



**Centro de Investigação
de Montanha**

**Major contributions to science, the economy and society:
From the local to the global**



From nature to products towards sustainability



Instituto Politécnico
de Viana do Castelo

FCT Fundação para a Ciência e a Tecnologia

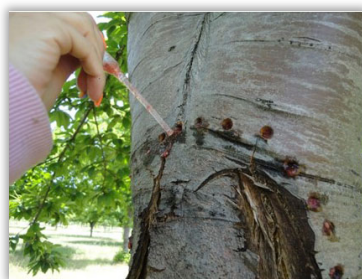
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR Portugal



Centro de Investição de Montanha · 2018
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FIVE MAJOR CONTRIBUTIONS OF CIMO

PLANT DISEASE CONTROL: DICTIS is the brand of a biological control product developed by CIMO for the treatment of chestnut blight (*Cryphonectria parasitica*). The disease was introduced in the Northeast of Portugal in 1989 and has since caused mortality in chestnut trees and losses in the #1 chestnut production region in Portugal. DICTIS was developed in the scope of 2 major research projects (FCT and PRODER funded) by exploring biological hypovirulence associated with CHV1 hypovirus to control the blight pathogen. CIMO research in this field allowed the identification and mapping of the *C. parasitica* strains in the region, the development and production of a compatible hypovirulent strain based product, the development of an application method, and the analysis of toxicity, pathogenicity and side effects of the product. CIMO also organized training sessions with farmers for DICTIS application. Currently the product is authorized by the Ministry of agriculture in Portugal (DGAV-009276, 10.04.2015) for the North and Alentejo regions. So far DICTIS has been applied in more than 15000 trees owned by hundreds of farmers through the involvement of 1 enterprise, 2 forest/farmers associations and 2 cooperatives. DICTIS impacts positively the economy (thousand Euro yearly in chestnut loss avoidance), the environment and the landscape.



KNOWLEDGE TRANSFER IN FORESTRY:

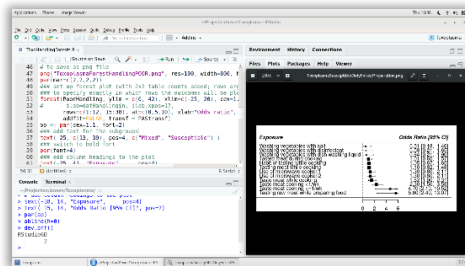
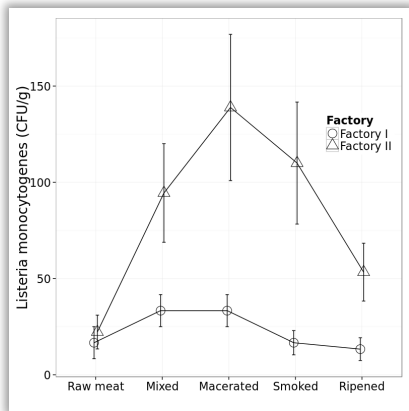
CIMO developed a series of software tools to support sustainable forest decision-making in the Northeast region at different scales. These tools include

WRoute®: a fuel consumption and carbon emissions calculator for wood transport; FlorNExT®: a forest growth-yield-management tool; FlorNextPro®: a multi-stand management optimization tool; AppTitude®: a supply-demand mobilization analysis tool; ApkFor: an Android project to generate mobile applications for forest growth and yield models; and ForestMTIS: a cloud computing project to generate forest simulators. The software (available through florestasdonordeste.esa.ipb.pt) was developed with the involvement of stakeholders such as Arborea (a forest association), and used in intensive training of forest owners, consultants, forest service, and other stakeholders to transfer knowledge and technology to increase sustainable forest mobilization and to raise awareness about sustainable forestry, under the SIMWOOD project (FP7 European Project). The tools were used with decision makers to support strategies and investments to promote development and reduce fire hazard. Through research and innovation, CIMO provided cutting edge technology supporting upcoming challenges, namely climate change and fire hazard. All software (open source) is registered as intellectual property.

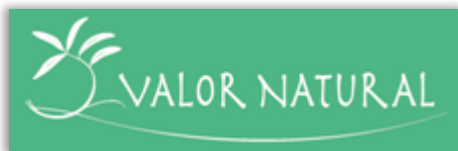


TOOLSET FOR FOOD SAFETY CONTROL:

The CIMO food safety modelling research team has developed novel and extensive approaches to integrate predictive microbiology and meta-analysis to improve food safety and public health, capturing national and international attention for its ground-breaking nature. At national level, this new set of techniques has been applied to identify faults in the processing of traditional sausages in Northeast Portugal. It has also awakened the interest of the international scientific community, as manifested through the cooperation procured by the Nestle Research Centre (NRC), in Switzerland, and the French Agency for Occupational Health and Food Safety (ANSES). Through collaborative work, NRC is adopting the new toolset of approaches to determine kinetic parameters of four foodborne pathogens using a comprehensive world's database of microbial growth experiments. The same innovative toolset has been sought for in a research project, subcontracted by ANSES, to attribute sources of foodborne diseases by meta-analysing large databases of epidemiological data from case-control studies. The originality, novelty and usefulness of these new methods have been recognised by the International Committee on Predictive Modelling in Food (ICFMH), which have bestowed CIMO the honour of hosting the next ICPMF Congress in 2019.



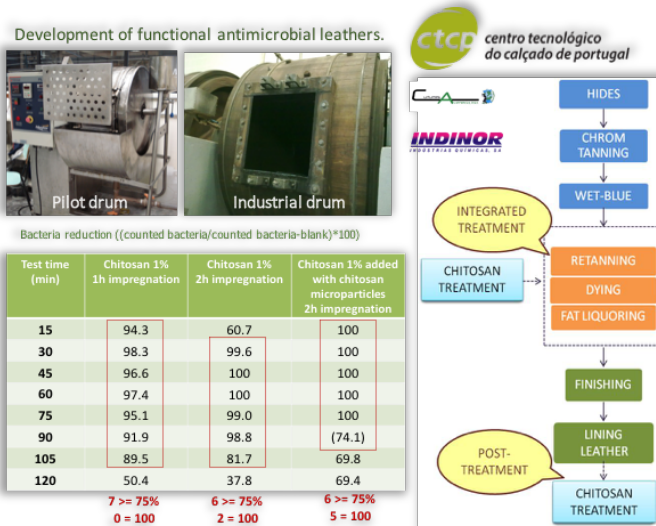
NATURAL BASED INGREDIENTS: The prospective research on the chemistry and biochemistry of plants and mushrooms provided CIMO with a privileged knowledge



that guided the exploitation of bio-based ingredients with colouring and preserving capacities. Different high added-value molecules with colouring (e.g. anthocyanins and betacyanins) and preserving (e.g. catechins and rosmarinic acid) capacity were isolated from natural sources and used as food ingredients/additives. Innovative food products were successfully developed with these stabilized ingredients, namely cheese, cottage cheese, yogurts, ice-cream, pastry and bakery products. These results originated patents related to the colouring capacity of *G. globosa* (10917.2017) and the preserving capacity of rosmarinic acid from leaves of *M. officinalis* (109883.2017), flowers of *C. sativa* (109448.2017; PCT/IB2017/052535), and fruits of *A. unedo* (109361.2017). This research has been published in highly cited articles (among the most cited and downloaded of their journals) in high impact journals in Food science and Technology. This led to the recognition of 2 CIMO researchers by Clarivate Analytics in the highly cited researchers top 1% list (2015, 2016 and 2017). Through the Mobilizing Project Valor Natural[®] (consortium with 13 enterprises from the entire agrifood value chain), this ground-breaking research is being scaled-up and transferred to the industry.

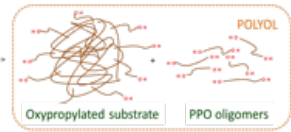
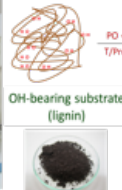
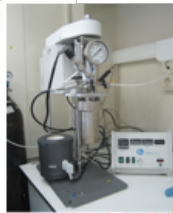
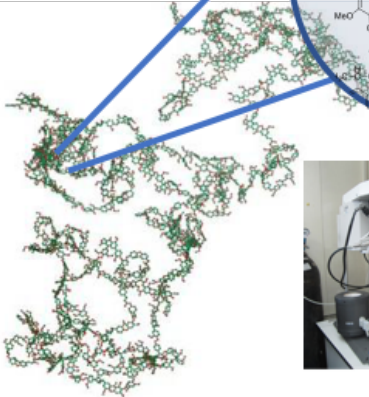
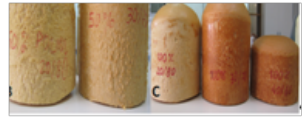
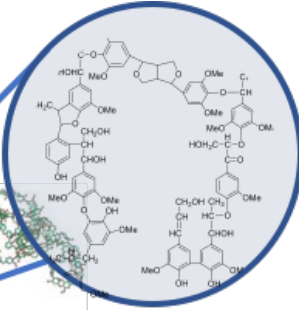


WIDE INDUSTRIAL COOPERATION: Textile, biomedical, pulp and paper, food, and footwear are some of the industrial sectors CIMO has been cooperating with. Several products, some at the prototype level but others already in productive processes, were developed (e.g. shoe-soles with improved biodegradation and bio-based polyols), or are under development (e.g. materials for bone regeneration, stabilized natural ingredients for the food industry and antimicrobial/moisturizing sprays). In particular, the case of footwear industry, where bio-based, natural-inspired solutions and novel functionalities, are increasingly desired by the worldwide consumers of this emblematic Portuguese industry resulted in a fruitful and long (since 2004) cooperation with the Footwear Technological Centre of Portugal (CTCP). CIMO has been involved in core projects of the sector, namely Mobilizing Projects, regarded as driving forces of the economy, promoting modernization, differentiation and internationalization. FAMEST, recently approved, is one of these projects where the use of natural additives (e.g. colorants and antimicrobials), selected based on CIMO expertise, will be applied to develop innovative leather products. The acquired experience supports research based on innovation, in close proximity and/or industrial symbiosis.

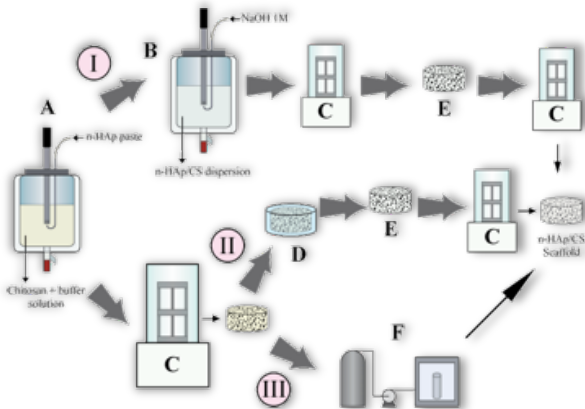
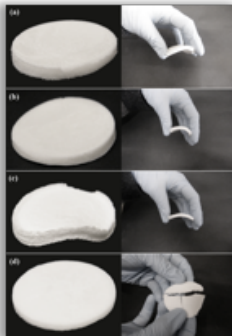




Former Portucel/Soporcel



Valorisation of lignin from the pulp and paper industry in polyols and polyurethanes.



NoMic2Bone – Development of nanoXIM® based antimicrobial structures for bone regeneration

THREE MAJOR CONTRIBUTIONS OF THE GROUP SOCIO-ECOLOGICAL SYSTEMS

Promotion of sustainable agriculture: Cover cropping has been adopted in wet climates and irrigated fruticulture due to soil protection from erosion and increased carbon sequestration. In rainfed olive growing areas, however, drought conditions, aggravated by climate change, are a barrier to this practice since live vegetation competes with crops for water, making soil tillage the dominant practice. CIMO researchers developed a new technology consisting in growing early maturing self-reseeding legumes as a cover crop. These legumes complete their growing cycles in winter, in asynchrony with the olive tree, greatly reducing the competition for water. Due to N fixation, legumes increase soil fertility and the tree nutritional status, reducing costs with N fertilizers and increasing olive yield. This innovative technology is being enthusiastically applied by farmers and it is a strong contribution to sustainable Mediterranean agriculture.



Ecology and conservation of freshwater ecosystems: CIMO has been involved in pioneering research on the ecology and conservation of freshwater ecosystems in the Mediterranean Basin. Novel methods have been applied in different scientific areas including genetics, habitat and species distribution modelling, physiology, ecosystem functioning, and biological invasions. Recent research, focused on the conservation of native freshwater fish and mussel species of the Iberian Peninsula and other Mediterranean countries (Italy, Greece, Morocco, Tunisia), has allowed an evaluation of the current conservation status of threatened species and in the definition of conservation measures and management plans for governmental agencies and decision-makers. Furthermore, several environmental awareness and educational programs have been organized, and networks established strengthening cooperation with national/international stakeholders.

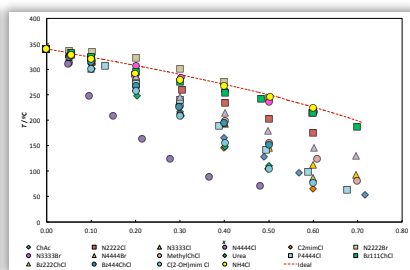
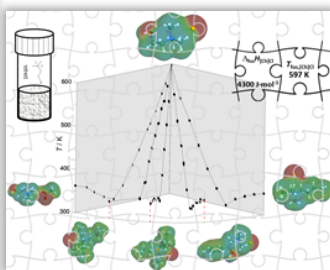


Conservation of honey bee diversity: The honey bee *Apis mellifera mellifera* is threatened by introgressive hybridization across much of Western Europe being extinct in some countries. To preserve the genetic integrity of pockets of pure *A.m. mellifera* and promote sustainable beekeeping using native genetic diversity, several conservation programs have been implemented across Europe. To assist population monitoring and management in *A.m. mellifera* conservation centres, CIMO developed a time- and cost-efficient SNP-based molecular tool capable of identifying introgressed colonies with a high accuracy. The tool is under validation and transferred to several countries running conservation programs (e.g. France, Switzerland, Austria, Norway, Denmark, UK, and Ireland). This tool will soon replace morphometry and microsatellites, currently in use. The developed molecular tool will have a major impact in population management and monitoring in conservation centres and will help safeguard a unique legacy of honey bee diversity for future generations.

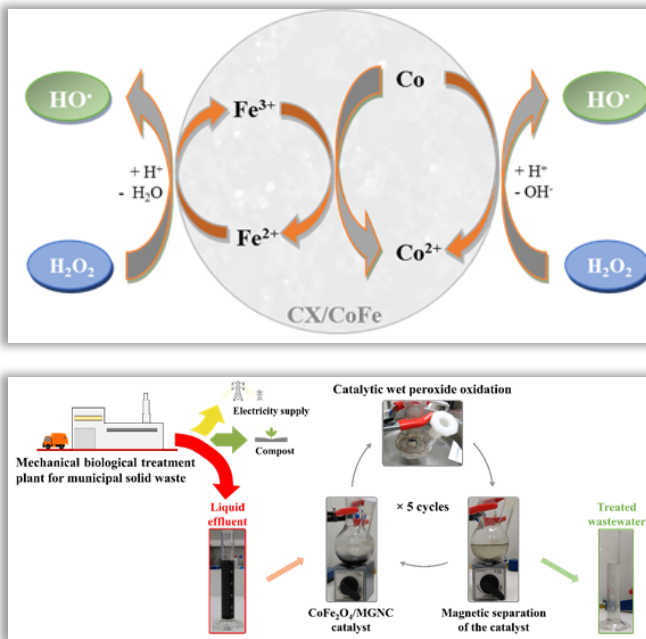


THREE MAJOR CONTRIBUTIONS OF THE GROUP SUSTAINABLE PROCESSES AND PRODUCTS

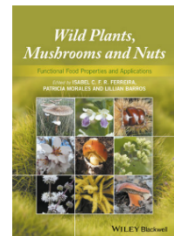
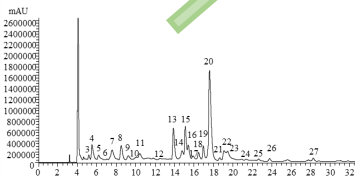
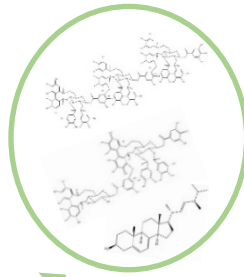
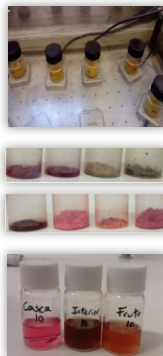
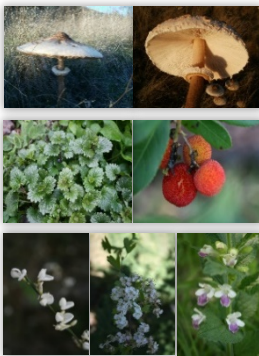
Deep eutectic solvents (DES) development: CIMO have proposed significant advances in the field of deep eutectic solvents (DES) development. Different techniques were implemented to establish the phase diagrams of new DES, composed of choline chloride, quaternary ammonium chlorides, fatty acids, fatty alcohols, terpenes or sugars. The large body of experimental data gathered showed extreme negative large melting-temperature depressions (up to 300K) characteristic of these systems, and possible applications for pesticides and antibiotics extraction from aqueous solutions. In addition to the use of semi-predictive modelling approaches for identifying new systems, they developed and applied consistency tests to analyze the quality of the experimental data and established a methodology to estimate melting properties of solid compounds that decompose upon melting, like choline chloride, often used in the preparation of DES. In 2017 Fluid Phase Equilibria published a special issue on DES, co-edited by a CIMO researcher of this team.



Catalyst design at the nanoscale: CIMO has been involved in catalyst design at the nanoscale, based on the understanding of surface reactions and interactions in catalytic wet peroxide oxidation processes. This approach allowed to move towards the treatment of industrial wastewaters with high pollutant loads, as the leachates resulting from the mechanical biological treatment in the municipal solid waste treatment plant located in North-eastern Portugal. The biodegradability of the wastewater was enhanced during the treatment, regardless of its high organic and inorganic contents. Disinfection was achieved and the treated water revealed no toxicity against selected bacteria. This solution allows the reduction of downstream treatment costs, presently fully based on membrane technologies, being relevant to the industrial management of wastes. It offers alternative and innovative treatment methodologies to leachate wastewaters from municipal solid wastes, a critical national and international challenge.



Identification of bioactives: CIMO researchers have been international leaders in the identification of bioactives for food and cosmetic applications, based in mushroom and plant sources. They have discovered that Portuguese wild mushrooms are powerful sources of bioactive molecules, such as tocopherols, phenolic compounds, triacylglycerols, and organic acids. They have developed innovative pathways for the extraction of different natural molecules from mushrooms to be used as natural additives, e.g. ergosterol, which led to a patent regarding mycosterols as hypocholesterolemic agents (109089.2017). They have also prospected plant species, including medicinal plants, that are unique sources of bioactives, particularly phenolic compounds. This research was the motivation for the recent publication of the international book “Wild plants, mushrooms and nuts” (Wiley Blackwell, 2017), among others edited by CIMO researchers.





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