

Results Summary Brief

Over four and a half years, BreedingValue has mapped the genetic biodiversity of strawberries, blueberries, and raspberries, applied new advanced genotyping technology and new phenotyping tools, developed tools for data access and visualisation, and established a sensory methodology to align breeding with consumer preferences. This work has been done on an unprecedented diversity of genetic material provided by 15 partner organisations and 6 external organisations.

The activities carried out within the BreedingValue project enabled the development of an innovative breeding strategy, based on an integrated analysis of genetic diversity – including genomic, metabolomic, and sensory aspects – with the goal of identifying novel genetic resources for traits related to plant resilience and fruit quality. These resources were evaluated for their potential use in pre-breeding as well as for possible commercial development, thanks to the implementation of new genotyping and phenotyping tools developed within the project.



Key achievements of BreedingValue

GENETIC RESOURCES

- **Selection of an unprecedented diversity of berry genetic resources** available in Europe and **in-depth characterisation** through phenotyping, genotyping and metabolomic studies.
- **Maintenance of promising berry germplasm** *on-farm*, *ex situ* and by *in vitro* conservation including exchange of true to type accession between germplasm collections.
- **Performance of Life-Cycle Assessment** studies on strawberry and raspberry covering a total of 26 field trials and demonstrating the adaptability to more sustainable cultivation systems of representative cultivars and promising advanced selections.

GENOTYPING

- **Characterisation of the genetic diversity** available in the European and North American variety collections, breeding, and pre-breeding materials (more than 1700 accessions for strawberry and about 100 for raspberry and blueberry).

- Provision of **extensive genotypic and phenotypic data**, allowing for **gene/marker identification, application, and validation**.
- Contribution to the **development of genomic tools** for strawberry, raspberry and blueberry, specifically in the areas of genome-wide association studies (GWAS), marker-assisted selection (MAS), and genomic selection.
These genomic tools have been **transferred to European breeding companies** through their involvement in the BreedingValue Open Calls.
- **Design and application of a Fluidigm[®] array**, as a useful and affordable platform for strawberry Molecular-Assisted Selection.
- Establishment of **sequence based genotyping tools** for raspberry and blueberry.

PHENOTYPING

- Application and further development of **innovative and rapid phenotyping tools** aiming to build up prediction models for plant resilience, yield, and fruit quality. A combination of advanced and fast screening technologies were developed and employed. Near-infrared (NIR) spectroscopy and 3D imaging were applied to strawberry fruits, while hyperspectral imaging was used to phenotype raspberry and blueberry plants.
- Development of **imaging-based root architecture trait mapping pipeline** to identify heritable traits and potential new indicators for root resiliency in stress conditions in strawberry.
- Development of a **software to visualise the plant architecture in 2D and 3D representations** and to analyse the aerial architecture of strawberry plants.
- **Characterisation of strawberry, raspberry and blueberry fruit quality** using metabolomics.
- **Performance of postharvest studies** in the three berry species providing valuable insights for selecting genotypes tailored to different market needs and identifying promising pre-breeding materials.

CONSUMER SCIENCE

- **Specification and communication of sensorial quality factors and consumer quality preferences** for different berry species in different parts of Europe. Sensory attributes that most influence consumer acceptance and willingness to pay for fresh berries were identified.
- Production of **harmonised sensory analysis tools and protocols** and creation of sensory profiles. Development of **multilingual (7 languages) lexicons for berry fruit sensorial analysis** providing descriptions of fruit quality harmonised on European level.
- Development of **harmonised visualisation methodology to fruit sensory quality** of European berry genetic resources.
- **Knowledge transfer of sensory analysis methodology, protocols and tools** to European breeding companies involved through the Open Calls allowing for a direct uptake of results into their breeding programs.

DATA ANALYSIS & VISUALISATION

- Providing a large collection of **open data dedicated to berry crops** within the **Germinate platform** supporting data analyses and combination of data set-important for data integration and the **development of rich data visualisation tools** to ensure user-friendly display of the BreedingValue data:

<https://breedingvalue.eu/results/the-germinate-berry-database>

Open access publications for the benefit of all scientific communities, available at:
<https://breedingvalue.eu/publications>

Partners

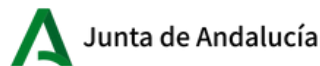


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Policy Recommendations

Fruit crops and berries in particular are crops more susceptible to the stress factors induced by climate change, and **the challenge will be to guarantee their access to consumers, with high quality at a sustainable cost.** Therefore, **we strongly recommend the European Union to continue to prioritize research on fruit/berry crops**, including support for the preservation of genetic resources, the development of new advanced genetic knowledge, and breeding strategies **to identify new competitive cultivars for the EU industry and European consumers.** The lack of this support will contribute to losing the capacity to control the full chain of production, from the plant to the consumer, and contribute to the increased dependence of this sector on non-EU large companies.

The BreedingValue consortium identified in particular the following **gaps that need to be addressed in future research funding:**

- 🍓 Focus on **phenotyping on multistress** as an important problem in environmentally dependent experiments.
- 🧬 **Development of cost-effective molecular marker arrays** for strawberry, raspberry and blueberry, affordable and useful for breeding programs.
- 🍓 **RNAseq studies in raspberry and blueberry, alongside metabolomics** to understand better the interplay of genetics and metabolites; eventually also accompanying medical studies to promote better health properties of berries.
- 🍓 **Development of pangenomes for berries** that are frequently inter-crossed with related species such as blueberry (to some extent also raspberry and strawberry) or of re-synthesized/re-constructed cultivars e.g. in strawberries.
- 🧬 **Market studies or interviews with growers and consumers/private gardeners:** needs and requirements for berry cultivation/gardening in different European regions (e.g. why are berries not cultivated widely in countries that meet the climatic requirements for the particular crop?)
- 🍓 **Environmental studies:** identify/quantify beneficial ecosystem services as well as negative environmental impacts of different berry cultivation systems.
- 🍓 Future research on breeding would need to **focus on a more effective interaction with local producers**, and explore the increasing technological opportunities of consumer involvement and education, through Virtual- and Augmented- reality.
- 🧬 **GxExM analyses and epigenetics** applied for breeding.
- 🍓 Use of the data generated by the project for the **development of new AI applications**, including prediction models.