleaner product, with a higher content of compounds (more whole), we will have a product with greater commercial value. We believe that the results of this research, together with the coordination of the interests of all the players in the sector, will help to increase the profitability of the resin maker and the sustainability of resin processing.

Maria Emília Silva
Assistant Professor at the University of Trás-os-Montes and Alto Douro
Researcher at CITAB - Center for Research and Agro-environmental and Biological Technologies, in the field of forest products technology.

One of the research lines currently underway involves the creation of a closed resin collecting container. What is the main advantage of this new container over the open containers currently in use?

Resin tapping in Portugal is done using an open container, either a plastic bag, used more in the North, or a clay or plastic jar, used more in the Center. The fact that it is open means that the resin collected from the tree is contaminated throughout the campaign with impurities such as insects, bark, leaves, and rainwater. This rainwater is sometimes so great that resin overflows, resulting in significant losses, especially in years with a significant amount of rain.

On the other hand, as resin is exposed to the air, its volatile compounds evaporate over time, making it a less rich product than when it leaves the tree. Using a closed container resolves both problems. Furthermore, depending on the type of closed container developed, it could make it possible to transport and deliver the resin to the factory while it is still in the container, eliminating the task of emptying and cleaning the resin from bags or pods into drums before it is transported, one of the most unpleasant and wasteful tasks.

What are UTAD's main expectations regarding its participation in the RN21 Integrated Project?

Our expectations are positive since we believe that this project, with its holistic approach to the resin sector, will make a difference to the development of the resin tapping sector.

The creation of this Consortium was itself a big step. By bringing together the entire value chain of the resin sector, joining players at different levels of development, with different expectations and readings of the activity, it has made it possible to build a common project that could lead to the creation of a Resin Cluster, which could provide a series of advantages, from stimulating innovation and competitiveness to economic development, job creation and the concentration of resources and knowledge.

"The main goal of all the actions planned in the research led by UTAD is to make the resin tapping activity more profitable and sustainable. The aim is to increase resin production from each tree and thus the amount of resin harvested per campaign. Ando also reducing operating costs by using new technologies and reducing the need for manual labor."

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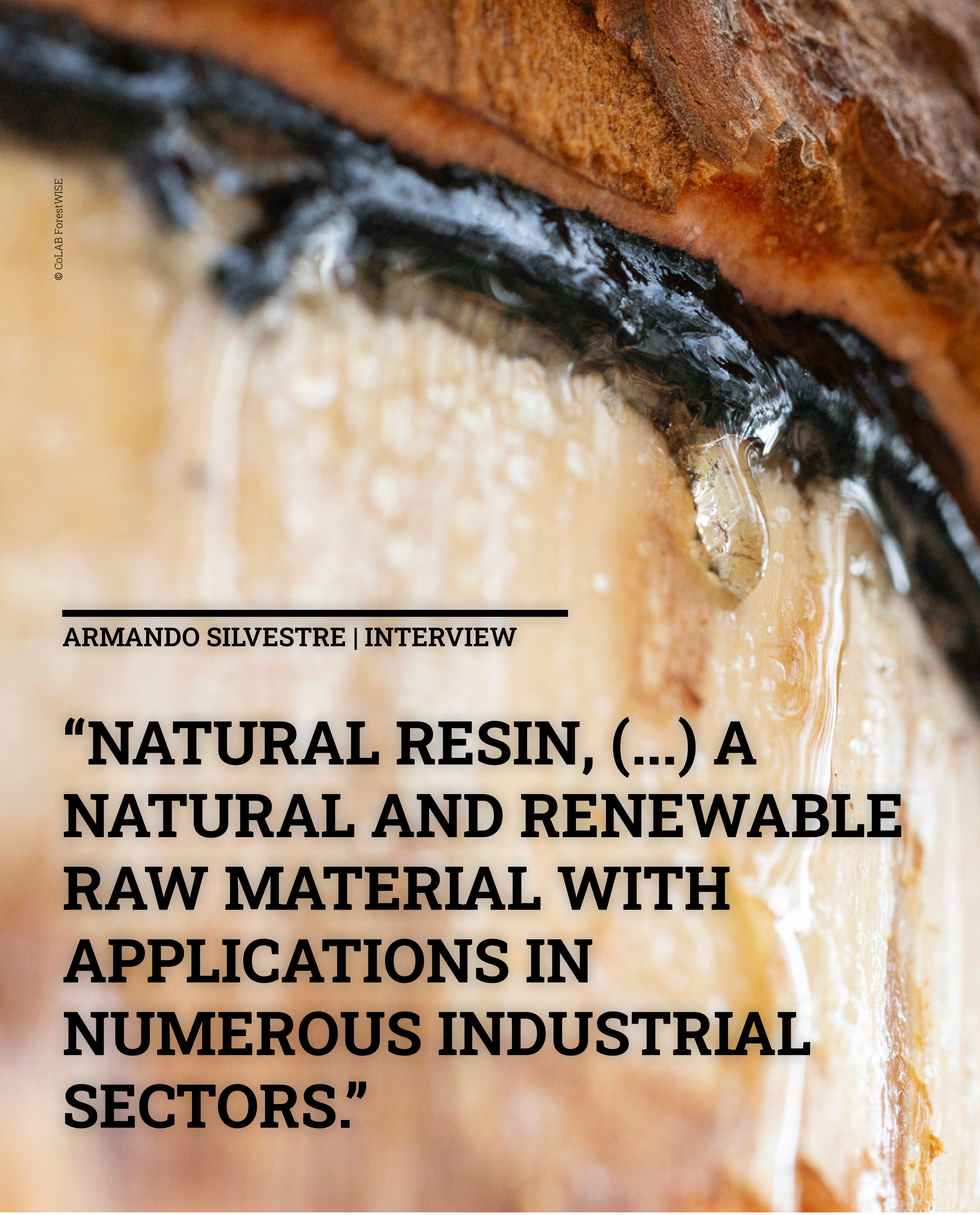

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ARMANDO SILVESTRE | INTERVIEW

“NATURAL RESIN, (...) A NATURAL AND RENEWABLE RAW MATERIAL WITH APPLICATIONS IN NUMEROUS INDUSTRIAL SECTORS.”

Armando Silvestre is a Full Professor in the Department of Chemistry at the University of Aveiro and the principal investigator of CICECO - Aveiro Institute of Materials, where he leads the BioPol4fun group. His areas of interest lie in innovation in functional materials based on biopolymers and bioactive compounds.

Armando Silvestre
Full Professor in the Department of Chemistry at the University of Aveiro
Principal investigator of CICECO - Aveiro Institute of Materials, where he leads the BioPol4fun group.

What motivated CICECO and the Department of Chemistry at the University of Aveiro to participate in RN21 Project?

CICECO and DQUA have recognized competencies in research and development in the area of valorization of renewable resources, particularly in the valorization of pine resin. Additionally, we have a strong tradition of research activities with industry. Therefore, our involvement in this project arises naturally.

One of the measures in which you participate aims to develop a new stimulant paste for resin tapping. What properties are you seeking to introduce into the new pastes?

The stimulant paste currently in use, which aims to increase resin production by preventing resin crystallization in the incision, is a compound based on sulfuric acid. This composition poses health risks to the user, the resin worker, as well as being a chemical substance of high concern under REACH regulations. Therefore, in developing a new stimulant paste for resin tapping, we seek above all a natural alternative that is efficient, capable of inducing resin production with higher yields than current solutions, and that is also inexpensive, easy to apply, and safe. And with this, generate knowledge and value for the national economy.

With sustainability emerging as a growing concern for consumers and markets, how can natural resin and its derivatives contribute to a more sustainable future?
The use of plant biomass as a source of chemicals, materials, fuels, and energy, as an alternative to fossil resources, is essential in developing a more sustainable growth model and in contributing to carbon neutrality in human activity.
Much of the research activity carried out at CICECO and DQ is aimed at this overarching goal, seeking to develop sustainable processes for integrated valorization of biomass through so-called Biorefinery processes.
Natural resin, due to its composition, can play an important role in this context, given its potential as a natural and renewable raw material with applications in numerous industrial sectors. Our participation in the Integrated RN21 Project is focused on the development of a new stimulant paste and research on new antioxidants and biobased raw materials for the production of 100% biobased colophony derivatives. Thus, we are working together towards a more sustainable future.

“UA hopes to contribute with its scientific knowledge and its long experience in developing projects in cooperation with the industry to improve processes and develop new ideas and solutions that will help enhance this economic sector.”


pinopine
innovation is nature

JOÃO SERRANO | OPINION

THE POTENTIAL OF NATURAL RESIN AS A SUSTAINABLE RAW MATERIAL

Pine natural resin, hereafter referred to as resin, is a mixture that, through distillation, separates into two distinct parts: a solid part known as rosin (or pitch, as it was formerly known) and a liquid part known as turpentine (or terpentine).
Dating back to several centuries before Christ, resin was initially used in its raw form before the discovery of its separation into the aforementioned components. The earliest records of resin usage date back to ancient Egypt (3100 BC), ancient Greece (1000-300 BC), and the Roman Empire (750 BC-480 AD), where it was employed in construction projects, shipbuilding, and as a component in medicines and perfumes.
Much later, during the Middle Ages and especially during the Industrial Revolution, the uses of resin became more diversified, ranging from ship waterproofing to the production of paints and varnishes for manuscripts, and extending to applications in textile and paper industries.
Today, due to significant investments in research and development by companies in the second transformation industry, the use of resin and its derivatives has expanded into areas and applications that were not as common in the past.
At a time when sustainability and "natural" or "organic" are increasingly at the forefront of national and international agendas, Pinopine's participation in the Integrated Project RN21 was a logical step, continuing the company's commitment to research and development of new products.
Thus, an ambitious project was outlined aiming not only to replace synthetic antioxidants with natural antioxidants but also to substitute some fossil-based raw materials with natural and/or renewable ones. The goal of the project is to obtain resin derivatives that are 100% natural, meeting the growing demand for such products.

Considering that in many potential applications of resin and its derivatives, the percentage of these products used is significant, having a 100% natural and renewable alternative will be a significant advantage for customers. This will allow them to subsequently market more "organic" products compared to, for example, using resins derived from fossil fuels, such as petroleum.


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Indeed, the growing trend is towards the replacement of non-renewable raw materials, whether they are resins and their derivatives or solvents. An example of this type of substitution is seen in the printing ink market. In flexographic inks, there has been a shift in recent years from solvent-based inks to water-based inks, also utilizing resin derivatives in the formulations. In the case of offset inks, what has been observed is not only a substitution of resin derivatives, with an increasing use of phenol-free resins as an alternative to traditional phenolic resins, but also the replacement of mineral oils with vegetable oils, resulting in more eco-friendly inks. Similarly, in other markets such as adhesives, to meet the increasing demands of both end customers and increasingly restrictive regulations, the use of resin and its derivatives will undoubtedly be enhanced in the coming years.

Sustainable development is increasingly becoming a key theme for companies' competitiveness, and it is also growing in importance for their short, medium,

João Serrano
Research and Development
Director at Pinopine

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“In markets such as adhesives, the use of resin and its derivatives is poised to be significantly enhanced in the coming years to meet the increasing demands of both end customers and regulations advocating for the substitution of fossil-based products.”

“The goal of the project is to obtain resin derivatives that are 100% natural, meeting the growing demand for such products.”

and long-term strategies. Considering that resin is a natural and renewable product sourced from forests where there is a growing investment in sustainable production, it is logical to assert that companies in the first and second transformation stages are clearly at the forefront of sustainability using this raw material. Furthermore, downstream, third transformation companies are also seeking to increase the use of natural products, moving away, as much as possible, from fossil-based raw materials. This creates a "perfect storm" in the positive sense, driving sustainable and interconnected growth across all transforming industries.

Another distinctive factor directly related to sustainability is the significantly lower carbon footprint of resin and its derivatives compared to their petroleum-derived counterparts.

It's easy to understand that if resin comes from living pine trees, which are carbon sequesters, the products in which it is used will consequently have a more favorable carbon footprint compared to other products derived from non-renewable raw materials, such as hydrocarbon resins derived from petroleum.

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This fact decisively contributes to the ability of most first and second transformation companies to easily achieve carbon neutrality, with clear advantages resulting from it. Consequently, following a chain logic, through greater incorporation of resin and its derivatives into their formulations, third transformation companies will also be able to bring more ecological products to the market, with a lower associated carbon footprint.

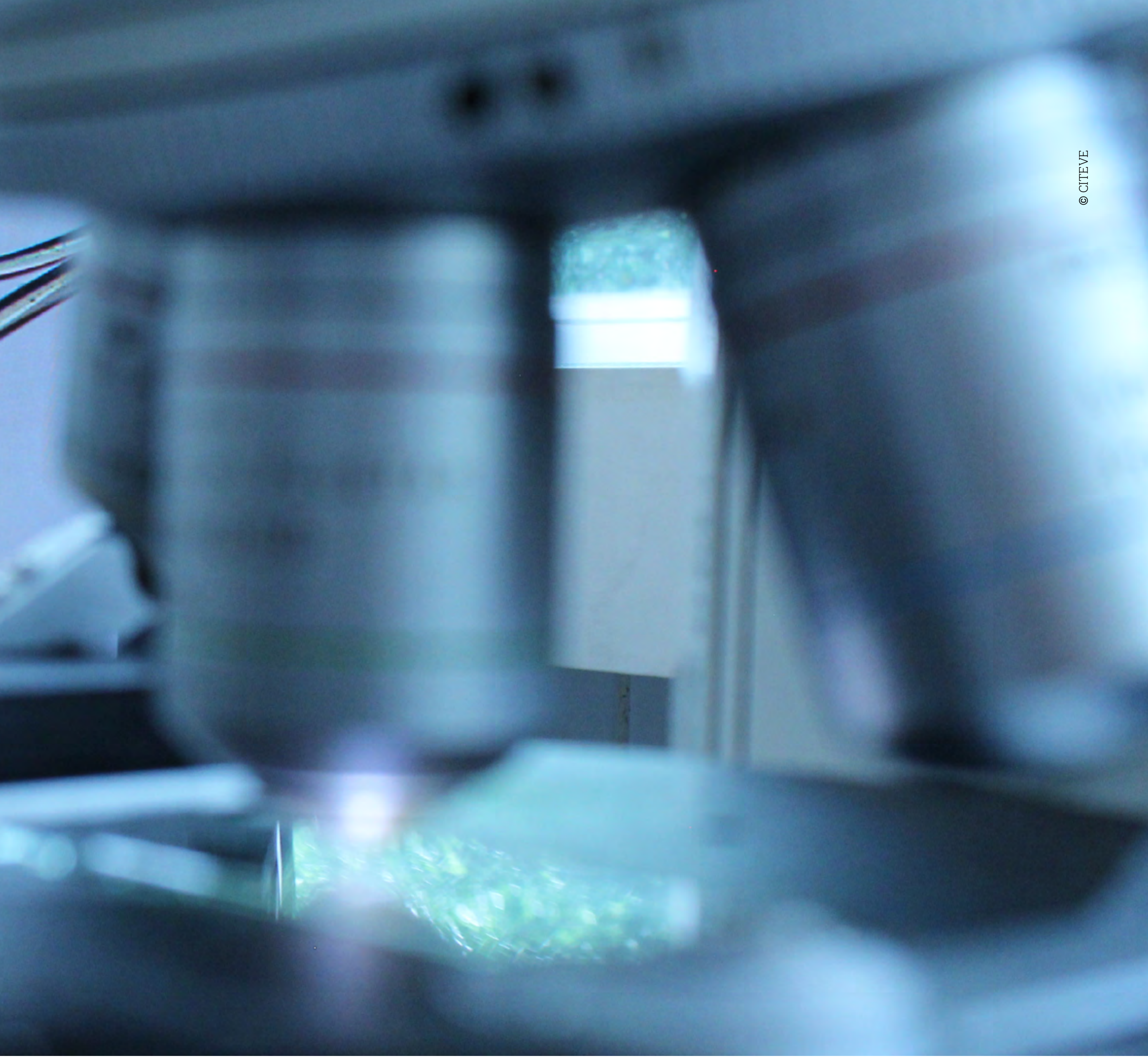
In other words, based on everything described above, it is expected that all three transformation industries associated with the use of resin will have great growth potential in the coming years.

To achieve this, projects like RN21 will undoubtedly leverage this growth through research, development, and training, the construction of new infrastructures, and the development of new production methods.

The fulfillment of the objectives initially defined and contracted by all companies in the Consortium will guarantee that they can all, in the very near future, be even more competitive and stand shoulder to shoulder with major international players, thereby contributing to greater exposure of Portugal in the world and also to a more sustainable economic growth of the country.

ANTÓNIO BRÁS COSTA | OPINION

INNOVATION AND SUSTAINABILITY: THE NEW ERA OF THE TEXTILE AND CLOTHING INDUSTRY



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The textile and clothing industry (ITV) is one of the pillars of the global economy. In Portugal, according to data from ATP - Associação Têxtil e Vestuário de Portugal (Textile and Clothing Association of Portugal), there was an all-time record of 6 092 million euros in Portuguese textile (including technical textiles) and clothing exports in 2022, representing a significant growth of 12.5% compared to 2021.
This growth, or even the viability of this industry in a European country, has been greatly helped by the excellent positioning of national ITV in terms of quality, sustainability, and innovation. In fact, National ITV has been characterized by the placement of differentiated textile products on the market, developed from the capacity installed in the companies themselves, but largely in cooperation with entities in the scientific and technological system, such as CITEVE - Centro Tecnológico das Indústrias Têxtil e do Vestuário de Portugal (Technological Center for the Textile and Clothing Industries of Portugal).

CITEVE is a private, non-profit organization, based in the epicenter of Portuguese ITV, Vila Nova de Famalicão, with sales offices on four continents, providing companies in the Textile and Clothing Sector, mainly SMEs (90%), with a portfolio of services including laboratory tests, product and process certification, technical and technological consultancy, R&D + innovation services, and training.

As a reference organization on the national and European scene in terms of promoting innovation and development in the textile and clothing industry, CITEVE's mission is to support the development of the technical and technological capacities of the textile and clothing industries by encouraging and disseminating innovation, promoting quality improvement, and providing instrumental support for the definition of industrial policies for the sector.

CITEVE is therefore strategically positioned between the public authorities, academia (universities) and companies, always looking for the sustainability and innovation of the ITV.

The growing awareness of ITV's environmental impacts is driving a paradigm shift throughout the value chain and even in consumer habits. According to the European Environment Agency, textile production is responsible for around 20% of drinking water pollution globally, mainly due to the use of dyeing and finishing products. It is also estimated that the fashion industry represents 10% of carbon emissions worldwide - more than international flights and maritime transport combined (for which the fashion industry is also relevant), contributing greenhouse gas emissions in the order of 121 million tons[1]. In addition to these facts, there is the circumstance that the strong growth in raw material consumption is increasingly focused on the massive use of those derived from petroleum.

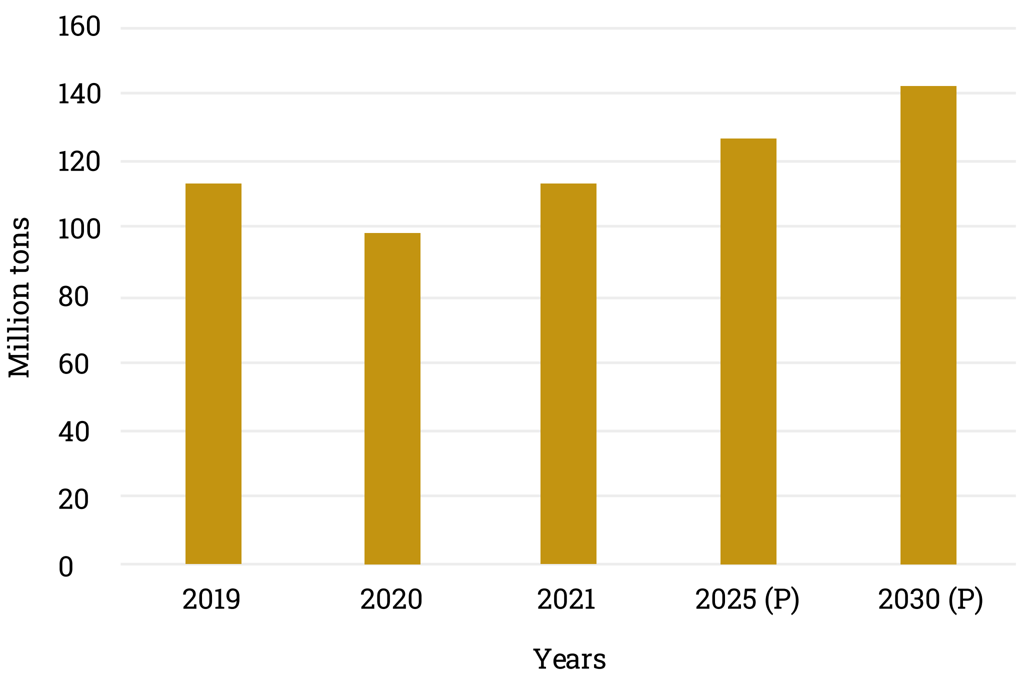

Figure 1. Global consumption of textile fibers (forecast P-values). Adapted from Gschwandtner (2022)[3].

“(...) innovation plays a key role in the transition to a more sustainable future for ITV. The need to use materials from renewable sources is clear and urgent. It is now recognized that the textile industry is much more than threads woven into complex patterns; it is a testimony to the intimate relationship between humanity and nature”

In this context, innovation plays a key role in the transition to a more sustainable future for ITV. The need to use materials from renewable sources is clear and urgent. It is now recognized that the textile industry is much more than threads woven into complex patterns; it is a testimony to the intimate relationship between humanity and nature. While many associate textile products only with cotton, wool, polyamide or polyester, the truth is that new sources of fiber play an essential and increasingly relevant role in this complex economic and environmental fabric, especially fibers produced with regenerated cellulose (MMCFs).

Overall, global demand for textile fibers is expected to continue to grow at a rate of 2-3% per year until 2030[2], which will lead to a total fiber consumption of around 142 million tons in 2030 [3] (see Figure 1). In terms of global figures, fibers derived from forest cellulose accounted for around 7% of total fiber consumption in 2021.

In this context, forests play a leading and promising role in the synthesis of these new fibers, due to their renewable and abundant origin in certified forest ecosystems, such as those found in Portugal. These fibers are derived from the cellulose found in trees such as eucalyptus and pine, and unlike synthetic

António Brás Costa
General Director of CITEVE

fibers derived from petrochemical products, forest-derived fibers have a more sustainable life cycle and are biodegradable. Trees can be replanted and grown renewably, unlike synthetic fibers which contribute to environmental pollution, the release of microplastics and the dependence on non-renewable resources.

The production of cellulose fibers derived from forests is a shining example of how the textile industry can be an ally of sustainability. It is noteworthy that Portugal will have, by 2025, installed capacity for lyocell fiber production as part of the productive investment planned in the be@t project (https://bioeconomy-at-textiles.com).

In addition to supplying cellulose for fiber production, the forest is also home to a wealth of natural resources that are essential for textile production. It is these alternative natural resources that are being explored in the RN21 project, in an unexpected symbiosis between the pine resin sector and the textile industry. While pine resin is traditionally associated with the manufacture of products such as varnishes and adhesives, its application in the textile industry is innovative. One of the most relevant applications is the use of pine resin as a textile finishing agent. This approach adds functionality to textile materials and offers an ecologically conscious, low environmental impact alternative to conventional chemical treatments of fossil origin. Pine resin is biodegradable, thus enhancing the development of more sustainable textile products, in perfect alignment with the new challenges

Figure 2. Examples of textile materials developed under the RN21 project: laminated and coated substrates with rosin resin derivatives.

for this industry.

In fact, natural resins such as pine rosin have functional properties such as adhesiveness and repellency, as well as antimicrobial and antioxidant properties, offering several advantages, such as their availability, low cost, and origin from a natural and renewable source. As part of the RN21 Integrated Project, CITEVE and CeNTI are exploring the use of rosin and its derivatives, produced by partners in the second transformation industry of natural resin, in the development of innovative and sustainable solutions for ITV (Figure 2). This strategy involves replacing the fossil-based polymers widely used (e.g. polyurethanes), both for the development of coatings and adhesives, with national, renewable raw materials such as rosin and its derivatives. Natural resin, extracted responsibly and sustainably from pine trees, can be used in the production of a wide range of textile products, providing a sustainable alternative to conventional chemical products.

“The alternative natural resources that are being explored in the RN21 project represent and unexpected symbiosis between the pine resin sector and the textile industry.”

The RN21 project is therefore based on the synergy between two robust industries in Portugal: the natural resin industry and the textile industry. Collaboration between these two sectors drives not only innovation but also economic growth, creating opportunities for both stakeholders. By promoting the use of local and sustainable raw materials, we are building a path towards a greener and more resilient economy.

Another important aspect of the symbiosis between the pine resin and textile industries is their contribution to the circular economy. In many regions where pine trees are abundant, resin extraction is a traditional economic practice. By integrating pine resin into the textile industry's value chain, waste from resin production can be reused, creating a closed resource cycle, and promoting a more efficient use of materials.

However, as with any symbiosis, there are challenges to overcome. One of the main challenges is optimizing the processes for applying pine resin to textile substrates, ensuring uniform distribution and durability, without compromising the natural properties, comfort and feel of the textile substrates. However, with the research and development being carried out by CITEVE and CeNTI as part of the RN21 Integrated Project, these challenges will certainly be overcome, allowing for widespread adoption of this innovative approach, and contributing to building a more sustainable and environmentally harmonious future.

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“One of the most relevant applications is the use of pine resin as a textile finishing agent. This approach adds functionality to textile materials and offers an ecologically conscious, low environmental impact alternative to conventional chemical treatments of fossil origin. Pine resin is biodegradable, thus enhancing the development of more sustainable textile products, in perfect alignment with the new challenges for this industry.”

Recognizing and valuing the importance of forests in textile production is essential to promoting a more sustainable and resilient global economy. As we move into the future, we must continue to weave the threads of innovation, responsibility, and respect for nature, ensuring that our society is strong, durable and, above all, sustainable.

It can therefore be concluded that the future of the textile industry is intrinsically linked to the future of forests. Investing in sustainable practices, preserving biodiversity, and guaranteeing the involvement of local communities are essential elements in ensuring that future generations can continue to reap the benefits of this symbiotic relationship between the forest and the textile industry.

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CENTRO PINUS

PINE FOREST: THE SOURCE OF LIQUID GOLD FROM OUR FOREST

The market differentiation of natural resin is at the core of RN21, and the pine forest contributes uniquely to this distinction. Through this article, we aim to highlight some aspects of the fascinating natural, cultural, scientific, and historical heritage that pine forest holds, offering a glimpse into the future.

With 26 years of existence, Centro PINUS continues to uncover facts and stories about the pine forest that surprise and enchant us. Recent examples include an elderly individual sharing how her mother cured her of the "whooping cough" with an extract from developing pinecones, or a charcuterie company that innovatively incorporates extracts of pine bark in its smoking process. We hope that reading this article will bring you surprises and inspire further exploration.

The Maritime Pine Forest

Maritime Pine is an indigenous species of the Portuguese forest with a significant presence in the landscape, history, and cultural heritage of our country. It often plays a unique ecological role: as a pioneer species, it can occupy and create value in poor and degraded soils, which cannot be colonized by other tree species, leading the way to other species after soil recovery.

In the 13th century, the Leiria pine forest was the first large-scale afforestation action in human history[1].

The capacity of maritime pine forest to provide ecosystem services is remarkable. It is currently the largest carbon reservoir in the national forest, which is noteworthy[2]. The National Forest Strategy designates the following areas of maritime pine forests for protection: hydrological regime, 135,000 ha; biodiversity, 131,000 ha; desertification, 66,000 ha; coastal areas, 33,000 ha. The total economic value of forest spaces with resinous trees was €253.93/ha, considering non-market goods and services values per hectare for the period from 2014 to 2019, excluding 20170[3]. In comparison, the total value of forest ecosystems, on average, was €173.52/ha over the same period.

However, this wealth is profoundly threatened, with alarming indicators of pine forest decline: the growth volume has decreased by 37% between 2005 and 2019, and 27% of the pine forest area was lost between 1995 and 2015[2]. The main cause of this decline has been attributed to wildfires, especially when they occur at time intervals shorter than the species' natural regeneration cycle.

Industries Dependent on the Maritime Pine

In addition to providing ecosystem services, maritime pine forests yield both wood and non-wood products, which are valued by society and a diverse market.
As a result, the business component of the maritime pine sector accounts for 80% of employment, 88% of companies, and 57% of the Gross Value Added of forest industries, as well as 3.4% of national exports [4].
The trend in the downstream transformation sector of the maritime pine products has been opposite to that of the forest resource. Market demand is high, with a growing and diversified trend. Industrial consumption of maritime pine wood in Portugal has remained at about 4 million m3/year, and it would certainly have increased if wood supply existed. Since 2015, the energy sector has gained increasing weight in maritime pine wood consumption, representing 25 to 30% of annual consumption.
The maritime pine forestry sector is extremely diverse and complex. This is a great advantage for forestry producers, due to the diversity of demand, but it is also makes it challenging to know and understand its specific characteristics.
This sector includes more than 300 primary wood processing companies, distributed in sub-sectors such as sawmills, packaging paper production, panel production, wood treatment for outdoor use, and energy. Of these, 8 are first transformation resin companies.
Most companies in the maritime pine sector are very small, often family-owned, and labor-intensive. There are fewer than 10 large-scale companies, the majority of which are associates of Centro PINUS. Centro PINUS associates represent about 50% of annual maritime pine wood consumption. Thus, a differentiating factor of this sector is the absence of any dominant wood consumer in the market.
Sawmills gather the largest number of companies (>200) and it is the main sector of maritime pine wood consumption, accounting for 42% of consumption in 2022[4].
Another differentiating factor of this sector is that its subsectors specialize in adding value to different parts of the tree trunk. The purchase value of wood varies considerably depending on trunk characteristics, so prices vary greatly. There is also a strong interdependence between subsectors – for example, all the milling sectors compete for sawmill by-products (e.g., wood chips, sawdust).
It is very common for companies in the maritime pine sector to own forest areas, as is the case with most Centro PINUS associates. The size of these areas is usually small and does not significantly contribute to the companies' wood supply. These companies rely on wood suppliers, mostly micro-enterprises, or SMEs, which can amount to hundreds for larger wood consumers.
From the perspective of wood processors, wood deficit is undoubtedly the main constraint. In resin tapping, the fact that, under certain market conditions, prices of imported resin-derived products are lower than domestically extracted resin, compromises the sustainability of resin producers and first transformation companies.

Maritime Pine
A History of Innovation

The Maritime Pine forests in Portugal have not only been natural spaces available for people and animals to enjoy, but have also been, at various times in the last 150 years, spaces for scientific experimentation, innovation, and development.

The well-known "Pinhal do Rei" or Leiria National Pine Forest was, until the fires of 2017, the most important pine forest of all national forests, whether private or public. When the “Direção-General dos Serviços Florestais e Aquícolas” (DGSFA) was created in 1917, of all the forests managed by the State, the one that provided the most profit and forestry products was undoubtedly the one based in Marinha Grande.

Therefore, the scientific investment made by the State, especially since 1924, is not very surprising. In that year, the DGSFA decided to create research laboratories in two small towns, Marinha Grande and Alcobaça, providing researchers with, although limited, means to conduct research and extension work. The first to be installed was the Maritime Pine Experimental Station (1924). It was initially directed by forester Francisco Santos Hall (1898-1954), the main researcher for the first six years, before being appointed a forestry professor in Lisbon. Primarily dedicated to Pinus pinaster, Santos Hall studied improvements in forest management and resin tapping methods.

Santos Hall received training abroad, in Germany and the United States. With him, the pine forest became a laboratory without walls: plantations were inventoried, hundreds of thousands of trees were measured, tables and various standards were drawn up to meet growth study needs and to define thinning techniques and the best exploitative methods.

Another significant moment in public R&D investment for maritime pine was the creation of the National Resinous Board (JNR) in 1936, whose objectives were to "guide, discipline, and supervise" the industry and trade and ensure its technical, economic, and social improvement, while promoting Portuguese resin in foreign markets. The Board had intense internal (statistics, technical standards, professional training) and external dissemination activities, especially

promoting the resin industry and national products. Santos Hall died young, in 1954, and since that year there has been another leading forester in the field of maritime pine, Domingos Pereira Machado, who was a consultant to the JNR at various times. Machado had started his scientific career in Alcobaça, where he learned genetics and plant breeding from one of the best teachers: Joaquim Vieira Natividade. In May 1954, for example, Machado published an article in the magazine Vida Rural, detailing his work on resin tapping. The main innovation of that decade was the application of stimulant pastes, i.e. compounds based on sulphuric acid, whose purpose was to stimulate resin production and delay the closing of the resin channels. These recommendations are still present in current manuals, such as the one published in 2018 by Resipinus.
In Machado's words, acid was important for increased gem production because it facilitated "its exit by dissolving the walls of the epithelial cells surrounding the secretory channels, and also because, by absorbing water from the cell walls, it delays the gem crystallization when it comes into contact with the air, prolonging its exudation period." The magazine "Vida Rural" was not a scientific publication, but Machado managed to explain procedures to forest producers and workers in a simple manner without completely abandoning technical language. Machado urged patience with the results of the Board's scientific research: "Haste, a characteristic of modern life, is the number one enemy of research." Indeed, some Portuguese resin producers took a while to abandon the traditional Hugues method and experiment with acid pastes, already publicized by Machado 70 years ago. Almost all resin producers now apply a chemical stimulating paste to incisions, with a new incision made every 15 to 20 days – a new incision slightly below the first.

What Is the Future of Maritime Pine?

The future will bring changes that we have difficulty imagining. But one thing is certain: the maritime pine forest will continue to integrate our landscape, history, culture, science, and economy.

For centuries, this species has demonstrated great resilience and utility to humans, and the future will certainly bring new chapters to the pine forest's history in our country. One of these chapters will likely involve more widespread use of genetically improved plants. We will have more productive pine trees in resin thanks to the new genetic improvement program launched by RN21. Some of these trees will probably also be more productive in sawn wood. And we will also have pine trees with an increased wood production higher than what we currently have, which is already at 21%.

The PRR's investment in resin sector innovation is evidence that governments continue to recognize the enormous environmental, social, and economic potential of the pine forest.

It is up to all professionals involved in the RN21 consortium to leave a legacy of knowledge to future generations, following the footsteps of Francisco Santos Hall and Domingos Pereira Machado.

Susana Carneiro,[a] Pedro Teixeira,[a] Ignacio García Pereda,[b]
[a]Centro PINUS
[b]Centro Interuniversitário de História das Ciências e da Tecnologia da Faculdade de Ciências da Universidade de Lisboa

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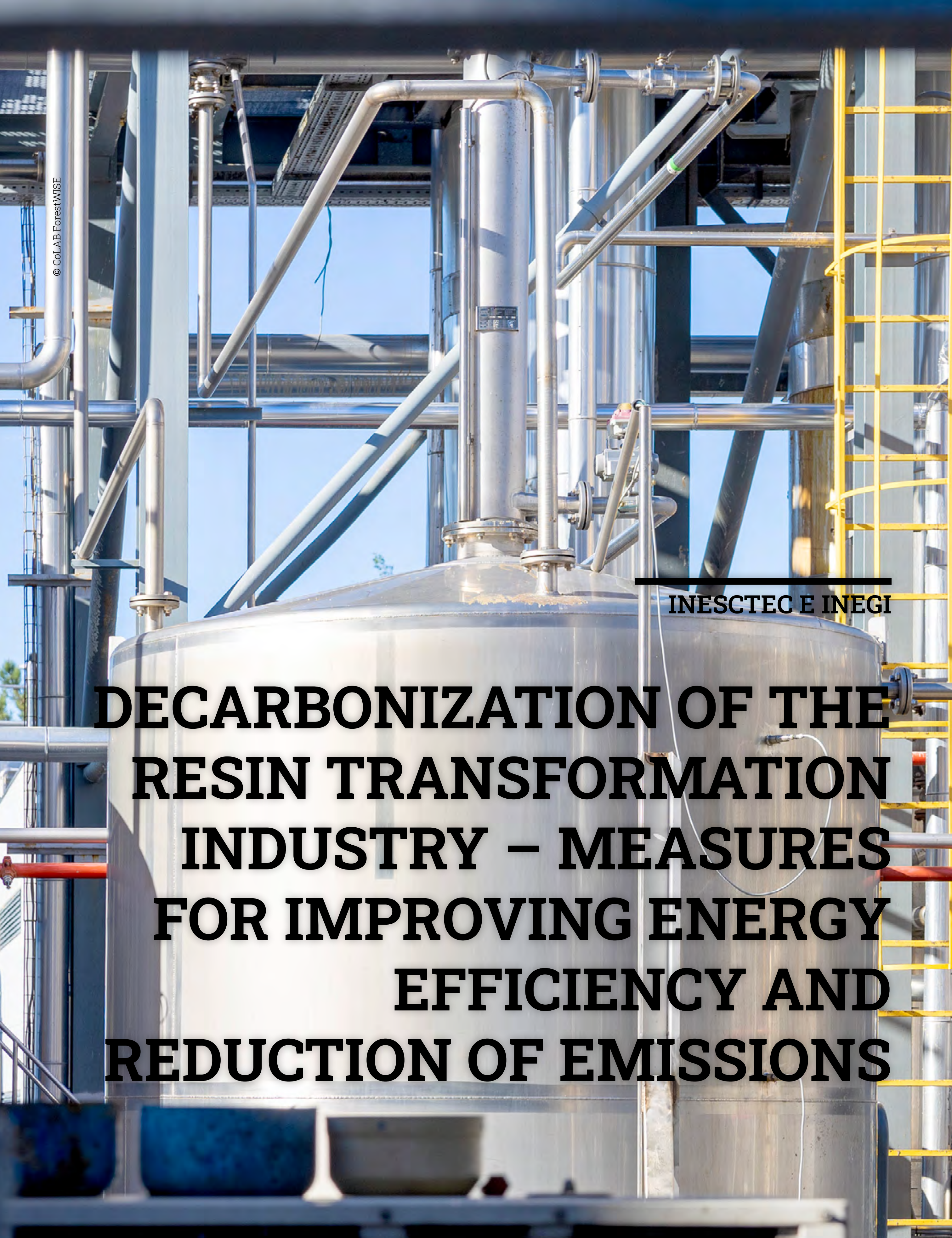

INESCTEC E INEGI

DECARBONIZATION OF THE RESIN TRANSFORMATION INDUSTRY – MEASURES FOR IMPROVING ENERGY EFFICIENCY AND REDUCTION OF EMISSIONS

Historically, Portugal was positioned as the world's second largest exporter of resin in the 1970s, having lost this status since the late 1980s mainly due to competition with the synthetic resin industry, rural abandonment and consequent increase in labor costs, and the affirmation of the Chinese industry in the international market with more competitive prices. Currently, importing resin for the processing industry is more attractive than exploiting it in Portugal due to its cost. However, the reinvigoration of this sector creates opportunities for rural development, job creation, fighting depopulation in the interior of the country, and the enhancement and protection of forest resources. Thus, investment in the sophistication and optimization of industrial processes and the promotion of environmental sustainability through efficient energy and water is essential for its reaffirmation in Portugal.

According to official data, in 2018 there were 218 registered operators in the resin industry in Portugal, operating in the 3 main activities of the sector: resin tapping (extraction, collection, cleaning and packaging), first transformation (production of rosin and turpentine), and second transformation (production of rosin and turpentine derivatives). Resin tapping is predominant with about 90% of registered operators, followed by transport (72%) and storage (68%) – the first processing, export, and import activities are less significant. Figure 1 shows the geographical distribution of the resin industry in Portugal. Resin tapping is mainly practised in the North and Centre, particularly in the districts where maritime pine has the greatest expression in terms of forest cover: Leiria (69 registered operators), Coimbra (27), Viseu (27), and Vila Real (22). Accordingly, the North and Centre of the country register a higher production of resin, albeit having registered a decrease in recent years – but the increase in the average price of resin minimizes this impact on industry revenue.

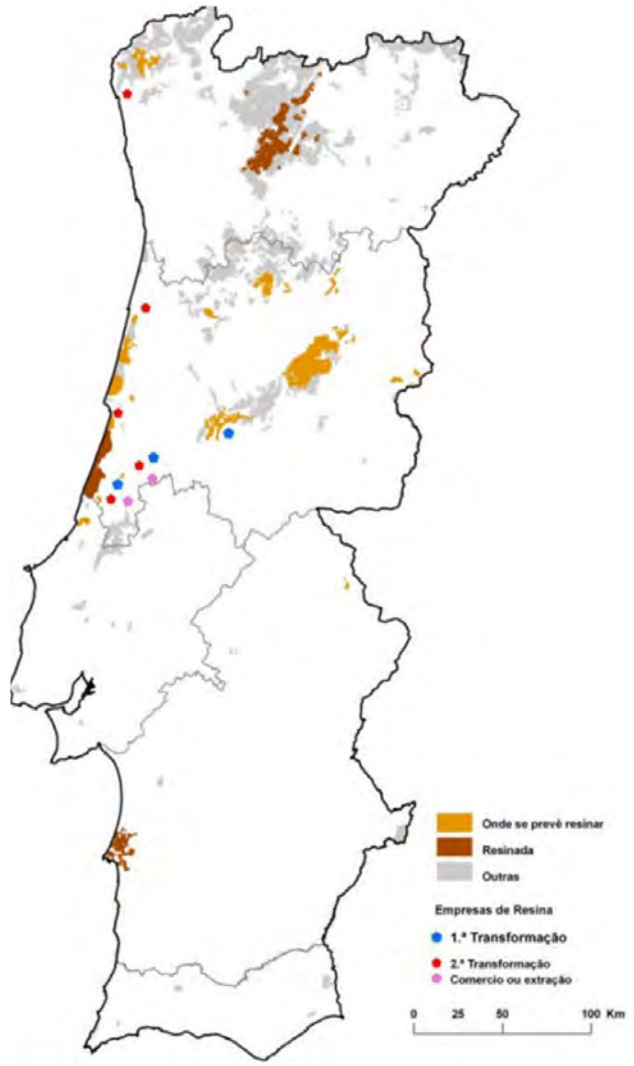

Figure 1 - Potential resin tapping areas and location of the first and second resin processing industries in Portugal.

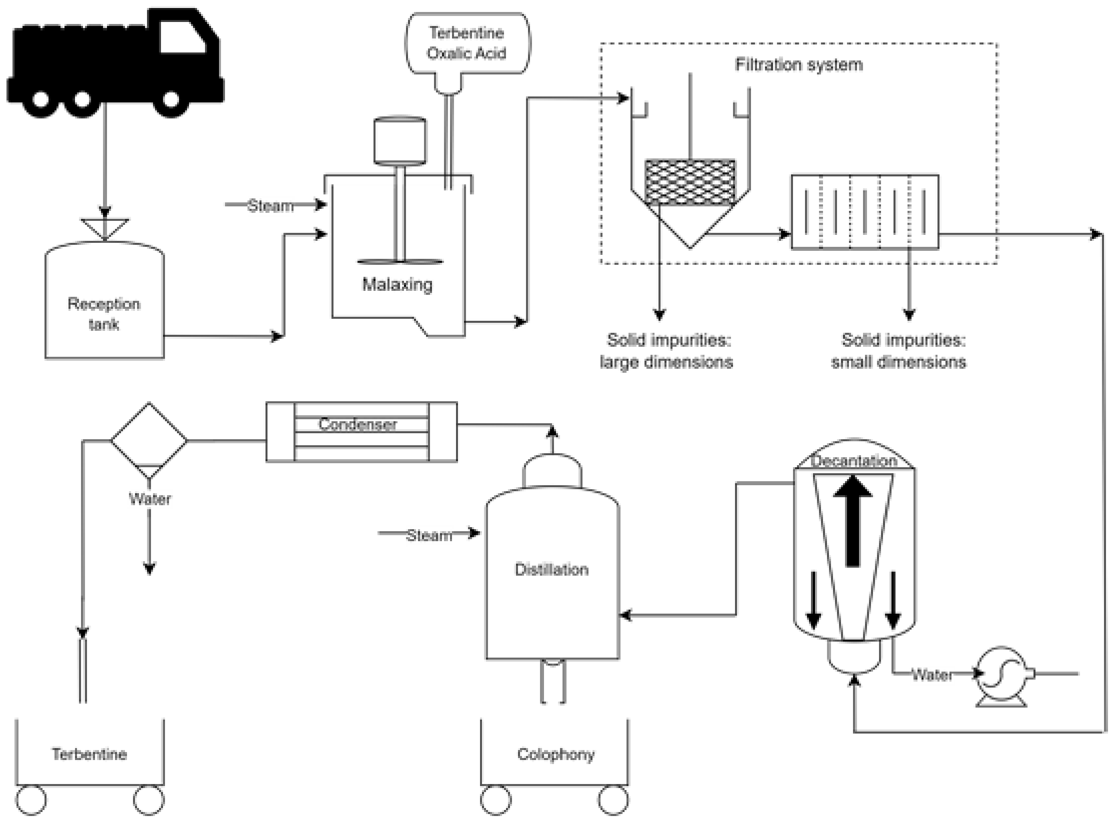

Figure 2 - Production process of the first transformation industry of resin.

Resin tapping is predominantly manual and is legally limited to the period between March 1st and November 30th. This process includes removing the bark from the trunk, perform an incision, and periodically renovating the incision to extract resin, and finally, at the end of the season, the cleaning of the remaining resin from the trunk. The use of an acid enhances the production of resin and facilitates its extraction. The resin industry is energy-intensive in all its activities, including thermal energy. This first stage is highly dependent of fossil fuels (such as diesel) used in the transporting of resin to industrial facilities.

The production process of the first transformation industry, illustrated in Figure 2, begins with the arrival of the resin to the industrial facilities. The resin is then discharged into a reception tank that constantly feeds the malaxing tank, where the resin is homogenized and heated to 85-100°C by direct steam injection. Subsequently, the mixture is filtered in several steps to remove all impurities and decanted to separate the aqueous and organic fractions. The latter undergoes a distillation process, allowing the rosin (non-volatile fraction) to be isolated. Rosin (or colophony) is a solid at room temperature, with a glassy appearance and colour from light to brownish yellow. The volatile fraction of the mixture is admitted into a condenser and originates turpentine, a clear liquid with a slight smell of pine and a bitter taste. The specific properties of these by-products depend essentially on the geographical area and the pine species at their origin.

The first transformation industry consumes energy primarily in the form of electricity, natural gas, and diesel – with natural gas being the predominant form of energy used mainly in boilers for steam production. The highest energy requirement is found in the filtration stage, followed by the distillation process.
The energy used in the first transformation of resin consists mainly of electricity, natural gas, and diesel – with natural gas being the predominant input and used mainly in steam boilers. The steam is used directly (malaxing and distillation) and indirectly (heating the feedstock) in the production process. Figure 3 illustrates the distribution of thermal energy consumption in the form of steam across the different stages of the manufacturing process. The filtration system's predominance in the industry's energy requirements is highlighted, followed by the distillation process. Losses are mainly due to boiler purging, steam leakage, and other losses in the steam distribution system.

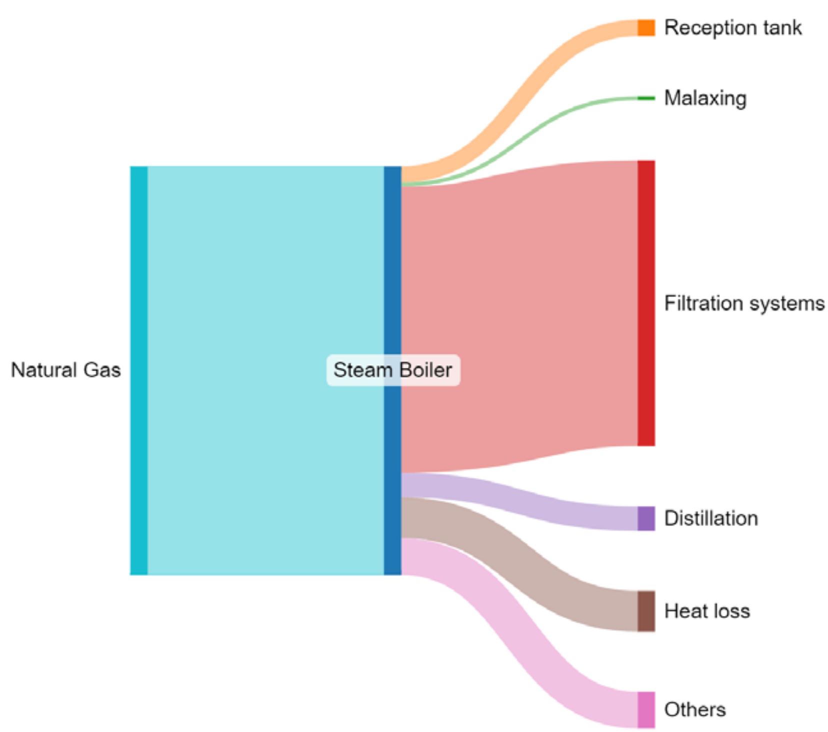

Figure 3 - Sources of thermal energy consumption in the manufacturing process in the first transformation industry.

The second transformation industry (Figure 4) produces rosin derivatives, its properties being modified to better serve different purposes. Rosin derivatives have applications the manufacture of paints, coatings, rubber, paper, food, beverages, cosmetics, among others. At the start of the production process, the rosin is admitted in the solid state and sent to a steam-heated melter, entering the reactor already in the liquid phase. Depending on the desired product, rosin can undergo different chemical modification reactions (esterification, salt formation, dismutation, and isomerization, for example). After this chemical reaction, the aqueous content is removed under vacuum (if necessary), and the rosin derivative is then sent to storage tanks maintained at a temperature of 120-240°C. The final product can be shipped in liquid (in tanker trucks or drums) or solid (after cooling) state.

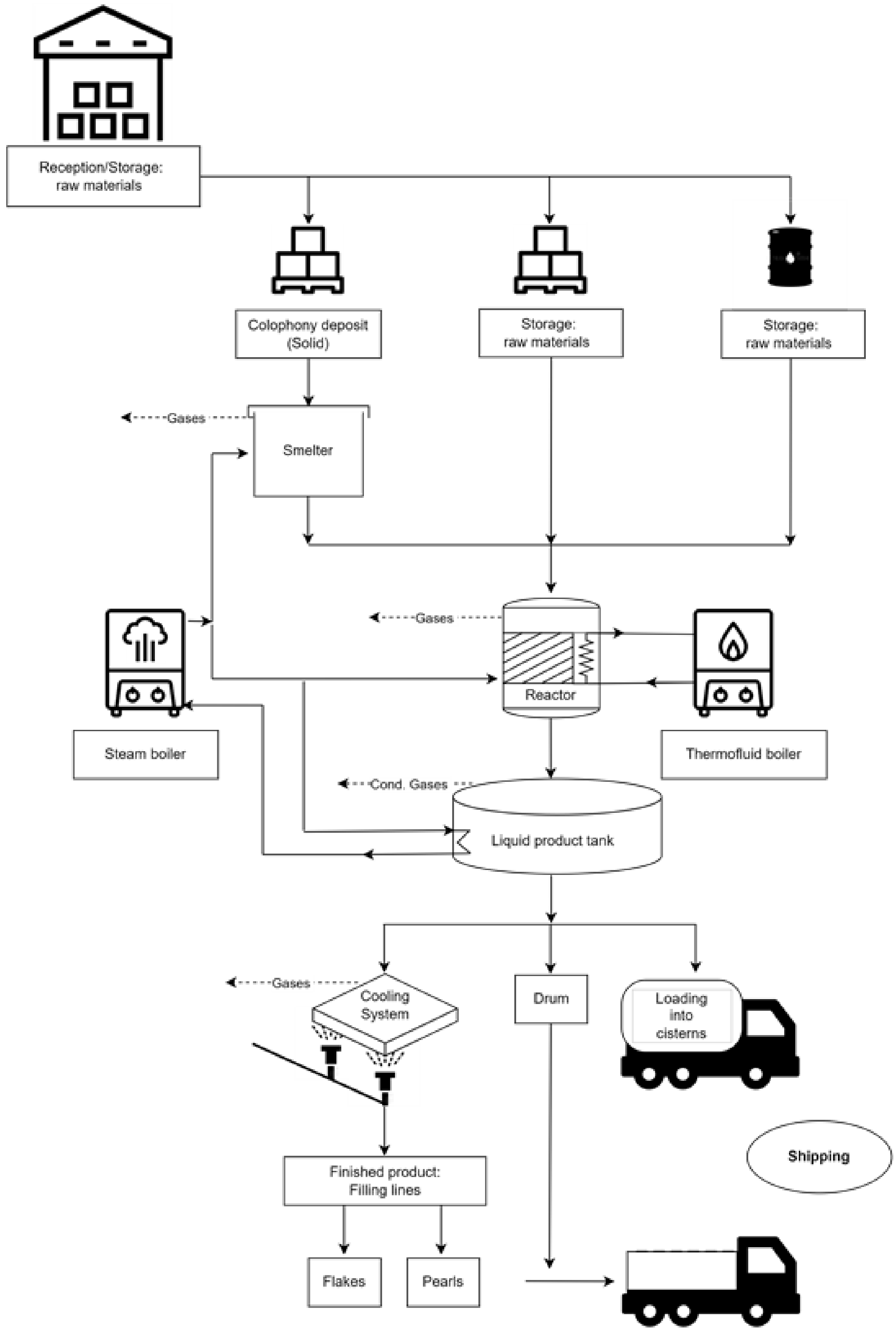

Figure 4 - Production process of the second transformation industry of resin.

Similarly to the first transformation industry, energy consumption in the second transformation industry is essentially due to the use of gas boilers. These boilers are used to heat the thermal fluid (maintaining the temperature of the reactor) and to produce steam (heating the raw material and directly introducing it into the production processes).
Similarly to the first transformation industry, energy consumption in the second transformation industry occurs mainly in the gas boilers. At this stage, two different boilers are required for steam production (for heating and direct introduction of the raw materials into the production processes) and heating the thermofluid (for maintaining the reactor temperature). Figure 5 represents the distribution of natural gas consumption among the various stages of the production process, showing the reactor as the main consumer of thermal energy in the second transformation industry. In addition to natural gas, the second processing industry also consumes diesel to drive emergency generators, but this consumption is not significant. As with the primary transformation industry, energy losses are related to steam leaks, boiler purges and other losses in the distribution network.

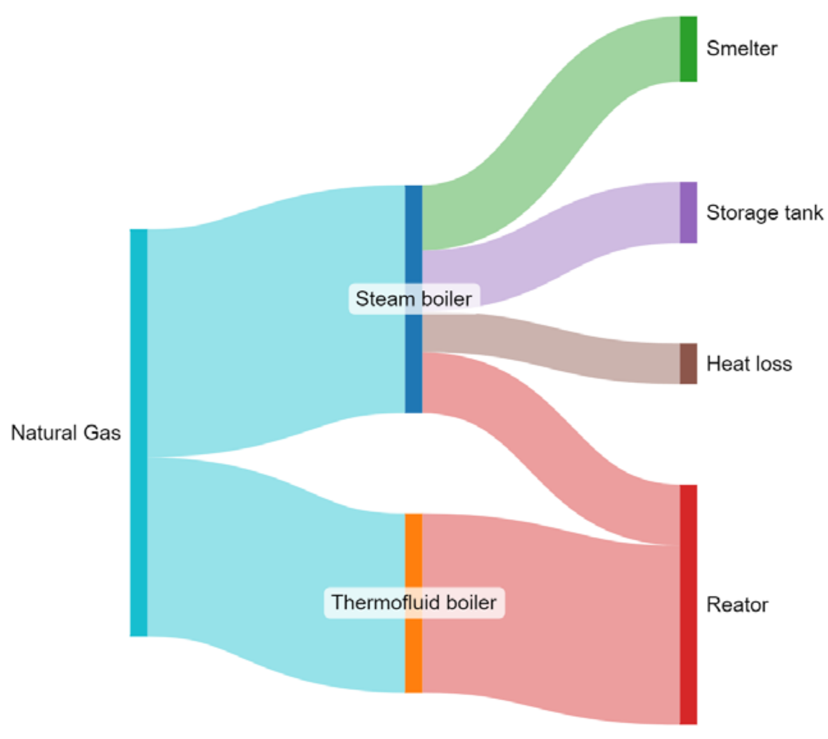

Figure 5 - Sources of thermal energy consumption in the manufacturing process in second transformation industry.

The transformation of rosin entails a substantial ecological footprint, particularly in terms of gaseous emissions. Thus, during the processes of smelting, reaction, storage, and cooling, gas emissions are collected and condensed to prevent their dispersion into the atmosphere. The liquid effluent is then directed to a wastewater treatment line.
Within the scope of the project RN21 - Inovação na Fileira da Resina Natural para Reforço da Bioeconomia Nacional, operational data were collected from four Portuguese companies in the resin sector, distributed among the first and second transformation industries. Data analysis confirmed the use of natural gas as the predominant vector, at 76.2% of total energy consumption, with electricity consumption making up the remaining 23.8%. Due to their different characteristics, these energy carriers contribute unequally to the aggregate Greenhouse Gas (GHG) emissions: natural gas consumption is responsible for 89.8% of total emissions, with the remaining 10.2% due to electricity consumption. One of the companies analysed ensures part of its electricity demand through

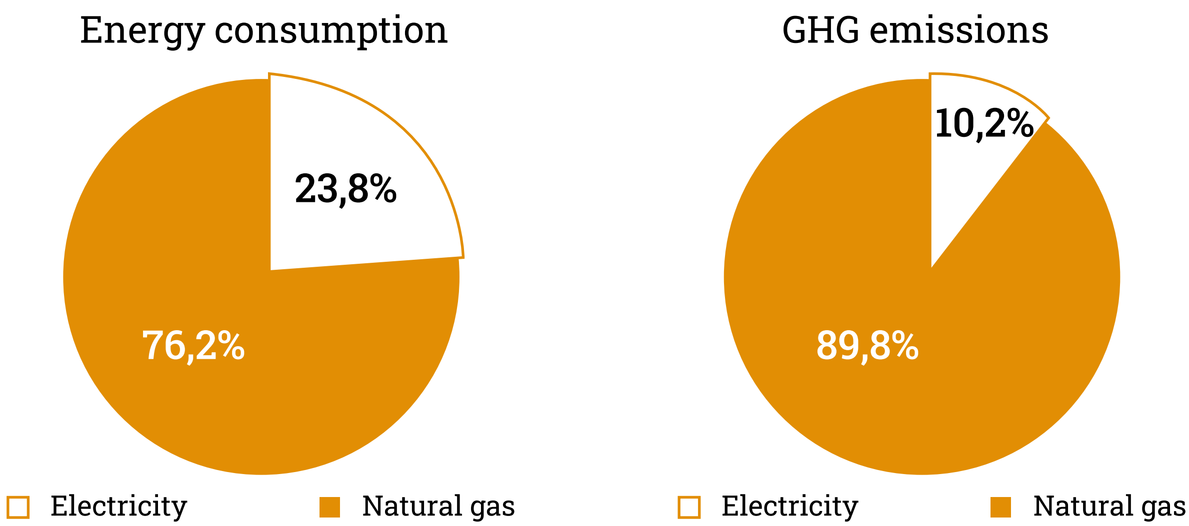

Figure 6 - Contribution of electricity and natural gas consumption to total energy consumption (left) and GHG emissions (right).

photovoltaic panels installed on-site, which leads to a lower contribution of this energy carrier to the company's total emissions. Figure 6 illustrates the contribution of electricity and natural gas consumption to total energy consumption and GHG emissions.
The collected data was also used to compute relevant energy and economic indicators for a more accurate assessment of the current state of the Portuguese resin industry. The Specific Energy Consumption evaluates the amount of energy used throughout the whole production process to produce a given amount of final product (rosin/turpentine and its derivatives in the first and second processing industries, respectively), allowing for the direct comparison of processing facilities of different sizes and even different industries. On the other hand, Carbon Intensity relates the total GHG emissions resulting from the consumption of the different energy carriers with the energy consumption of the company/industry; it thus evaluates the ecological footprint of the energy sources used in the production process. Table 1 specifies the average values of these indicators for the analysed companies.

Table 1 - Energy Intensity, Specific Consumption, and Carbon Intensity of the first and second transformation industries.

Specific energy consumption [kgep/t]	**Carbon intensity [tCO2/tep]**
248.40	1.97

The search for sustainable solutions in the resin transformation industry aims to optimize the use of energy resources, minimizing waste and its environmental impact. Thus, the adoption of measures to promote energy efficiency stimulates the technological innovation and competitiveness of the industry, reduces the costs associated with energy consumption, increases energy security, and ultimately contributes to mitigating climate change. These measures cover different areas of action (Table 2).

Table 2 - Energy efficiency measures to be applied in the resin transformation industry

Area of action	**Description**
Improved termal insulation	The insulation of industrial equipment minimizes heat losses to the outside through the application of insulating materials on the exposed surfaces, keeping an adequate temperature for the production process with a lower energy consumption. These solutions can be applied to valves, pipes, and storage tanks, for example.
Waste heat recovery	Depending on the specific production process and/or the equipment, a significant fraction of the energy input may be dissipated as (residual) heat. The use of this (otherwise wasted) energy and its re-introduction in the production process may allow for significant energy savings, being a potentially attractive solution from a financial and environmental point of view.
Integration of renewable energy sources	Renewable energy sources may be used to replace polluting and non-sustainable forms of energy, such as fossil fuels (namely natural gas in the case of the resin processing industry), contributing directly to the decarbonization of the production process. In this project, only solar energy and biomass were considered.

Area of action	Description
Retrofitting of equipment and processes	The refurbishment of production lines and/or the replacement of some of their components with more technologically sophisticated versions increases productivity and efficiency, resulting in a reduced energy consumption.
Electrification of equipment and processes	Replacing conventional forms of energy (such as natural gas) with electricity generally increases the efficiency of the equipment and production processes (replacement of diesel forklifts with electric equivalents, use of heat pumps for heating), reducing energy consumption and the associated cost. Combining this measure with the integration of renewable energy sources enhances its contribution to decarbonizing the industry.
Valorization of by-products	Waste from the production process may still hold energy value, thus it may be used to reduce the total energy consumption of the industry. Solid waste from the filtration of the raw material in the first processing and liquid waste from the condensation of reactor gases are examples of by-products that may be recovered for energy.

Table 3 details the potential impact of the different efficiency measures above, assessed in terms of the reduction in annual energy consumption and annual GHG emissions achieved. The Payback Period (PBP) indicates the number of years after which the accumulated savings in the energy bill, resulting from the reduction in energy consumption by adopting the different measures, equals the initial investment. The Improved thermal insulation of industrial equipment has a reduced impact on both total energy consumption and GHG emissions. However, it is an easy-to-implement solution, and the return on investment is fast due to its low cost. On the other hand, the adoption of Waste heat recovery promises a substantial reduction in consumption and emissions while maintaining a reasonable PBP. The Integration of renewable energy sources leads to a very significant reduction in the energy bill, and is also the most significant measure in terms of emissions due to the substitution of polluting conventional sources (such as natural gas). Retrofitting of equipment and processes is the least appealing efficiency measure, as it allows for a very modest reduction in energy consumption and GHG emissions and its PBP is the longest. This type of solution does not introduce very significant changes in the production process, which explains its low impact on the analysed indicators. On the other hand, electrification of equipment and processes generally improves the energy efficiency of industrial processes and thus reduces their consumption. However, its contribution to decarbonisation is directly related to the use of renewable energy sources – the predominance of (non-renewable) natural gas consumption in the resin sector limits the impact of this measure on reducing emissions. Finally, the Valorization of by-products has a reasonable impact on the energy bill, with the added interest of reusing the equipment already available in the manufacturing facilities without the need to purchase new solutions. Thus, this measure does not require an initial investment and, therefore, is not associated with a PBP. However, the burning of by-products leads to increased GHG emissions.

Considering the potential of the different measures and their applicability to the companies under study, 12 specific measures were proposed to promote energy efficiency, considering the different areas and types of industry (first transformation / second transformation / first + second transformation).

Table 3 - Impact of energy efficiency measures (by typology) on energy consumption and GHG emissions and respective Payback on Investment Period

Area of action	Reduction in annual energy consumption [%]	Reduction in annual GHG emissions [%]	PBP [years]
Improved termal insulation	5	2	0.10
Waste heat recovery	30	11	1.85
Integration of renewable energy sources	25	70	0.54
Retrofitting of equipment and processes	< 1	< 1	7.15
Electrification of equipment and processes	28	20	2.75
Valorization of by-products	12	-3	-

Francisco Lázaro,[a] Ricardo Barbosa,[a] Tomás Rocha,[b] Zenaida Mourão,[b]
[a]INEGI: Instituto de Ciência e Inovação em Engenharia Mecânica e Engenharia Industrial
[b]INESC-TEC: Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciência

CITEVE

NATURAL RESIN DERIVATIVES AS SUSTAINABLE ALTERNATIVES IN THE TEXTILE AND CLOTHING INDUSTRY

Todays imperative to reduce the negative impact of industrial activity on the environment has driven the quest for renewable raw materials that can be incorporated in the production of polymeric materials[1]. Residues or natural additives can promote various functional properties, such as antimicrobial, anti-odor, or even improve the mechanical and structural characteristics of textile substrates, opening an opportunity for the development of innovative textile solutions. The need to place textile products on the market with differentiated technical and functional properties and better environmental credentials is growing; however, it is also necessary to guarantee the technical commitment with textile characteristics in terms of appearance, touch and comfort of the article, these factors being increasingly relevant in the choice of the final consumer.

Pine resin is a natural substance derived from various species of pine trees, which has historically been valued for its versatile properties and has been used for various purposes over the years. In Portugal, the pine ecosystem covers around 1 million hectares of forest, dominated by maritime pine (*Pinus pinaster Ait.*) and stone pine (*Pinus pinea L.*), accounting for around 22% and 6% of the total forest area, respectively. The former, *P. pinaster*, is mainly exploited to produce wood by-products, paper, and oleoresin (often defined simply as resin or rosin). Resin tapping, a traditional activity, has made a comeback in the Iberian Peninsula due to the growing demand and rising prices of natural products[2]. Rosin is obtained by steam distillation of oleoresin, the non-volatile fraction of which accounts for around 80% of its weight. Pine resin is valued for its intrinsic properties, both at a technical level (adhesiveness and support) and at a medicinal level (antimicrobial properties)[3], which is why its natural form and derivatives have been used as adhesives, water repellency[4], antimicrobials[5], and antioxidants[6]. It is a sustainable industrial raw material used in varnishes, emulsifiers, polymers, and coatings[7]. Due to its composition, it is also used in the synthesis of polymers and additives (adhesive, waterproofing[9], antimicrobial[10], antioxidant[11], stabilizing, plasticizing, and viscosity promoting properties[8]). Rosin therefore has several advantages, such as its availability, low cost, and origin from a natural and renewable source[9].

2. Practical applications of resin in the production of solutions for ITV

The textile sector has shown a growing demand for diversified and innovative products, through more sustainable approaches that cut across the entire life cycle of textiles. Pine resin has emerged as a promising solution for boosting sustainability and functionality in the textile industry, standing out for its renewable origin and functional properties. In this context, the synergy between the textile and resin sector is highly innovative for the ITV sector.

The main objective of the RN21 project is to develop new textile products using rosin and rosin-based derivatives to produce coatings and adhesives, fibers and textile structures (Figure 1).

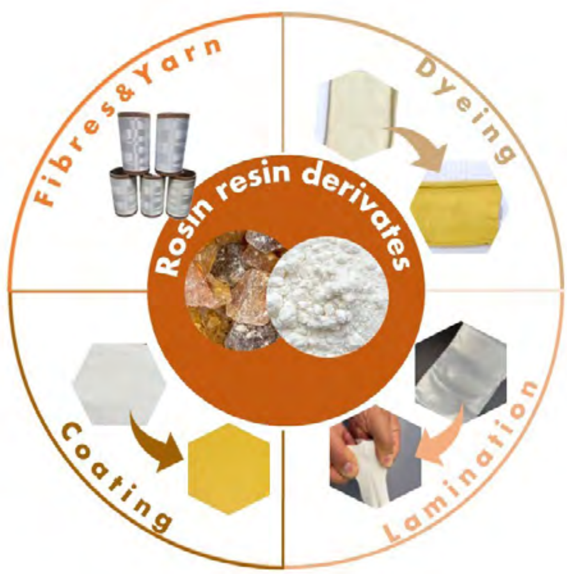

Figure 1. Schematic representation of the different applications explored for the use of rosin and its derivatives in ITV.

2.1 Production of fibers/yarns

There are few references to studies involving the production of textile fibers containing resins of natural origin, such as rosin and its derivatives. However, in addition to its reported antimicrobial properties[10], the adding rosin to polymers also has the potential to lower the melting point and the degree of crystallization[11], which could be beneficial from the point of view of the process, resulting in a lower temperature profile and a consequent reduction in costs and greenhouse gas (GHG) emissions associated with the production process. However, it will always be necessary to optimize the mechanical properties of the textiles obtained from these blends.

Within the scope of RN21, renewable polymer-based materials combined with natural resins have been developed. In this context, fibers and jersey knits were produced using two types of resins (Resin A and Resin B) and two different polymeric matrices, high-density polyethylene (BIO-HDPE) and bio-polyamide (BIO-PA), Figure 2 and Figure 4, respectively. The addition of

Resin A to the BIO-HDPE-based formulation promoted an increase in the fluidity of the mixture, which made it possible to reduce processing temperatures by more than 10°C when compared to a control material (100% BIO-HDPE), without there being any significant changes in the mechanical properties measured in jersey knits obtained from these yarns (Figure 2 and Figure 3). In addition, fibers, and jersey knits (Figure 4) were produced using BIO-PA and different percentages of Resin B [%1 and %2 (m/m)], characterized by having a higher melting temperature than Resin A. Increasing the percentage of resin incorporated resulted in greater bursting strength compared to the control (Figure 5). This increase in resin did, however, cause yellowing of the textile substrates, which did not impact the final application and was easily fixed in the dyeing processes.

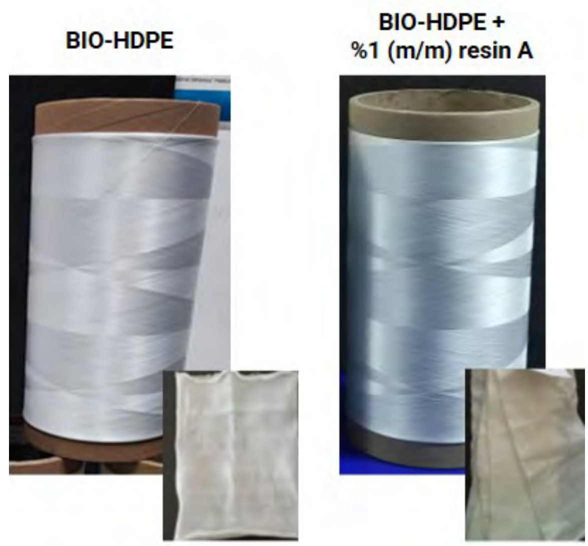

Figura 2. BIO-HDPE fibers and meshes with and without Resin A.

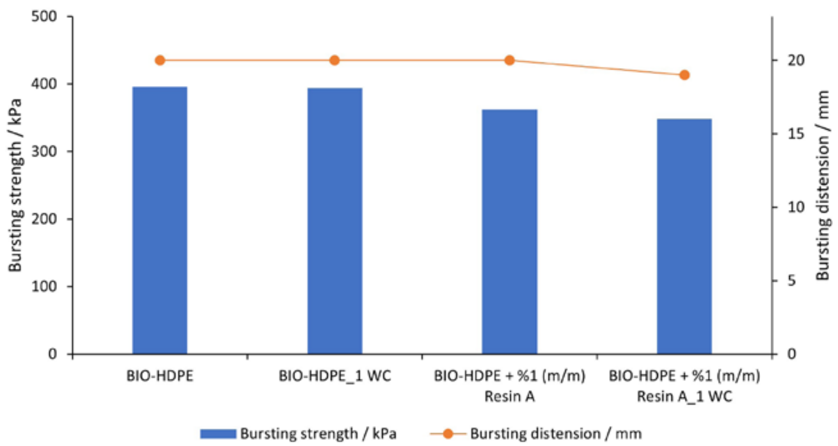

Figure 3: Mechanical properties of BIO-HDPE meshes, with and without Resin A: burst and elongation strength before and after 1 wash cycle (_1 Lav).

Figure 4: BIO-PA fibers and meshes with and without Resin B.

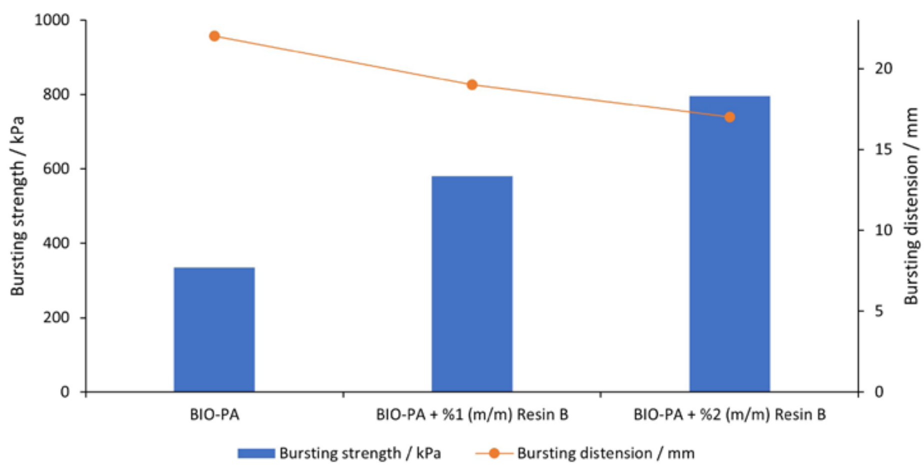

Figure 5: Mechanical properties of BIO-PA meshes, with and without Resin B: burst and elongation strength.

2.2 Dyeing

One of the most relevant aspects of the dyeing process is color fastness. Various methods are available to increase color fastness, such as the control of dyeing variables, appropriate selection of the pigment and auxiliaries, and their affinity with the textile structure to be dyed. The use of mordants is intended to improve and/or promote the fixation of natural dyes to textile structures. In RN21 we are studying the use of rosin and its derivatives as a biomordant. Although scarce, there are references in the literature to the use of rosin as a natural mordant, particularly in the process of coloring hemp and cotton fibers with natural dyes, where the use of rosin improved the fastness and intensity of the color compared to synthetic mordants[14, 17]. Within the scope of RN21, it is planned to develop systems derived from rosin as auxiliaries in the (bio)coloring processes of textile structures by exhaustion. The preliminary results obtained show that the addition of rosin derivatives in the biocoloring process does not interfere with the final color and aesthetic properties of the cotton-based textile structure (Figure 6).

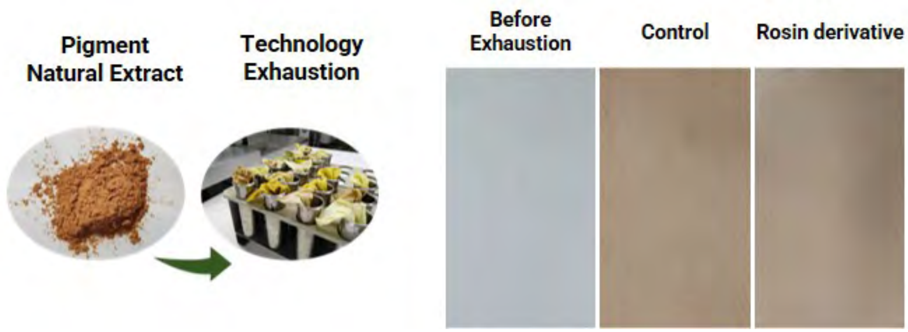

Figure 6. Biocoloring process using rosin derivative as a natural mordant.

2.3 Laminating

Rosin derivatives are important components and have already been widely explored in both pressure-sensitive and hot-melt adhesives[3]. However, their use for this purpose in the textile industry has not yet been fully explored, with only a few developments aimed at formulations and adhesive systems, for example for shoe linings[3]. Due to their adhesive characteristics, resins and their derivatives can be important for promoting adhesion between textile substrates. To this end, a 100 µm film with a melting point of 130 °C was developed by United Biopolymers and laminating tests were carried out on substrates of different compositions, cotton and polyester. The lamination test took place in two stages in which parameters such as pressure, temperature and time were studied. This process successfully produced laminated textile substrates with a high potential for application in ITV (Figure 7).

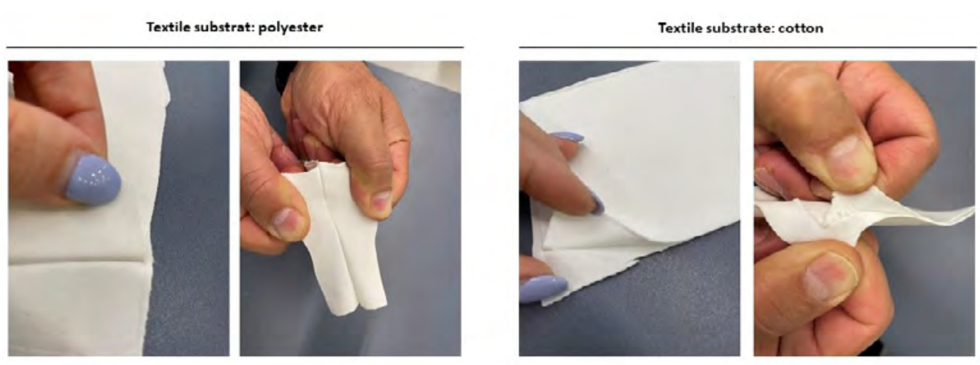

Figure 7. Laminations carried out using the polymeric film with rosin resin derivative in its composition.

2.4 Coatings

Rosin derivatives are used in paints and coatings for the electronics and construction industries. However, their use in applications in the textile industry has not yet been properly explored. In order to explore the potential of rosin and its derivatives, they have been used as raw materials for functional finishing through coating processes and have been used as a solid filler in paste and/or foam formulations for coatings. The application of rosin and its derivatives in paste formulations for coating a cotton mesh was therefore studied. The formulation under study involved a polymer (with a biocompatible component), a resin/its derivatives, a binding agent, and a thickening agent. In the coating process, the polymerization agents (the base polymer and the additives/catalysts for the polymerization reaction), the additives regulating the fluid's rheology and the filler elements (e.g. pigments or particles for mechanical reinforcement/aesthetic embellishment/functional actuators) were carefully selected. It was found that the use of rosin and its derivatives resulted in a continuous and homogeneous deposition of the paste on the surface of the textile substrate, obtaining uniform coatings (Figure 8).

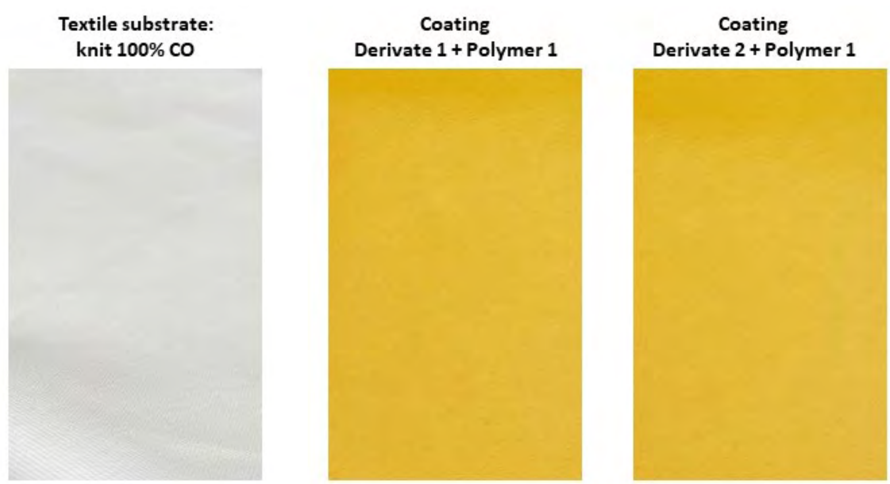

Figure 8. Examples of coatings developed using rosin resin derivatives.

CONCLUSIONS

The studies carried out as part of this project aim not only to explore the specific applications of rosin and its derivatives in ITV, but also to target specific segments such as fashion and technical products. By incorporating rosin and/or its derivatives into manufacturing processes in the textile production cycle, from fabric production to final finishing, the aim is not only to improve the technical properties of textile products, such as their strength and durability, but also to promote innovation in eco-design and in the decorative features and functionalization of fashion products. In addition, the use of rosin and its derivatives in technical fabrics will generate new application opportunities in a wide variety of areas, thus boosting the synergy between the resin and textile sectors, as well as the diversification and sustainable growth of ITV in multiple market segments.

Filipa Dinis,[a] António Mendes Ferreira,[a] Joana Góis,[b] Pedro Magalhães,[c] Teresa Gomes,[c] Carlos Silva,[c] Lorena Coelho,[d] Bárbara Abreu,[d] Bruno Peliteiro,[d] José M. Barbosa,[d] Anabela Carvalho,[d] Bruna Moura,[d] Nelson Durães,[d] Carla Joana Silva,[e] Filipa Costa,[e] Jéssica Antunes,[e] Joana M. Gomes,[e]

[a]United Resins – Produção de Resinas S.A.
[b]United Biopolymers, S.A.
[c]Tintex Textiles S.A.
[d]CeNTI - Centro de Nanotecnologia e Materiais Técnicos, Funcionais e Inteligentes
[e]CITEVE – Centro Tecnológico das Indústrias Têxtil e do Vestuário de Portugal

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OUTREACH

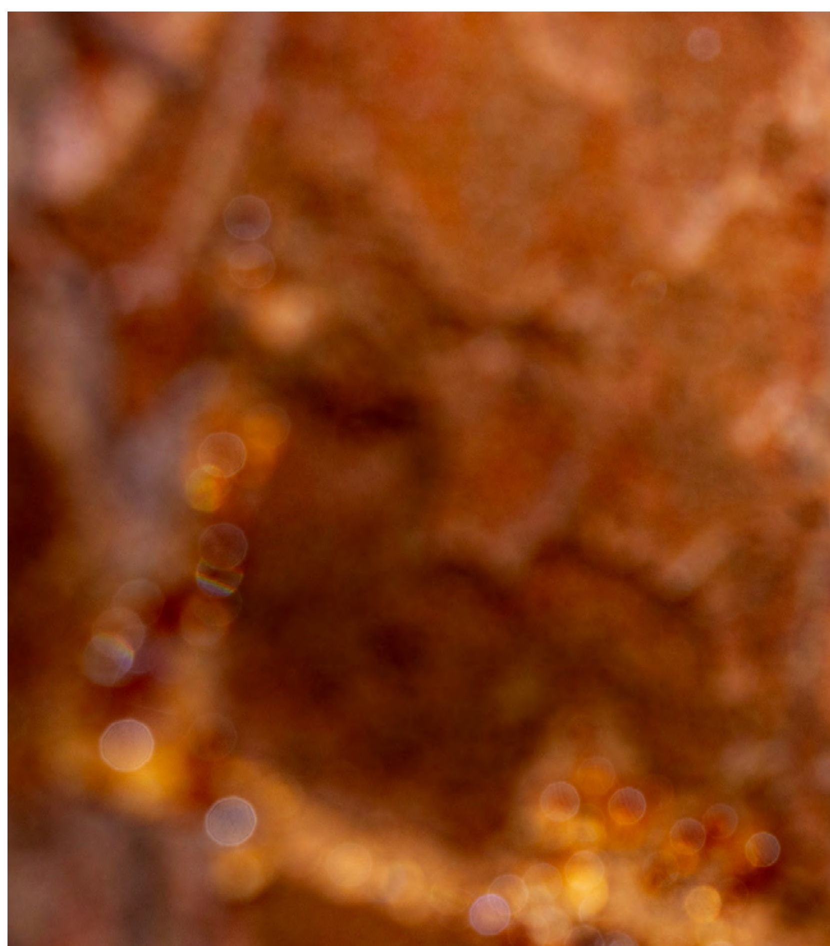
At the forefront of sustainable innovation, RN21 shares knowledge and advancements, connecting stakeholders in the Natural Resin sector towards a greener and more prosperous future.

CERTIFICATION: A STRATEGY FOR VALORIZING NATURAL RESIN

Certification is a mechanism that ensures the consumer that a certain product meets criteria and specifications that guarantee the traceability of the raw materials throughout the industrial transformation process.

In the context of Natural Resin, certification presents itself as an opportunity for the Natural Resin sector to demonstrate that extraction and industrial transformation processes comply with environmental, social, and economic requirements, positively differentiating and adding value to their products in the market.

The production of Natural Resin in the Iberian Peninsula has deep roots. In its peak, it was a forestry activity of great economic relevance in Portugal and Spain, mainly due to the tapping of Natural Resin from Maritime Pine (Pinus pinaster Ait.), a resinous species



with the highest representation in the territory, whose resin is recognized for its exceptional chemical and physical qualities.

The RN21 Consortium brings together the main stakeholders of the Natural Resin sector in Portugal, who, in a concerted manner, aim to assert Natural Resin as a renewable, high-quality product, contributing to sustainable forest management, reducing the risk of forest fires, and valorizing the Center and Interior of Portugal, through the enhancement of the entire value chain of the Natural Resin sector.

The Integrated Project RN21 aims to develop a certification system that will implement a brand that differentiates resin from stands of Maritime Pine originating from forests in the Iberian Peninsula.

In this way, RN21 intends to implement a Natural Resin Certification process based on two aspects: a Production component, through sustainable forest management certified by an independent and globally recognized forest certification system; and a Transformation component, through Chain of Custody certification, a Certification Standard that ensures the traceability of certified raw materials from their origin to the consumer.

Thus, it is intended that this brand becomes a symbol of trust for conscious consumers, indicating that they are making a choice that values the origin and quality of the raw material, promotes economic resilience of the forest, and fosters territorial cohesion. The implementation of a certification system for Natural Resin contributes not only to the competitiveness of this sector in the global market but also to carbon neutrality through the promotion of European raw materials, thus reducing carbon footprint.

Jani Pires,[a] Juliana Salvação,[a]

[a]CoLAB ForestWISE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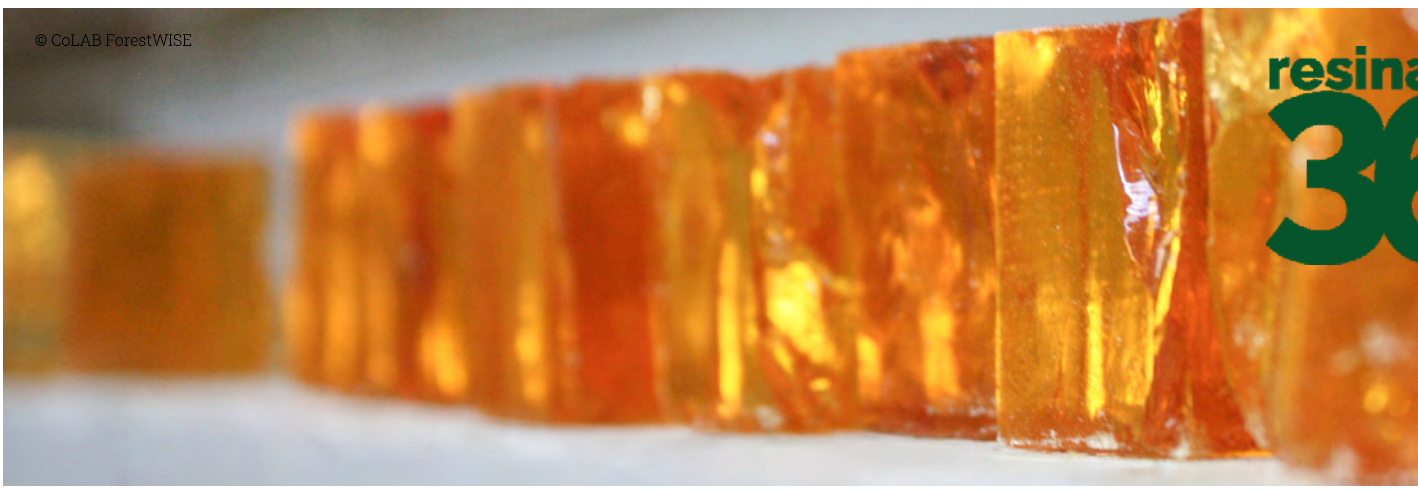
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WEBINARS

SOCIAL MEDIA

Our social media channels for the Integrated Project RN21 have the goal of strengthening our relationship with the audience and creating an informal mean of communication. This initiative reflects our commitment to keep all stakeholders updated on the latest developments of the Project, providing a space for closer interactions, sharing valuable information, and creating a community engaged around Natural Resin and our vision for a more sustainable future.

RN 360º PODCAST

Our initiative aims to promote knowledge about Natural Resin and its incredible contribution to a sustainable future. Each episode, approximately five minutes long, is an opportunity to expand your knowledge about this valuable resource. Join us in engaging episodes where we explore the Natural Resin sector and its various applications.

You can find all the episodes at https://rn21.forestwise.pt/podcast

WEBINAR RN21

Each webinar offers insights from experts, researchers, and professionals in the field on the importance of natural resin, its properties and applications, traditional and innovative extraction techniques, among others. Join us on this exciting journey of learning, discovery, and innovation as we unveil the economic potential, forest sustainability, and entrepreneurial opportunities driven by Natural Resin.

You can review all the webinars at https://rn21.forestwise.pt/webinar

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