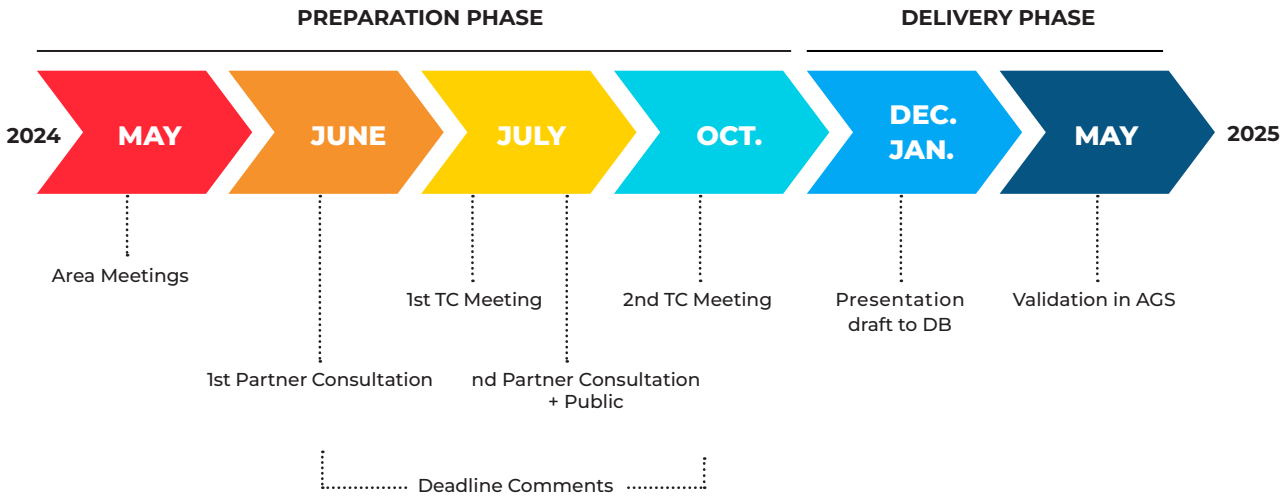
STRATEGIC INNOVATION AGENDA

2025 - 2027

PTV
PLATAFORMA TECNOLÓGICA DEL VINO

SPANISH R&D&I I+D+i STRATEGY 2025/2027

STARTING POINT AND METHODOLOGY



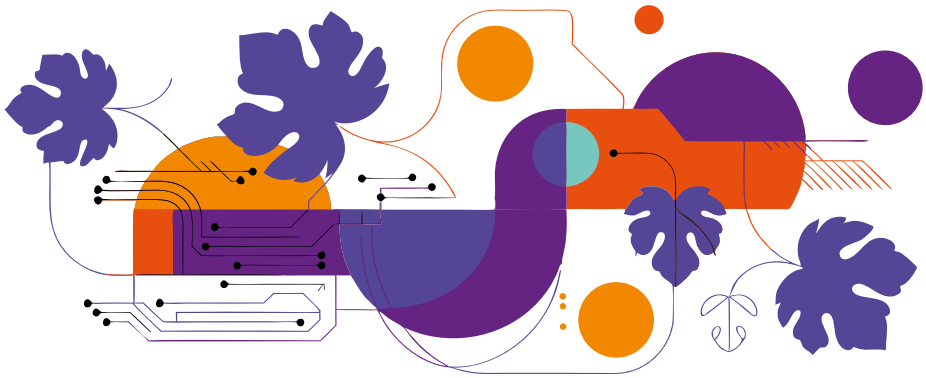
In response to the current needs of the wine sector, and following the significant impact of the 2020 crisis, a vision for the sector's future has been established. To this end, the PTV Technical Committee collaborated with the Technical Secretariat to renew, update and draft the Strategic Innovation Agenda 2025-2027. To execute this technological audit, the support of experts in the sector was required in order to obtain an analysis and diagnosis of the new scientific and technological reality of the wine sector at a national level.

The first step was to conduct a technological audit during the second half of 2024. This involved several consultations with experts from the sector and PTV partners, with the aim of identifying the priorities and needs of the Spanish wine sector.

Having analysed the received data, the Technical Commission began a series of meetings with the aim of conducting an exercise to evaluate the priorities and requirements of the Spanish wine sector.

The aim was to carry out an exercise to identify, select, reflect and prioritise for the sector's strategic objectives in the 2025-2027 period. This exercise forms the basis of the scientific-technological diagnosis and the core of the new Strategic Innovation Agenda for 2025-2027. In addition to this joint effort, the coordinators of each of the seven areas that comprise the Technical Commission met separately to delve deeper into the various disciplines and scientific and technological areas that constitute the entire wine value chain, from viticulture to the consumer.

It should be noted that this document has also been reviewed by the International Scientific Committee of the PTV in order to achieve harmonised versions of the text in different languages (Spanish and English), and to ensure that its content aligns with the scientific and technological landscape at an international level, particularly in leading countries in this sector.

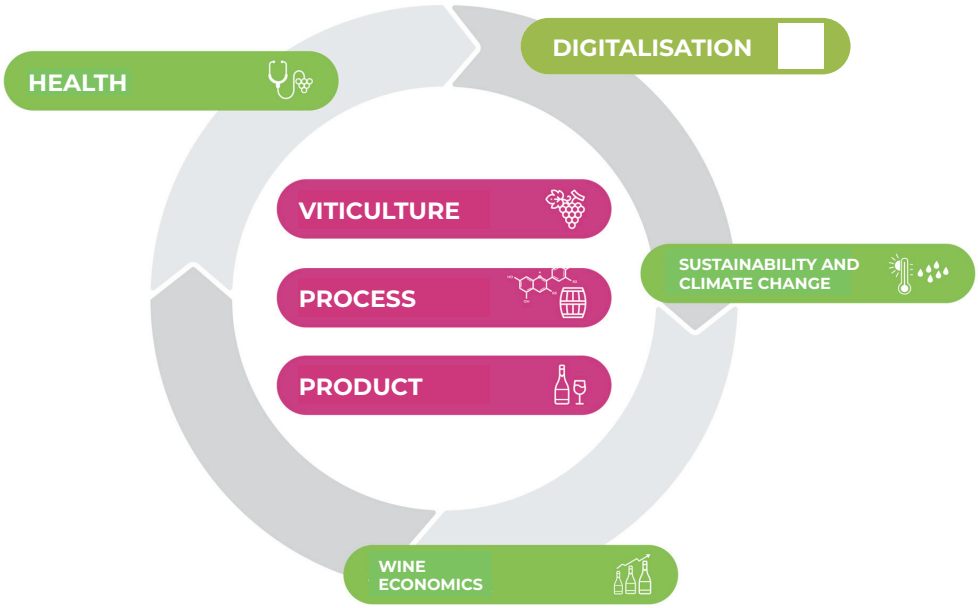


THE PTV TECHNICAL COMMISSION

The Technical Commission of the PTV is made up of a group of experts from the business and scientific spheres of the national wine sector. This group of experts is the most active nucleus of reflection and debate in the association and is structured into seven areas of interest. These areas cover all the scientific and technological disciplines related to the wine industry and make up its entire value chain.

Each of these seven areas operates under a dual business and scientific coordination system. The Technical Commission currently comprises a total of 14 coordinators, including the president and vice-president, who fulfil representative duties and act as direct liaisons with the Board of Directors.

At the organisational level, the coordinators of the seven areas convene the R&D&I Groups each year, which consist of different meetings for each of the areas of interest, open to all members and whose purpose is to identify and launch strategic projects. In addition, one or two annual meetings of the Technical Committee are organised to coordinate and seek synergies between the different areas, as well as to review the status of the R&D&I projects identified and promoted by the R&D&I Groups.



FUNCTIONS AND RESPONSIBILITIES

- Review of the Strategic Innovation Agenda for its updating.
- Definition of priorities for temporary promotion actions.
- Review of national and European work programmes, and submission of reports to the Public Administrations.
- Representation of the interests linked to its area of interest in PTV's own conferences and other external events in the sector.
- Identification and dynamisation of strategic R&D&I projects.
- Review of the status of R&D&I initiatives open on the PTV's intranet website.

VITICULTURE **Area**

José María Ayuso
Vineyards and Projects Manager of Gonzalez-Byass

Jesús Yuste Bombín
Viticulture Researcher at the Agricultural Technological Institute of Castilla y León (ITACYL)

PROCESS **Area**

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Technical Director of VITEC

Pablo Ossorio
Director of Oeno Consulting

PRODUCT **Area**

Rosana Lisa
R+D+I Director of Bodegas Ramón Bilbao

Antonio Palacios García
Manager of Laboratorios Excell Ibérica

SUSTAINABILITY AND CLIMATE CHANGE **Area**

Mireia Torres Maczassek
Innovation and Knowledge Manager of Familia Torres

Javier Carroquino
Director of Technology and Strategy at Intergia

Robert Savé Monserrat
Researcher emeritus at IRTA - specialist in viticulture and climate change

HEALTH **Area**

Sonia Villanueva
Director of Quality and R&D&I of Bodegas Familiares Matarromera

Mª Victoria Moreno Arribas
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Dr. Josep Masip
President of the FIVIN Scientific Committee

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General Director of Bodega y Viñedos Pradorey

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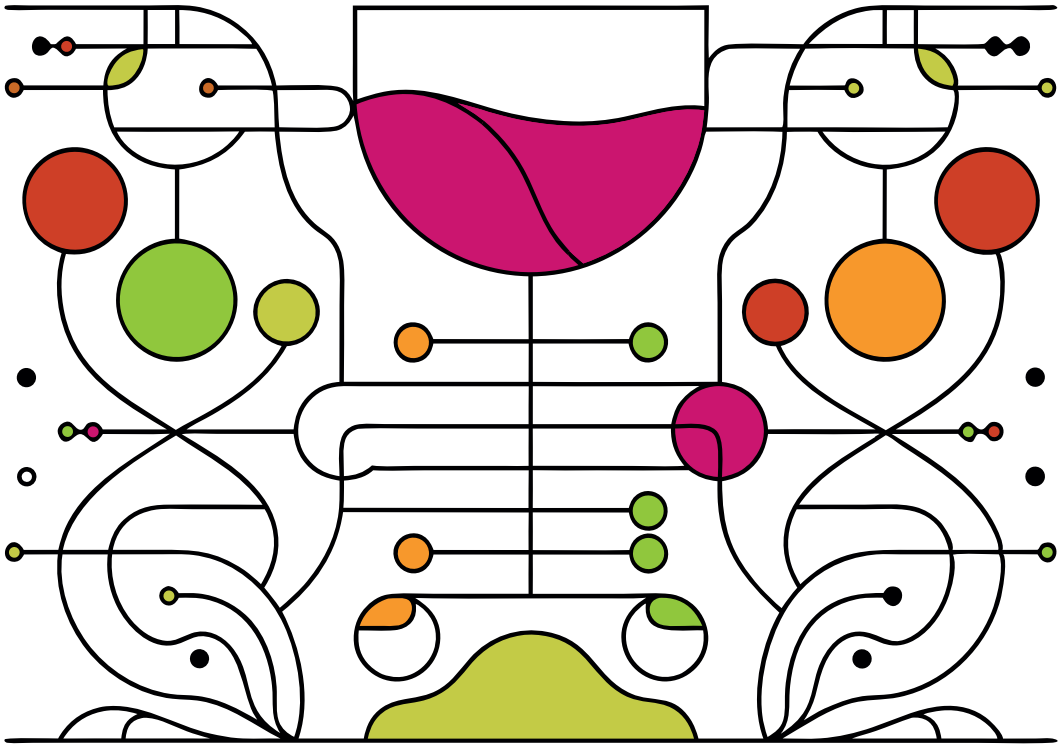
Eva Navascués
R&D&I Director of Alma Carraovejas

Juan Manuel Corchado
President of AIR Institute

David Martínez
Head of Strategic Business Development and Digital Transformation Alliances at AINIA Technology Centre



R&D&I OBJECTIVES AND PRIORITIES FOR THE WINE SECTOR

The objectives set out in the Innovation Strategy for the period 2025-2027 are divided into seven scientific-technical areas: Viticulture, Sustainability and Climate Change, Process, Product, Health, Wine Economy and Digitalisation.

Each area of work presents a series of strategic lines and specific objectives. Thus, the new Strategic Innovation Agenda comprises strategic lines that represent the means of overcoming the sector's major challenges through strategic cooperation and innovation, thanks to the development of its various specific objectives.

Within the strategic lines and specific objectives set out in each area, core ideas define the main issues to be addressed by the PTV in this new period.
For this reason, key strategies have been established that integrate the scientific and technical objectives of each area of interest. These strategies will determine the future competitiveness of the wine sector.

These key strategies are a commitment to the resilience, stability and growth of the wine sector, based on innovation as the main axis.

The aim of developing these strategic lines is to adapt the sector to the ever-changing environment by using innovation as the main tool. Given that the sector has a well-established scientific and business infrastructure, this will enable growth at both the national and international levels in an increasingly globalised world.

These key strategies must be based across the board on the commitment to collaborative innovation and knowledge transfer to promote the conversion of research into practical innovation for the sector, and on the use of the conversion of research into practical innovation for the sector, and on the use of intelligent financing for wine R&D&I through specific lines of the PERTE, European funds, regional funds and public-private collaboration mechanisms.

KEY STRATEGIES	
SUSTAINABILITY	Encourage and promote sustainable winegrowing methods and systems from an environmental and socio-economic point of view, consolidating Spain as an international benchmark in winegrowing sustainability and thereby seeking the cultural and tourist revaluation of wine and the promotion of generational change and the necessary attraction of young talent.
CLIMATE CHANGE	Design and develop strategies that contribute to the adaptation and mitigation of Climate Change in viticulture, through the recovery of native varieties, genetic improvement, efficient water management and the valorisation of the vineyard's ecosystem services, supporting regenerative and low-carbon agricultural practices.
BIODIVERSITY AND GENETIC RESOURCES	Promote existing knowledge on biodiversity, characterising and promoting its functionality and integration in productive wine ecosystems.
PLANT, PEST AND DISEASE PROTECTION	Incorporate science and technology to minimise the effects of vine pests and diseases, prioritising the sustainability of the vineyard.
CIRCULAR ECONOMY	Commit to the Circular Economy in the sector for a more efficient management that promotes the revaluation of by-products. waste, co-products and derivatives of wine production.
HEALTH AND FOOD SAFETY	Encourage the generation of knowledge that validates and verifies the beneficial effects of wine and/or its components, within a framework of responsible and moderate consumption, as a safe food and an integral part of a healthy Mediterranean diet, promoting effective communication that reinforces the "Wine of Spain" brand as a symbol of quality, innovation and sustainability.
HEALTH	Encourage studies that promote Citizen Science: participation of the population, including young people of legal age, in the design and development of scientific studies.
AUTOMATION AND DIGITAL TRANSFORMATION OF THE SECTOR	Identify, assess and implement the use of new emerging technologies for the automation of wine-making processes and the promotion of a comprehensive digitalisation plan for the sector (IoT, AI, Machine Learning, Deep Learning, predictive maintenance and asset management, artificial vision, digital traceability, precision viticulture, etc.), with the aim of moving towards a connected, safe, responsible, collaborative and reliable wine industry.
CONSUMER	Promote an intelligent system of information and observation of the sector that enables data-based decision-making, to promote diversification and innovation in new wine products (organic, non-alcoholic, functional, premium), with marketing strategies that connect with new generations and healthy consumption trends.

SWOT analysis of R&D&I in the wine sector

STRENGTHS

Leadership and quality: Spain is one of the largest wine producers in the world, with high quality, price competitiveness and leadership in organic vineyards

Diversity and heritage: large surface area of vineyards, as well as a variety of types of vineyards and Designations of Origin associated with a rich cultural and gastronomic tradition and the Mediterranean diet.

Interest in technological innovation: growing adoption of advanced technologies (IoT, blockchain, precision viticulture, digital twins) and sustainable technologies (efficient use of resources).

Wine tourism attractiveness: wine tourism in expansion, reinforcing the image of wine as a cultural experience.

Scientific and strategic capacity: consolidated research groups, critical mass of experts with the capacity to generate useful and applicable knowledge, and international alliances such as "Wine in Moderation".

Strategic sector: for the structuring and fixation of the population with a great positive impact on the economic, social and environmental aspects.

Sustainability: favourable conditions for organic farming. Proactivity and capacity for traction through sectoral initiatives (e.g. "Sustainable wineries for Climate Protection").

WEAKNESSES

Fragmentation of the sector: high atomisation between small and large wineries, with a lack of a unified vision of Spanish wine.

Lack of consumer orientation: product poorly adapted to the demands of new markets, with inadequate or insufficient communication and marketing approaches.

Dependencia climática: vulnerabilidad frente al cambio climático, con dificultades en la gestión sostenible de viñedos.

Climate dependence: vulnerability to climate change, with difficulties in the sustainable management of vineyards

Limited knowledge transfer to society: lack of effective mechanisms to connect research with the needs of the sector, especially in areas such as sustainability, climate change and health.

Lack of digitalisation and resistance to change: of small wineries and companies directly or indirectly linked to the sector. Traditional sector with digital gaps and lack of investment in R&D&I.

OPPORTUNITIES

Sustainability and organic leadership: potential to consolidate as a global leader in organic viticulture and sustainable practices.

Digitalisation and innovation: possibility of using advanced technologies (AI, IoT, aerial imagery and geolocation) to improve efficiency and competitiveness, supported by data and scientific developments.

Opening up to new markets: increased consumption in non-traditional markets and growing demand for differentiated products (non-alcoholic, organic, premium wine, partially fermented must, wine-based aromatic beverages, etc.).

Enhancing the value of wine: associating it with culture, gastronomy and a healthy lifestyle in the context of the Mediterranean diet, always based on scientific evidence.

Valorisation of indigenous varieties and recovery of varieties that show greater adaptation and resilience to climate change.

Economic profitability of CO2 capture from the vineyard: carbon credits, industrial derivatives of CO2 captured and liquefied in the winery, etc.

THREATS

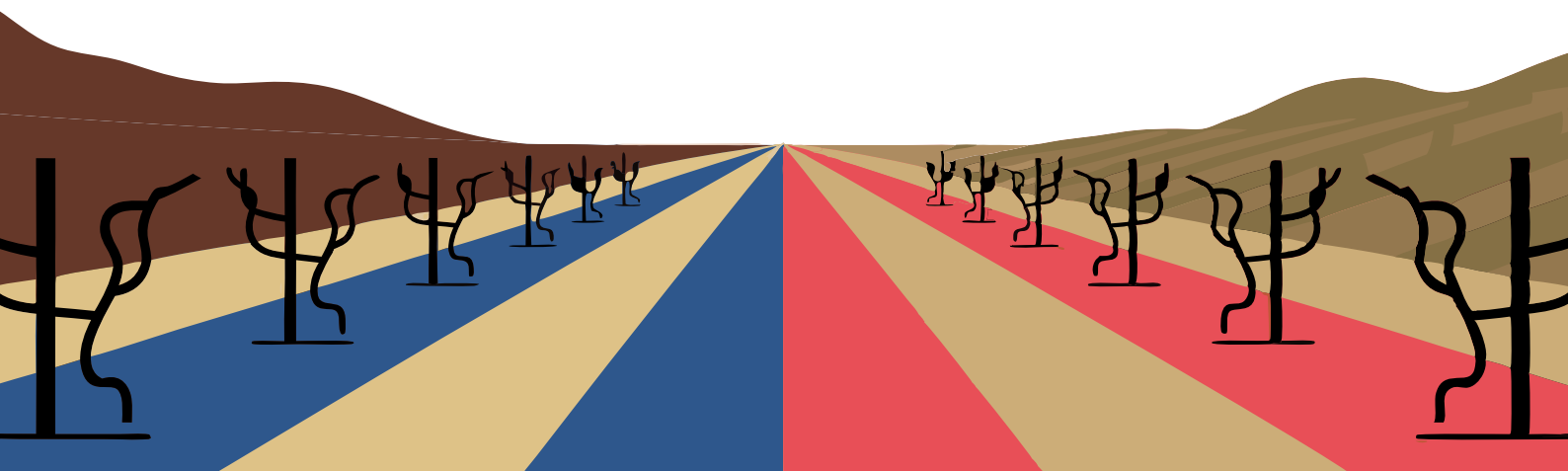
Global competition: pressure from emerging markets (France, Italy, Australia, Argentina) in terms of price, quality and innovation. Political and economic instability (tariffs).

Restrictive regulations: stricter legislation on alcohol and labelling that does not differentiate the singularity of wine.

Climate change: impact on quality and production volume, with loss of vineyards and traditional varieties and organoleptically unbalanced wines.

Disconnection with the consumer: complexity in the wine discourse, perceived as elitist, and a tendency towards lower consumption of alcoholic beverages in younger generations, in a context of rapidly changing consumer and market trends.

Lack of generational replacement: ageing of the population in rural areas and abandonment of unproductive or unprofitable vineyards. Limitation of planting rights.



VITICULTURE AREA

Spain maintains its world leadership in vineyard surface area, with 911,080 hectares registered in 2024, consolidating its position as the country with the largest global vineyard surface area. This vast surface area, distributed between rainfed (59.2%) and irrigated (40.8%), covers a diversity of areas, climates, soils and varieties that enrich its wine offer.

Spain's long-standing winemaking tradition is complemented by increasing innovation in both the vineyard and in the winery. However, the sector faces significant challenges: limited economic performance due to the sometimes insufficient profitability of grape production; the small size of many farms, which hampers competitiveness and sustainability; the high average age of winegrowers and the lack of generational change; the emergence of traditional and indigenous grape varieties; the high average age of winegrowers and the lack of generational replacement; the disappearance of traditional and indigenous varieties, which threatens biodiversity and wine heritage; and the impact of climate change, water scarcity and extreme weather events.

In order to overcome these challenges, technological innovation is essential, as is the adoption of tools such as precision viticulture, big data, predictive models and drones. These technologies can improve efficiency, reduce costs and promote sustainability. Furthermore, it is important to encourage specialised training and collaboration among professionals in the sector.

Adaptation to climate change and the preservation of native varieties are fundamental to guarantee the competitiveness and sustainability of Spanish vineyards in the future.

STRATEGIC Lines

Monitoring, optimisation and precision management of the crop and soil.

- Infrastructures to provide irrigation for rainfed areas and training for winegrowers on the efficient use of water.
- Development of high-efficiency irrigation strategies to improve water management and availability in vineyards and to reduce the use of scarce resources, promoting "second generation modernisation". Improve soil preparation and its continuous maintenance to minimise compaction and improve infiltration and functional physical properties of soil and roots.
- Study and development of alternatives for trellis mechanisation and alternatives to trellising.
- Implementation of agro-ecological models that favour vineyard resilience to climate change and yield, based on the soil microbiome, regenerative viticulture and functional biodiversity.
- Precision viticulture (sensors, drones and digital twins) for modelling, monitoring and simulation in real time of the behaviour of the vineyard and the state of the soil, to optimise crop management.
- Study of organic matter accumulation and H2O storage capacity in the vineyard soil.

02 CONSERVATION AND ENHANCEMENT OF THE GENETIC BIODIVERSITY OF VARIETIES AND ROOTSTOCKS IN THE FACE OF CLIMATE CHANGE.

- Knowing the agronomic behaviour of the varieties cultivated in the national territory, generating models for the evolution of ripening parameters (acidity, sugar, etc.) and expressing the results with comparable ratios for different climatic situations and growing conditions.
- Using plant material diversity (intra and inter-varietal) as a tool to improve adaptation to climate change that is compatible with the typicity of the wine in each area.
- Genetic improvement of varieties and rootstocks for adaptation to climate change (more acidity, less sugars, greater tolerance to pests; rootstocks that are better adapted to conditions of low water availability -drought- and efficiency in the absorption of nutrients, etc.).

03 EFFICIENT AND SUSTAINABLE CONTROL OF VINE PESTS AND DISEASES

- Control of fungal diseases (mildew and powdery mildew) by means of alternatives to sulphur and copper to facilitate production in organic farming.
- Integral protection against pests and diseases by means of management systems and product types that allow environmental and economic sustainability over time.
- Evaluation and development of interspecific hybrids resistant/tolerant to fungal diseases (mildew and powdery mildew) and bacterial diseases (Xylella fastidiosa).

PROCESS AREA

The main driver of oenological technology is the optimisation of winemaking processes, seeking to increase both the efficiency and quality of the final product, as well as its added value on the market.

A key challenge in this field is ensuring the sensory, chemical and microbiological stability of wines, which facilitates their distribution and marketing beyond traditional production areas, both nationally and internationally. This improvement is achieved through the knowledge generated by specialised research groups and the constant investment in innovation and technology by wineries.

Another crucial objective for the sector is adapting to consumers' changing demands, as people are increasingly looking for healthier, more environmentally friendly products. One of the major challenges in this respect is reducing the use of potentially allergenic additives such as sulphur dioxide. Although it is an effective preservative and antioxidant, there is currently no substitute that can fulfil all its functions, so research is ongoing to find viable and safe alternatives.

In addition, climate change is significantly altering the characteristics of wine. Among the most notable effects are the increase in pH and the imbalance between technological maturity (sugar level and acidity) and phenolic maturity (tannins and aromatic compounds), forcing wineries to develop strategies to mitigate these impacts. Adapting to these new climatic conditions is essential to maintain the quality of the wine and the competitiveness of the sector in the future.

STRATEGIC Lines

01 RESEARCH LINKED TO THE LINE OF LOW-ALCOHOLIC WINES OR DE-ALCOHOLISED GRAPE-BASED BEVERAGES

- Improvement of agronomic and oenological processes for the total or partial reduction of alcohol in wine.
- Improvement of sensory quality in partially or totally dealcoholised wines. Texture effect and tannin modulation in red wines.
- Additives or physical techniques that allow the stability of partially or totally dealcoholised wines.
- Improving processes from the point of view of energy and vineyard extraction.

03 NEW PROCESS TECHNOLOGIES AND WINEMAKING CONTROL AIMED ON IMPROVING QUALITY AND STABILITY.

- Emerging non-thermal physical technologies (pressurisation, pulsed electric fields, pulsed or continuous UV irradiation, cold plasmas or ultrasound) to reduce the use of chemical additives such as sulphites and improve yeast implantation.
- Development of viticultural and oenological production processes involving an increase or preservation of wine acidity and reduction of alcohol content.
- Development of production processes that imply an easy control of the ageing stage, as well as a reduction of ageing times.
- Winery processes that help to combat the phenolic maturity lag of red grapes and their sugar content. Resume studies on the total or partial elimination of seeds when they are immature.
- Development and study of harmless chemical substitutes for sulphites, in their anti-microbial and reductive aspects: ozone, chitosan, glutathione, yeast-reducing nitrogen derivatives, tannin-polyphenols, etc.
- More sustainable and efficient winery technologies (saving and modulation of cold in fermentation, reduction of water consumption, carbon footprint control, etc.).
- Development and application of process modelling in winemaking (e.g. digital twins).

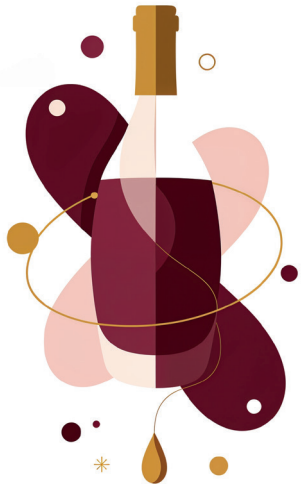
03 NEW TECHNIQUES AND STRATEGIES FOR THE KNOWLEDGE AND IMPROVEMENT OF OENOLOGICAL BIOTECHNOLOGY PROCESSES.

- Bioprotective biotechnologies that improve acidity and control oxidation.
- Study and dynamisation of the use of bioacidification with Lachancea thermotolerans and enhancement of the reducing effect and oxygen consumption with Metschnikowia pulcherrima and Pichia Kluyveri.
- Improvement of aroma in neutral varieties with benzenoid ester-producing species of the genus Hanseniaspora.
- Development of new virus biotechnologies in oenological processes.

04 NEW STRATEGIES FOR CHEMICAL AND SENSORY EVALUATION OF WINE.

PRODUCT AREA

A product is anything that responds to the needs or desires of the consumer. In the case of wine, for example, it is not only about its colour, aroma or taste. More emotional and symbolic aspects also come into play, such as the brand, the origin, the story it tells, the sensations it awakens or the social value it conveys. These aspects are divided into intrinsic factors (the wine's own characteristics) and extrinsic factors (everything that surrounds it and gives it added value).



What makes a product relevant is its ability to offer us exactly what we are looking for. Therefore, three elements are key: its design, its style and its quality.

The combination of these three factors is essential for a brand to remain competitive over time.

In the world of wine, this translates into the need to constantly renew existing wines and launch new proposals that respond to the expectations of the modern consumer.

Designing a product is not the exclusive task of the winery or the technical team. It also involves financial decision-makers, marketing departments and quality controllers. Today, design must be the starting point, not a stage after production. Because the product itself communicates who the company is and what its commitment to quality is.

Moreover, wine is not just bought for its taste. It is often part of a lifestyle. It can convey sophistication, exclusivity or belonging to a group. Consuming a certain type of wine can make a person feel more special, more confident or connected to a particular identity. Therefore, wine should also be understood as a product with a strong psychosocial or aspirational component.

And as the market is constantly evolving, companies must always be aware of trends. It is essential to listen to the consumer, to observe changes and to adapt quickly. This is the only way to create innovative products that connect with what people really want.

STRATEGIC Lines

01

ENHANCING THE VALUE OF NON-ALCOHOLIC WINE THROUGH FORMAT

- New innovative designs for non-alcoholic and low-alcoholic products.
- Developing a non-alcoholic product that allows the product to be elevated and enjoyed as a "real and valid" alternative to the world of alcohol. Offering products that consumers perceive as premium or better ultra premium (French Bloom).

02 NEW WINE PACKAGING AND NEW STRATEGIES FOR ADAPTING WINE TO THE MARKETPLACE

- Wine conditioning for new packaging and formats. Use of inactivated yeasts for Petnat-type products, use of nucleophiles for better product preservation, market study of new consumers, etc.
- Development and broadening of the spectrum of consumers and consumption scenarios for canned wine. Understand the world of packaging as an opportunity to approach a new consumer and design a product style in accordance with this new consumer profile.

03 DYNAMIC WINE PERCEPTION AND PAIRING

- Studies of the attributes perceived during wine consumption in a dynamic, non-static way, using the sensory technique known as TDS: “Temporal dominance of sensations”.
- Development of scientific knowledge in the world of gastronomic pairing.

04 STRATEGIES TO ENCOURAGE WINE CONSUMPTION

- Reconceptualisation of wine to promote greater acceptance among consumers (blanc de noir, co-fermentation with white varieties, etc.).
  Link with the lower alcohol content of red wines, maintaining acidity and enhancing or preserving their aromatic and sensory profile.
- Promote the production and consumption of other wines (e.g. rosé, sparkling, etc.).

AREA OF SUSTAINABILITY AND CLIMATE CHANGE

Climate change is having an increasingly significant impact on viticulture around the world, and Spain is no exception. For years, winegrowers have observed changes in the stages of grape ripening, increased susceptibility to diseases and pests, more intense droughts, and altered phenological cycles. These factors affect not only the quality and characteristics of our wines, but also the economic viability and biodiversity of the vineyards.

In response to this, both public administrations and the wine sector have become more environmentally aware. Furthermore, there is sufficient scientific and technical expertise available to develop mitigation strategies, such as carbon sequestration in soils and the use of perennial woody structures, to help reduce the sector's carbon footprint.

To assess the effectiveness of these measures, impact indicators are essential for evaluating the implementation of sustainable methods and systems in viticulture. Particular attention should be given to aspects such as efficient water and energy use, proper soil management, and the microbiota of the crop-grape-winery-wine system. A comprehensive and sustainable approach is the only way to ensure the future viability and competitiveness of the Spanish wine sector.

STRATEGIC **Lines**

01 WATER-ENERGY NEXUS AND EFFICIENT MANAGEMENT OF WATER RESOURCES

- Efficient use of energy through the use of renewable energy sources in production processes in the field and in the winery.
- Studies on the use of regenerated and underground water to establish more efficient designs for the use of water resources (from rainwater, spring water, saline water, grey water, etc.) both in the winery and for irrigation.
- Projections or predictions of precipitation at fine time scales (sub-daily) to determine its importance on erosion, soil loss and water retention capacity.
- Analysis of the effects of extreme drought on the productivity and survival of rainfed and irrigated vineyards in arid climates in the Mediterranean Basin.

02

ECO-INNOVATION AND ENVIRONMENTAL SUSTAINABILITY

- Valorisation of the wine-growing sector as an agri-food model of sustainability, mitigation and adaptation to Climate Change.
- Measurement and management of the carbon footprint and reduction of CO_2 emissions and other greenhouse gases.
  Facilitate the adaptation of vineyards in mountainous and/or steeply sloping areas to preserve them.
  Regionalised climate projections at high spatial resolution.
- Plant covers as tools for agronomic and sustainable vineyard management in an arid climate, avoiding competition for resources (water, nutritional, etc.) and pest problems (e.g. spiders and mosquitoes), but valuing their advantages with respect to soil management (improvement of structure and fertility).
- Study of respectful crop management practices (e.g. agro-ecological models, functional biodiversity, regenerative viticulture, preservation of the microbiome, etc.) on the sustainability and resilience of the vineyard in the face of Climate Change.

03

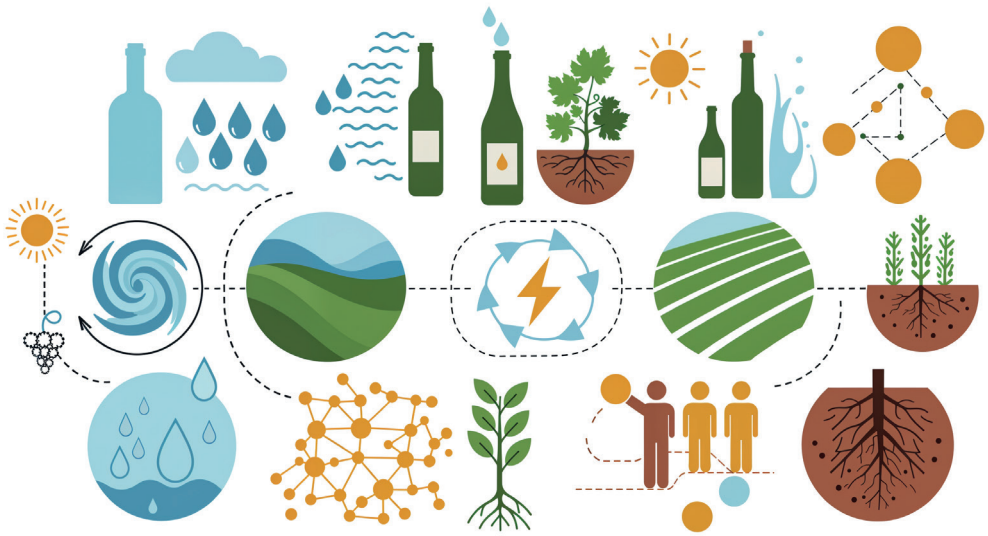
POSITIVE IMPACT OF THE WINE SECTOR ON SOCIAL SUSTAINABILITY

- Improvements in Social Impact Certification. Develop certification standards that assess and recognise the positive social impact of wineries and vineyards (e.g. on local job creation, promotion of gender equality, social inclusion and contribution to community development).

04

IMPROVEMENTS ON ECONOMIC SUSTAINABILITY

- Implement circular economy practices in winemaking (e.g. recycling of wine by-products and reuse of materials, to reduce waste and improve economic and environmental sustainability).
- Improvements in the field of Sustainability Certification. Develop and improve certification standards to ensure sustainable practices in winemaking.
- Construction of winery facilities and building solutions that allow better adaptation and resilience to Climate Change to ensure their viability and competitiveness.



HEALTH AREA

Wine has traditionally been considered part of a balanced diet, particularly within the Mediterranean diet, which is recognised for its potential to promote healthy living. In countries such as Spain, France and Italy, wine plays a central role in gastronomy and social culture. Furthermore, the moderate consumption of wine has spread beyond the Mediterranean region, becoming popular in various parts of the world, including Nordic countries and those in Asia.

Numerous scientific studies have investigated the effects of moderate wine consumption, particularly red wine, due to its polyphenol content, including resveratrol. These antioxidant compounds have shown potential in reducing the risk of cardiovascular disease, type 2 diabetes, certain cancers, and neurological disorders.

Current recommendations suggest limiting moderate wine consumption to one glass per day for women and two for men, always with meals. This pattern of consumption has been associated with greater longevity and a lower incidence of chronic diseases in regions such as Ikaria in Greece and Sardinia in Italy, which are known as 'blue zones' due to the longevity of their inhabitants.

It is essential to promote responsible wine consumption in Spain, particularly among young adults aged 18–35. Educational initiatives that encourage moderate and mindful consumption can help to prevent alcohol abuse and introduce the younger generation to the country's rich wine tradition.

The PTV collaborates closely with FIVIN, whose main objective is to investigate the beneficial effects of moderate wine consumption on health and disseminate this knowledge to the medical community and general public.
This collaboration is made effective, not only with the presence of a representative of this entity on the PTV Technical Committee, but also with the Health area being responsible for detecting possible ideas for innovation or needs on which to work, supported by the FIVIN Grants and the "Lifestyle, Diet, Wine and Health" congresses.

STRATEGIC **Lines**

01 *NEW STUDIES TO IMPROVE KNOWLEDGE ON MODERATE WINE CONSUMPTION AND HEALTH. ANALYSIS OF WINE CONSUMPTION PATTERNS IN THE CONTEXT OF DIET AND LIFESTYLE USING DIFFERENT TOOLS AND NEW AI TECHNOLOGIES. INTERVENTION STUDIES*

- Study of moderate wine consumption and its relationship with health in the presence of a Mediterranean diet. High-incidence chronic diseases: influence on cancer incidence, cognitive health, circadian rhythms, microbiota, type 2 diabetes, cardiovascular diseases, etc.

- Study of the relationship with health of moderate wine consumption, non-alcoholic wine and wine with low ethanol content. Considering variables such as alcohol content, variety, frequency of consumption, etc.

- Analysis of the consumption trajectory and complete description of the consumption pattern considering:

  - Different doses (low risk or other doses) at different life stages.

  - Different age groups (young people, adults and older people).

  - Gender differences.

  - Drinking history (abstainers, occasional drinkers)

  - Lifestyle (psychological problems, mental health and well-being).

  - Dietary pattern (physical activity, genetics, educational level, socio-economic factors, demographics, etc.).

  In turn, the following should be considered: 1) ESP-PORT comparative studies, given the significant differences in consumption and lifestyle patterns between the two countries;
  2) studies on the health status of participants at the beginning of the study, to minimise the impact of drinking on the inclusion of stick quitters in the studies;
  3) the promotion of Citizen Science, encouraging the participation of the population, including young people, in the design and development of scientific studies.

  In turn, considering 1) ESP-PORT comparative studies due to the high contrast of con- sum, lifestyle and consumption patterns of the two countries; 2) studies on the health status of the participants at the beginning of the study in order to reduce as much as possible the confusion of drinking to the inclusion in the studies of stick quitters; 3) promoting studies that promote Citizen Science: participation of the population, including young people, in the design and development of scientific studies.

- Identification of consumption patterns and their impact through the definition of biomarkers of anti-aging effect. Such as, for example, the study of mechanisms of the protective effect of wine polyphenols and their interaction with the human microbiome.

- Integration of massive data through computational analysis to identify the impact of wine consumption on the improvement of biomarkers. Study of the relationship between moderate wine consumption and health using new technologies: Artificial Intelligence (AI), machine learning, omic sciences (e.g. metabolomics), personalised nutrition, nutrigenomics, nutrigenetics, microbiota, etc.

- Study on the effects on individual and societal health in Spain of the agricultural abandonment of vineyards due to their social non-acceptance: depopulation, destruction of the landscape, risk of forest incentives, increase of population in metropolitan areas, increase of mortality due to heat waves, increase of stress and cardiovascular diseases, loss of cultural identity.

02 AGRONOMIC AND OENOLOGICAL STRATEGIES FOR OBTAINING RED/WHITE WINES WITH HIGH POLYPHENOL CONTENT AND REDUCED ALCOHOL CONTENT (CROSS-CUTTING LINE PROCESS AND VITICULTURE)

- Improvement of water and heat stress in the plant. Crop/vegetation management techniques for the reduction of saccharimetric degree in the berry and delaying ripening.
- Search for a balance between sugar content, aromatic and polyphenolic precursors to obtain wines with lower alcohol content and more bioactives.
- Genetic improvement of varieties and rootstocks for better adaptation to climate change (more acidity, less sugars, lower alcohol content).
- Improvement of agronomic and oenological processes for the total or partial reduction of alcohol in wine.
- Improvement of sensory quality in partially or totally dealcoholised wines. Texture effect and tannin modulation in red wines.
- Additives or physical techniques that allow the stability of partially or totally dealcoholised wines.

03 VALORISATION OF AGRONOMIC AND OENOLOGICAL CO-PRODUCTS THROUGH BIOCONVERSION AND REFINING PROCESSES. CIRCULAR ECONOMY AND SDG

- Development of new food ingredients.
- Development of biostimulants and biofertilisers.
- Development of new materials that improve people's quality of life: packaging, labelling and other materials (furniture, etc.).

WINE ECONOMY AREA

The Spanish wine sector has evolved notably in recent years, becoming more competitive in a demanding global market. Although the total volume exported has fallen, turnover has grown to reach €2,977.8 million in 2024 thanks to a clear commitment to wines of higher quality and added value.

Wineries have begun to move away from a model based on cheap bulk production, instead focusing their strategy on packaged wines with greater differentiation. In order to remain competitive, they are also investing in innovation and adaptation, including developing products that combine tradition with current market trends, such as organic produce, low-alcohol beverages, and sustainable practices. Additionally, territorial marketing and the connection between gastronomy and wine are being promoted to enhance the identity and value of the products. The current challenges facing the Spanish sector include increasing domestic demand, improving international competitiveness, promoting innovation in products and processes, and supporting SMEs with lower investment capacity.

Moreover, the combination of tradition, sustainability, territorial marketing and gastronomy is generating new opportunities. To remain competitive, the sector must continue to focus on differentiation, quality and in-depth consumer knowledge.

STRATEGIC **Lines**

01 *SUSTAINABILITY AND CLIMATE CHANGE IMPROVEMENT STRATEGIES*

- Sustainability indicators for grape producers and processing based on existing information.
- Adaptation and innovation for continued sustainability: traditional and new financing options and models; traditional and new entrepreneurial structures or models.

02 *IMPLEMENTATION STRATEGIES FOR DIGITISATION AND ADVANCED TECHNOLOGIES FOR PREDICTIVE MODELLING DEVELOPMENT*

- Development of predictive models in vineyards.
- Development of predictive models in demand.
- Optimisation of marketing mix through Artificial Intelligence tools.
- Blockchain technology applied to wine: the aim is to contact the end consumer, minimising the risks of the “cookie less” world.

INNOVATION STRATEGIES AND PRODUCT DIVERSIFICATION

- Updating the product and extending the offer to meet the demand of new consumers.
- Recovery and valorisation of indigenous varieties linked to the territory.
- Use of beacons and sensors to improve the wine tourism experience.
- Implementation of specific platforms for wine tourism, extension of the offer, marketing mix, micro-marketing, etc.

CIRCULAR AND COLLABORATIVE ECONOMY

- Implementation of Circular Economy practices (recycling of by-products, reuse of materials, etc.) throughout the value chain and its implementation in the territory.

INTERNALISATION AND COMPETITIVENESS. PROMOTION OF INTERNATIONAL MARKETS AND EXPORTS

- Dynamisation of the product in international markets.
- Viability analysis in non-traditional markets.
- Analysis of market trends for young people.
- Coordination between actors along the entire value chain and also between markets to improve the position of grape products (e.g. grapes, grapevine, etc.) through the value chain and its implementation in the territory.

CERTIFICATION IN DIFFERENT AREAS OF THE VALUE CHAIN

- **Quality:** innovate in methods that guarantee the quality of wine from the vineyard to the bottle (use of advanced technologies for the monitoring and control of production, ensuring that products comply with international quality standards).
- **Origin:** strengthen origin certification systems to protect and promote designations of origin and geographical indications.
- **Innovation:** create specific certifications for innovative products in the wine sector, such as wines with unique characteristics or wine-derived products.

DIGITALISATION AREA

Digitalisation is a key and critical opportunity for positioning and business development, especially in small and medium-sized wineries. The integration of innovative technologies such as AI, IoT, Machine Learning, Deep Learning and precision viticulture- enology can greatly improve the sector's productivity.

However, the adoption of new technologies such as IoT, blockchain, and AI is very uneven and limited to large wineries or companies (not many in the wine sector)
There is a "double speed" in the adoption of these technologies, with large companies being the fastest and most advanced, but most wine SMEs are at low levels of digital maturity.

It should be noted that the PTV maintains close collaboration with the FEV's Digitalisation Hub (September 2020), whose main objective is to bring existing technology to wineries and, to this end, works together with IT companies, wineries and stakeholders. The Hub and the PTV's Digitalisation Area are established as key players in defining the ideal meeting point between digital agents and companies in the wine sector. The Hub's working groups aim to identify the digitalisation shortcomings of wineries and promote real solutions, close to the market.
The digitalisation area of the PTV is in charge of detecting possible ideas for innovation or needs, on which it would be possible to work in R&D&I. Through this active collaboration, projects or pilot tests of industrial viticulture needs will materialise and R&D&I projects applied to the sector will be developed.

STRATEGIC Lines

01 DIGITALISATION APPLIED TO VITICULTURE

- Precision agriculture (sensors, drones, hyperspectral images and digital twins) for real-time monitoring and simulation of vineyard behaviour, facilitating efficient management in the field (irrigation, fertiliser dosage, pest and disease control, environmental footprint impact).
- Mechanisation and robotisation of cultivation operations for heroic viticulture or vineyards that are difficult to access.
- Modelling of plant-phytopathogen interaction behaviour.
- Agro-climatic modelling to carry out efficient predictions in the field for better adaptation to Climate Change (e.g. digital twins).

02 IMPLEMENTATION STRATEGIES OF DIGITALISATION AND ADVANCED TECHNOLOGIES FOR THE DEVELOPMENT OF PREDICTIVE MODELS.

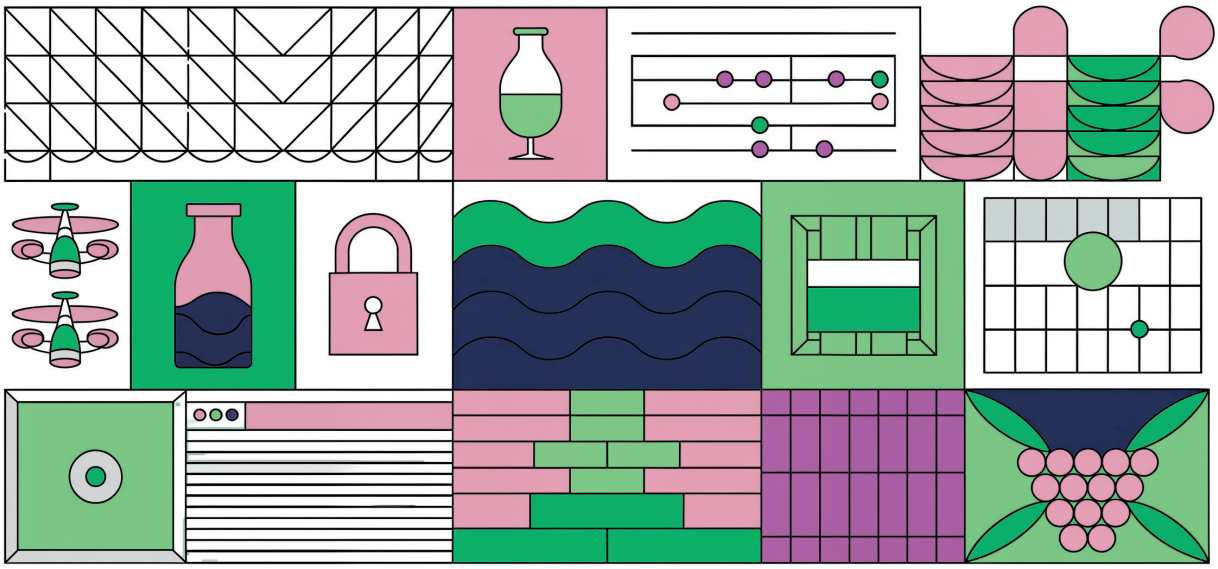
- MES (Manufacturing Execution Systems) management systems for handling Big Data.
- ERP and CRM systems for the integrated management of resources and internal warehouse processes (from production to distribution).
- Development of data spaces.
- Implementation of digital certification systems using technologies such as blockchain to ensure traceability and transparency throughout the wine supply chain.
- Intelligent logistics and optimisation of product distribution.

MONITORING AND OPTIMISATION OF THE PRODUCTION PROCESS

- Winery sensors for key variables in the vinification and maturation process (temperature, pressure, density, CO_2, acidity, glucose, ethanol, etc.) in the tank, barrel and bottle, wine packaging systems and decision making with AI.
- Use of Artificial Intelligence to identify patterns, qualities and other sources of competitive advantage (IoT data management, resource management, production estimation, etc.).
- Integrated and centralised automation of the winemaking process to optimise quality variables, reduce human error, reduce energy consumption and improve sustainability.

DEVELOPMENT OF SPECIFIC DIGITAL PLATFORMS. TRAINING AND WINE TOURISM

- E-learning platforms to develop online training programmes to train workers in the latest technologies and digital tools.
- Standardised knowledge-sharing platforms to act as a repository where actors from the entire value chain can deposit knowledge, experiences and best practices.
- Immersive augmented and virtual reality platforms to offer immersive experiences to customers and virtual tours of vineyards and wineries.



CONCLUSIONS AND PERSPECTIVES

CONCLUSIONS

After analysing the operation of the four strategic innovation plans managed by the PTV between 2011 and 2024, as well as the content of Section 4 of this Strategic Agenda, sufficient information was generated to assess the situation of the Spanish wine sector in relation to its innovative efforts, and to highlight current and future trends. The main conclusions of this analysis are as follows:

a) Climate change is a direct and urgent threat, which has an impact both on the quality of the product and on the viability of cultivation of the varieties. Innovation must focus on varietal resilience and adaptive vineyard management, promoting the economic profitability of vineyard carbon sequestration.

b) Spain has potential leadership in **organic and sustainable viticulture**: thanks to its extensive organic vineyard area, favourable environmental conditions and sectoral pro-activity. This positions the national wine sector as an international benchmark in sustainability, provided that innovation strategies (R&D&I) are strengthened.

c) There is a solid **academic** ecosystem in the Spanish wine sector, offering a wide range of oenology and viticulture training. Spain leads the world in terms of the number of scientific publications in the wine sector, ahead of the USA, Italy and France. We are also the country that contributes the most to international projects and research. Spain has a very solid **scientific and technological base**, with leading research groups, associations, innovation working groups and international alliances, as well as the pioneering Wine Technology Platform (PTV), which is unique in Europe and should accelerate innovation in the sector. However, this capacity is still underutilised due to its limited connection with the practical needs of the sector.

d) Digitalisation is a key and critical opportunity, especially in small and medium-sized wineries. The integration of innovative technologies such as AI, IoT, Machine Learning, Deep Learning and precision viticulture and oenology can greatly improve the productivity and competitiveness of the sector.

e) Leader in **sectoral investment in innovation** (€185 M per year), which represents 50% of the agri-food sector, 66% of the food and beverage subsector and 1% of the total internal R&D expenditure in Spain. Leader in **strategic sectoral projects** in national R&D calls (CIEN-CDTI call, MAPA Operational Groups, MAPA digitalisation package (PTVino Innovation School), or agri-food PERTE and the GRAPERTE project). However, public investment in R&D&I and above all in **knowledge transfer** is still holding back the technological development of the sector. A greater institutional commitment to market-oriented innovation programmes is needed.

f) Commitment to youth. The demands of younger and global consumers must be met: **new formats**, product innovation, **new consumer trends** (non-alcoholic, organic, premium wines, etc.), to penetrate **new markets**, provided that they are combined with a narrative of health, culture and sustainability based on scientific evidence. There is also an urgent need for **generational renewal:** a structural challenge, but at the same time an opportunity to attract young talent with innovative and sustainable projects that could revitalise the sector and ensure its continuity.

g) Wine tourism offers a strategic way to diversify income and create added value, as well as serving as an ideal platform for disseminating the culture, heritage and sustainability of Spanish wine.

h) The atomisation and traditionalism of the sector slow down its transformation, hindering a **common strategy** that promotes **innovation**, open and collaborative, and the differentiation of Spanish wine at international level, gaining in value and positioning. To achieve this, it is essential to collaborate with public authorities and to belong to national and international innovation advisory groups, such as those in which the PTV participates.

Prospects for the *FUTURE*

The Spanish wine sector is of strategic economic, social and environmental importance, as reflected in its figures. However, it has traditionally invested less in research, development and innovation (R&D&I) than other industrial sectors, although it outperforms other agri-food sectors. The following section puts forward ideas on some R&D indicators of the sector in an attempt to identify challenges and propose recommendations to improve its competitiveness and innovation.

Main R&D Ratios and Indicators

R&D investment and participation

- Most Spanish wineries allocate less than 1% of their annual turnover to R&D activities.
- The most innovative wineries reach levels of 2% to 4%, especially in regions with active institutional support.
- High participation of the sector in national collaborative projects (CIEN, Transmissions, Missions, Public-Private Collaboration, etc.) but low or diffuse participation in European programmes, although there are successful cases of PTV and some sectoral or regional agri-food clusters.

R&D funding

- Approximately 70% of R&D investment in the sector comes from companies' own resources.
- Public funding and European funds are still under-utilised (average execution rate of 50%).

Digitalisation and new technologies

- The adoption of new technologies such as (IoT, blockchain or AI) is very uneven and limited to large wineries or companies (not many in the wine sector).
- There is a "double speed" in the adoption of these technologies, with large companies being the fastest and most advanced, but most wine SMEs are at low levels of digital maturity.

Challege

In view of the above, the main general challenges facing the wine sector are summarised below:

- Low innovation culture and scarce professionalisation in R&D management.
- Moderate collaboration between companies, technology centres and universities.
- Lack of stable mechanisms for knowledge transfer.
- Active alignment with the challenges of sustainability, digitalisation and climate change.

Horizon 2030 recommendations

In view of the new H2030 programme and its integration into national, regional and sectoral innovation plans, the following recommendations should be considered::

01. Increase the investment effort in R&D to at least 2.5% of the sector's average turnover, taking as a reference that the sector's average turnover in 2023 amounted to 8,490 million euros, the investment effort in R&D&I by the wine industry should increase to 210 million euros per year.

02. Encourage participation in European programmes such as Horizon Europe, InterREG, PRIMA, Erasmus+ and LIFE. Initiating participation in other international calls for proposals less known by the wine sector (e.g. partnerships or JTIs).

03. Reinforce the role of the clusters and the PTV as articulators of collaborative projects, as well as the value of their strategic innovation agendas to the Public Administration.

04. Support digitisation with sectoral diagnoses and specific tools for SMEs, promoting their transfer to the sector.

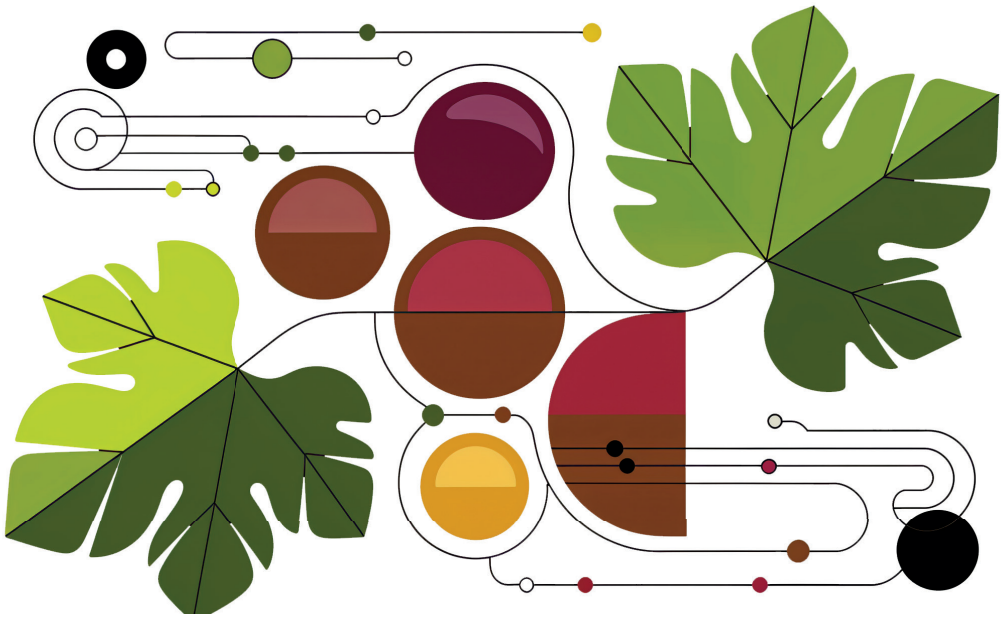
05. Promote applied and accessible knowledge transfer channels..

06. Create a sectoral innovation observatory to collect and analyse key R&D&I indicators.

07. Establish a specific wine innovation fund, with national and European funds.

08. Design specific fiscal and financial incentives for wine R&D&I.

Finally, strengthening R&D&I in the Spanish wine sector is essential to guarantee its sustainability, competitiveness and capacity to respond to the challenges of the future. Undoubtedly, there is a structural basis and clear opportunities to build a robust and collaborative innovation ecosystem, provided that institutions, companies and knowledge agents act in a coordinated manner.



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