Pre-breeding strategies for obtaining new resilient and added value berries

Workshop Advancing Berry Breeding: From Phenotyping to Genomic Innovation package overview

BERRY GENETIC RESSOURCES. Importance of a large germplasm and breeding material for BV: Results of phenotyping.

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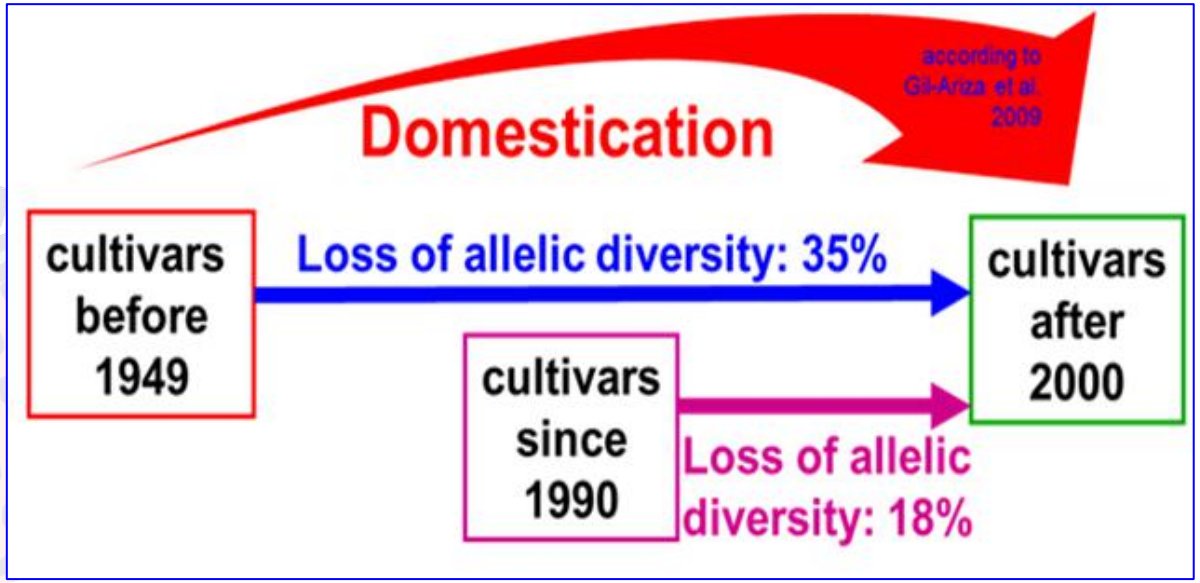
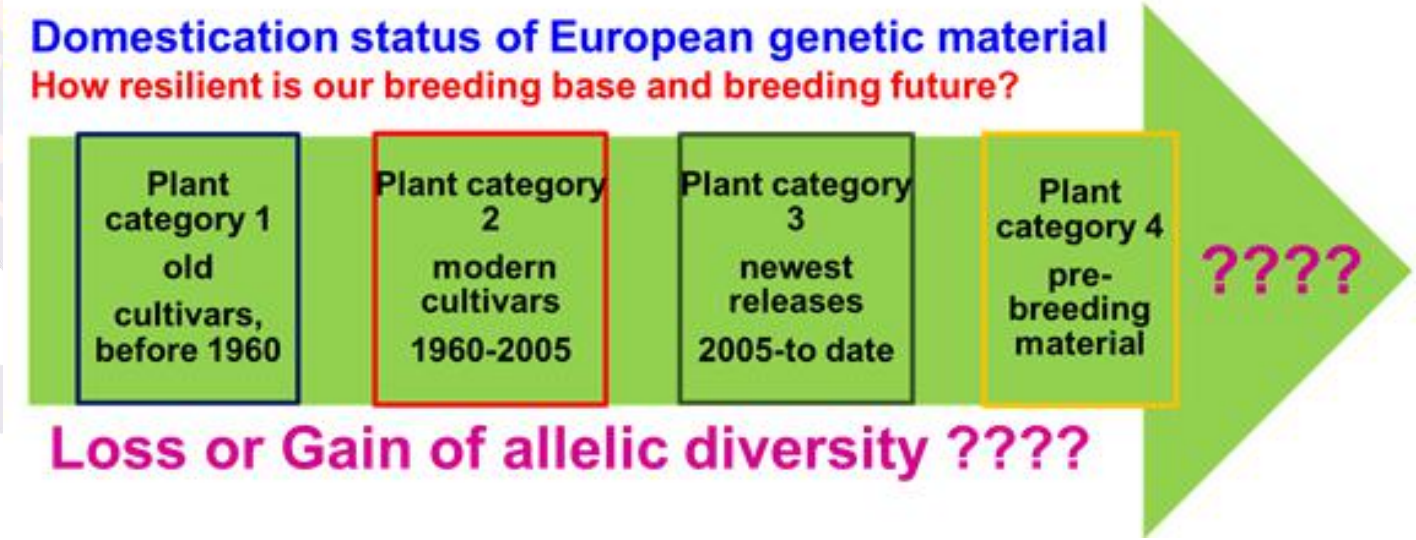
Paolo Zucchi, Sant´ Orsola
Daniele Duca, UPM
Monika Höfer, JKI

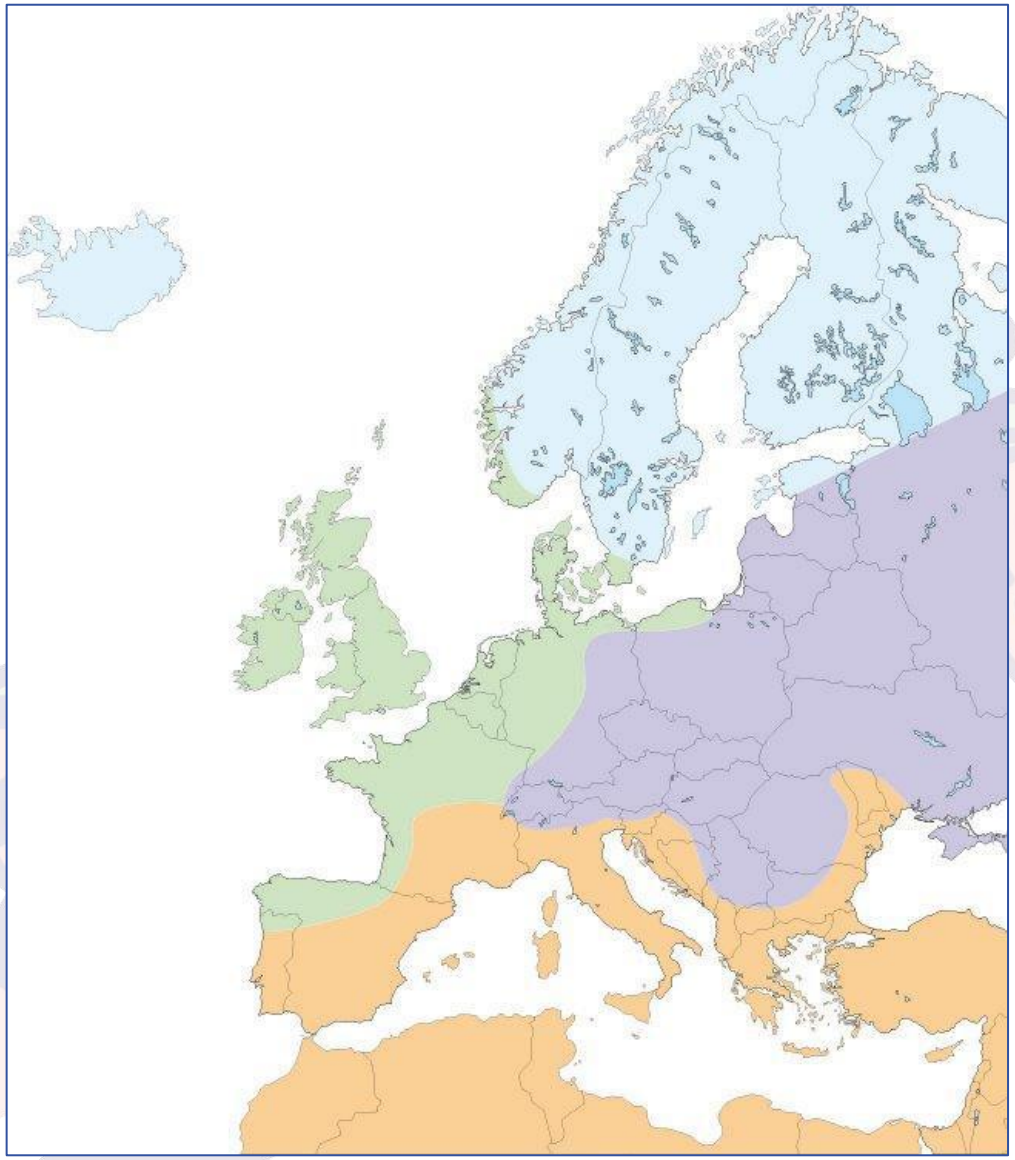
The BreedingValue project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000747.

Basic Theses and Questions of the Project



Gil-Ariza et al.,m2009



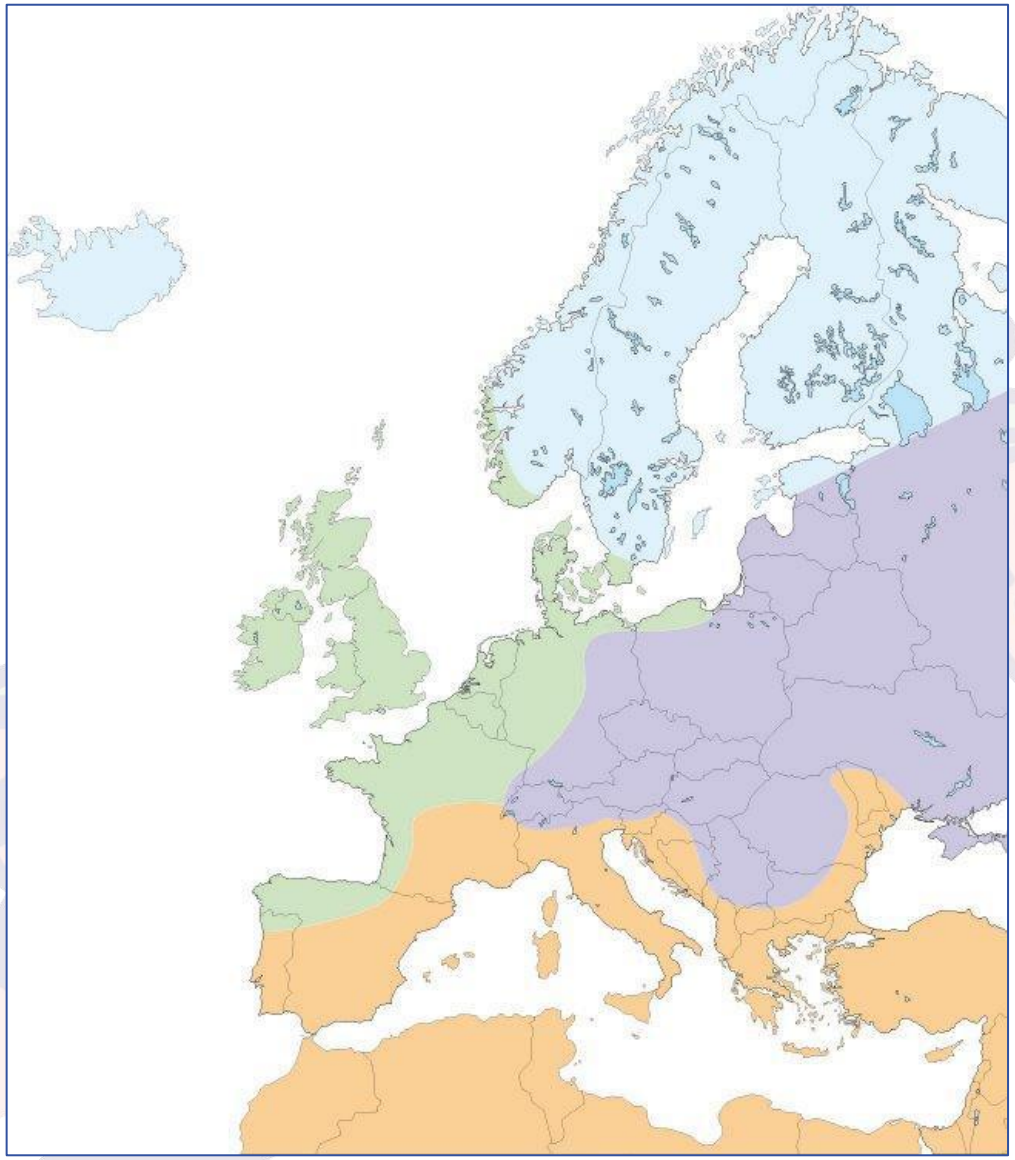


Divers climate requests diverse plant material

Climate change requests adapted plants

Northern European Regions	**Nordic Climate** (cold winters and mild, humid summers)
Middle and East European Regions	**Eastern Continental Climate** (cold winters and hot, dry summers)
West European Regions	**Oceanic Climate** (mild winters and humid summers)
South European Regions and Mediterranean Area	**Middle East**

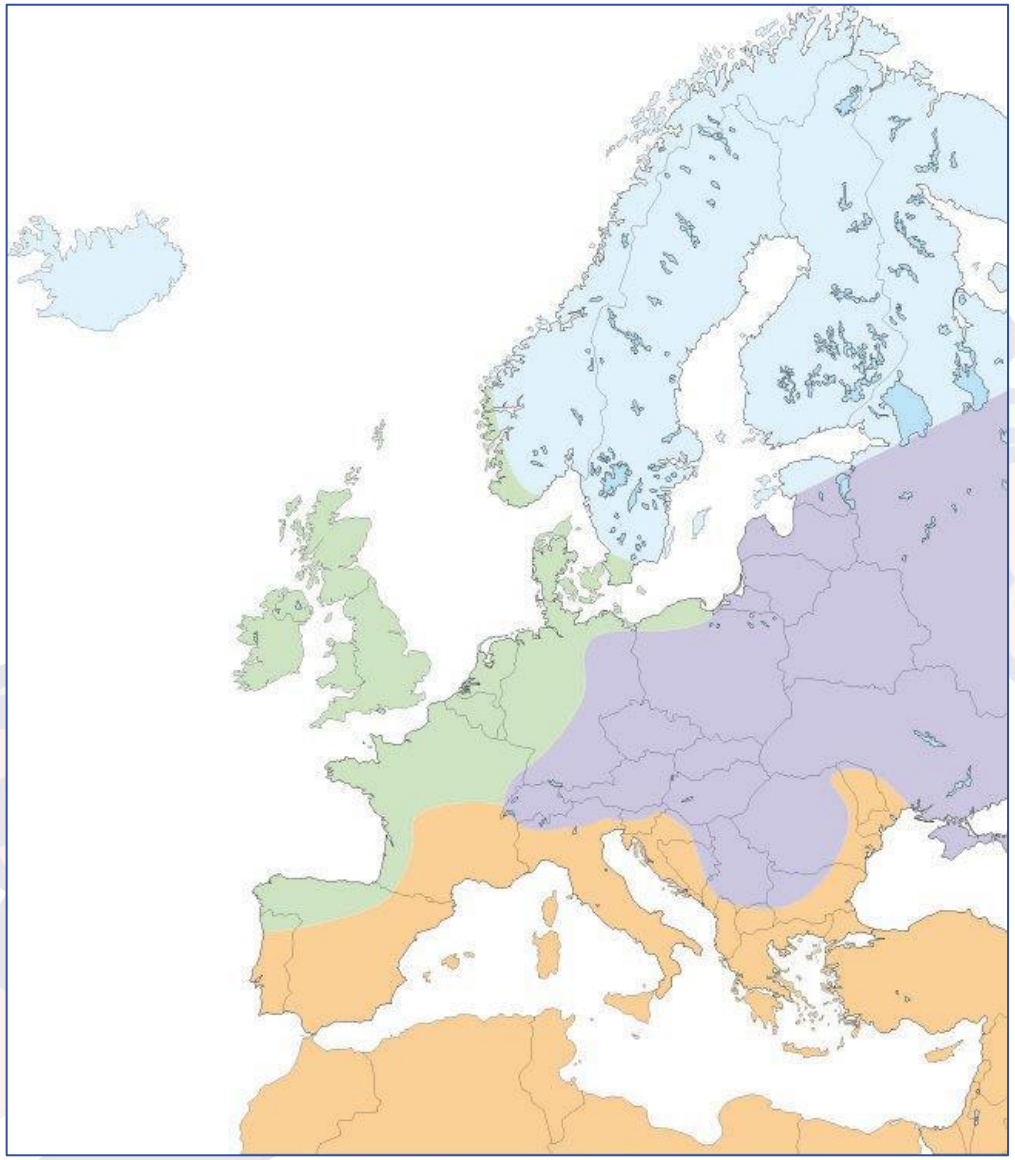
https://www.barenbrug.de/futterbau/klimazonen-in-europa-und-im-mittelmeerraum



https://www.barenbrug.de/futterbau/klimazonen-in-europa-und-im-mittelmeerraum

Strawberry:

- Mediterranean cluster with short day types and day-neutrals
- North / Middle and East: Junebearer with chilling requirement and day-neutrals



https://www.barenbrug.de/futterbau/klimazonen-in-europa-und-im-mittelmeerraum

Raspberry:

- Mediterranean cluster with low chilling requirements, remontant cv.`s dominant
- North / Middle and East: medium and high chilling requirements, single fruiting cv.´s dominant

Blueberry:

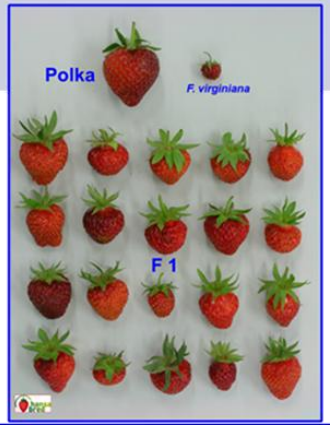
- Mediterranean cluster with „Southern Highbush“
- North / Middle and East: „Northern Highbush“

https://www.dtbrownseeds.co.uk/products/long-cropping-blueberry-fruit-plant-collection

Objectives

- **O1.1:** select proper plant material in six defined categories as the base for all work packages
- **O1.2:** maintain plant material as the basic collection for all work packages
- **O1.3:** performing field trials for plant material as the base for genotyping, phenotyping and consumer science studies, apply phenotyping methods to the selected material
- **O1.4**: performing Life Cycle Assessment (LCA) of agronomic performance of the pre-breeding material based on the information collected with field trials to assess the sustainability

Germplasm collections: Definition of plant categories and maintenance

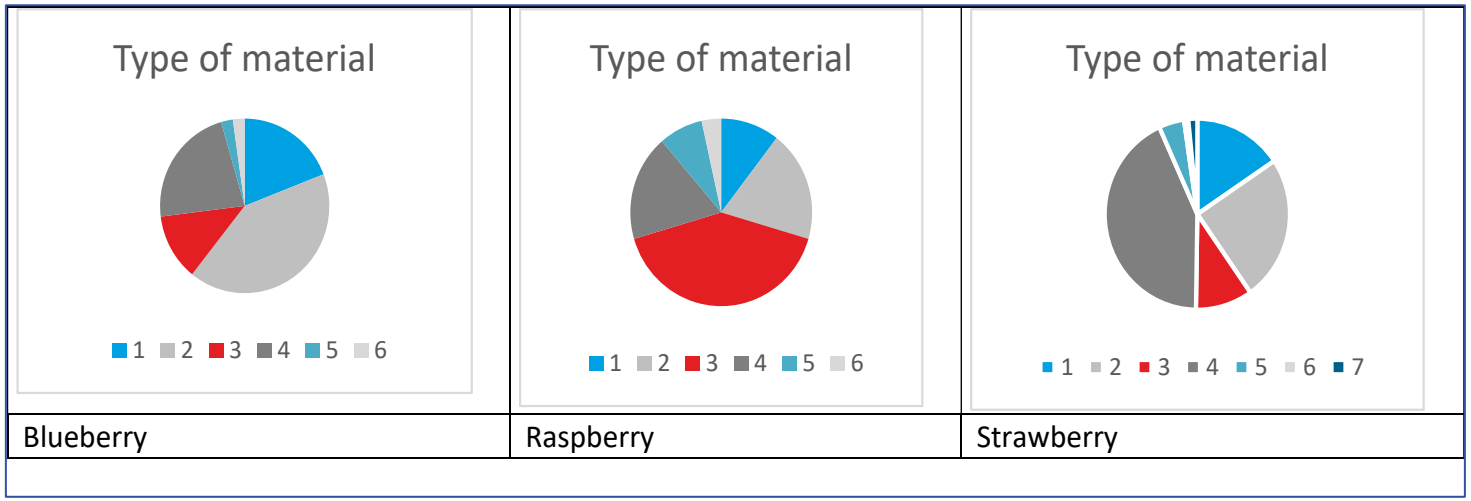
Plant category 1 Old cv. (before 1960)	Plant category 2 Modern cv. (1960-2004)	Plant category 3 Newest (released) cv. (2005 till now)	Plant category 4 Pre-breeding (advanced selections or selections in new breeding directions)	Plant category 5 Species	Plant category 6 Populations
					

Germplasm maintenance

- on-farm
- ex situ
- In vitro/ cryo conservation

Selection of accessions

	Sum	WP1	WP2	WP3	WP4	Allelic diversity
Fragaria						
	1510 and populations	819	1081	215	107	376
Rubus						
	86 and populations	74	54	59	16	-
Vaccinium						
	81 and populations	45	78	57	19	-



Blueberry	Raspberry	Strawberry

Evaluation in different climates

Crop	Partner N°	Partner	Year			Total*
			2022	2023	2024	
Strawberry	1	UPM	266			**266**
	4	LUKE	16	13	12	**26**
	6	IFAPA	11	11		**11**
	10	JKI	174	194		**196**
	12	INVENIO	33	36	7	**36**
	13	NIAB	326	112		**328**
	15	FNM	7	10		**10**
	17	Hansabred	47	278		**281**
	18	S'O	5	5	2	**5**
	19	CIV	12	12	12	**12**
	Total*		**871**	**552**	**31**	**1042**
Raspberry	7	JHI	280	282		**290**
	16	Yaltir	2			**2**
	18	S'O	10	12		**12**
	Total*		**291**	**293**		**303**
Blueberry	7	JHI	32	31		**32**
	16	Yaltir	4	4		**4**
	18	S'O	7	10	2	**10**
	Total*		**37**	**39**	**2**	**40**

* unique accessions tested across partners and/or years

Crop	Plant category	Unique accession number	Datapoint number
Strawberry	Modern cultivars (1960 - 2004)	166	7920 *
	Newest cultivars (2005 until now)	69	6784 *
	Old cultivars (before 1960)	100	2546 *
	Other cultivars	84	1292 *
	Populations	266	1847 *
	Pre-breeding / advanced selections	322	12515 *
	Selfings	13	264 *
	Undefined	17	839 *
	Wild species	5	72 *
	Total	**1042**	**34079 ***
Raspberry	Modern cultivars (1960 - 2004)	13	1331
	Newest cultivars (2005 until now)	11	5408
	Old cultivars (before 1960)	2	48
	Other cultivars	24	204
	Pre-breeding / advanced selections	17	7755
	Undefined	236	1851
	Total	**303**	**16597**
Blueberry	Modern cultivars (1960 - 2004)	14	2027
	Newest cultivars (2005 until now)	8	2095
	Old cultivars (before 1960)	8	542
	Other cultivars	8	879
	Populations	2 [a]	10886
	Total	**40**	**16429**

** numbers are block datapoints and not the single time datapoints*

[a] number of tested populations

Evaluation in different climates

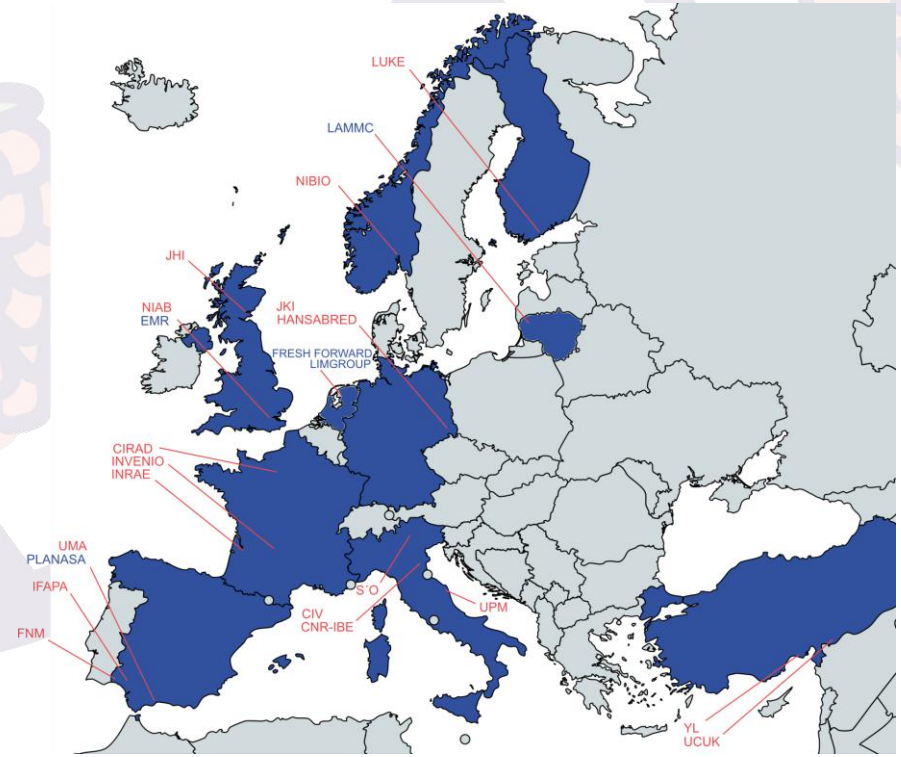
Dots mark the trial location; numbers represent number of trial sites per location.

Extensive network of trial sites:

- 12 different environments;
- 44 trial sites.

Material for the Allelic diversity study in strawberry

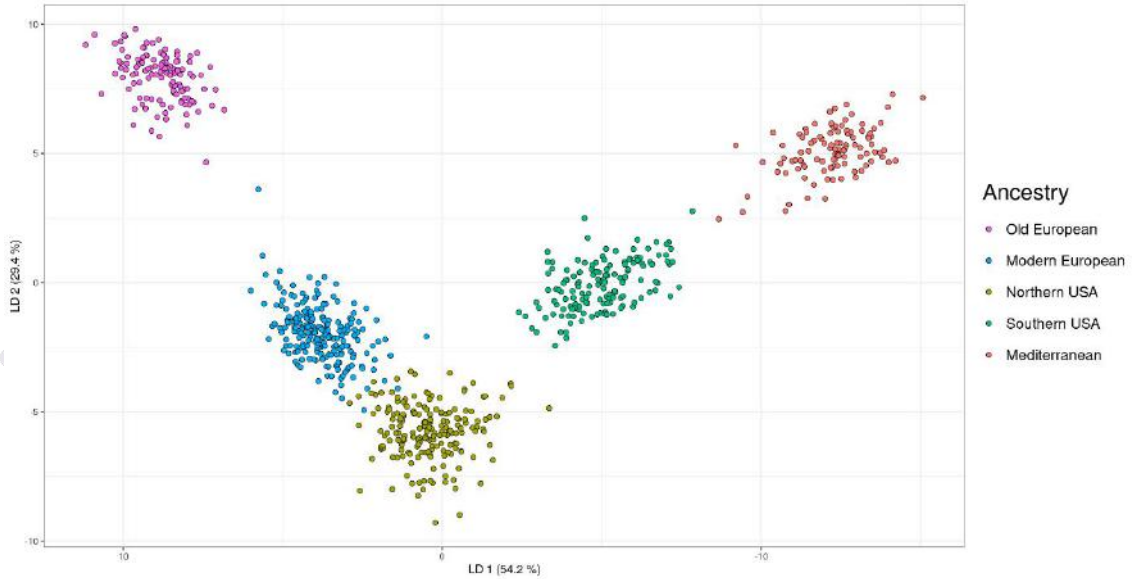
Plant category		Samples on plate	Existing Data
1	old cultivars (before 1960)	75	87
2	modern cultivars (1960 - 2005)	87	151
3	newest cultivars (2005 until now)	91	24
4	pre-breeding / advanced selections	95	25
5	wild species accession	9	-
7	selfing (S1-S5)	23	-
	not sorted yet	-	40
Sum		380	327



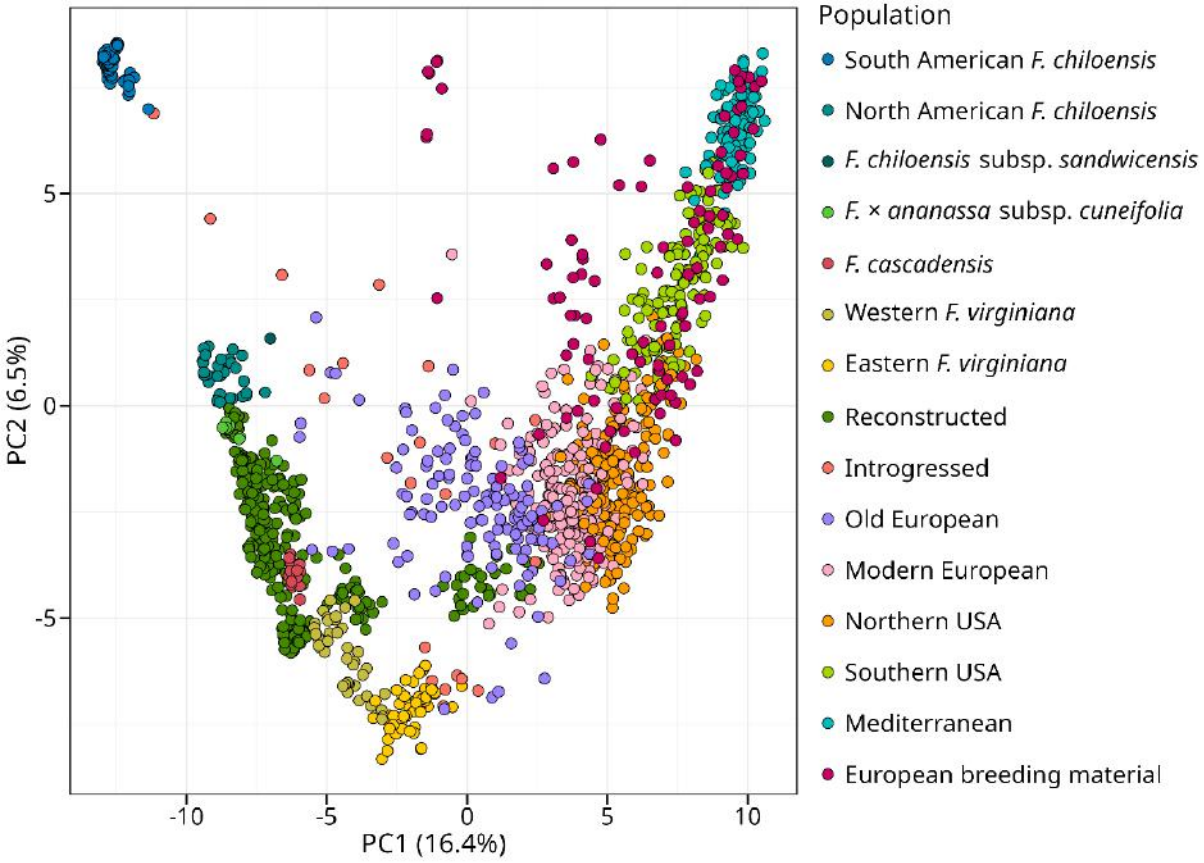
Country of origin	Breeding institutions	Number of cultivars from a country	
		Samples on plate	Existing Data
AUS	1	1	-
BEL	2	2	2
CAN	2	2	16
DEN	-	-	18
DEU	22	65	31
ESP	8	20	1
EST	-	-	1
FIN	2	2	14
FRA	12	30	20
GBR	8	35	27
ITA	6	31	13
JAP	2	2	-
LET	-	-	1
LTU	1	2	3
NDL	6	12	29
NOR	-	-	13
POL	-	-	3
ROM	1	1	-
RUS	-	2	8
SWE	1	1	7
TUR	-	5	-
USA	10	38	44
unknown	-	-	51
Sum	84	251	302

Tracing strawberry population structures: The legacy of domestication and intertwined breeding

Jacob Junkers et al., manuscript in progress



DAPC of strawberry cultivars. The DAPC dived the garden strawberry cultivars into five groups that somewhat reflected their ancestry.



„Study of metabolite diversity in strawberry and raspberry“

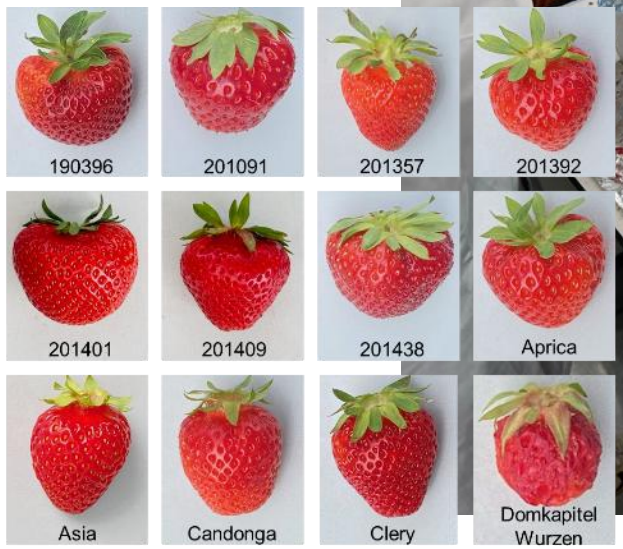
- Study the metabolite structure with regard to the breeding history and metabilite diversity
- Include newest releases and advanced selections to draw a picture of domestication effects and the status of current and perspectives of future strawberry breeding in Europe
- Partners involved: UMA, JKI, Hansabred, SO´, Luke, FZJ
- Time frame: summer/autumn 2023, 2024

Strawberry
ca. 290 genotypes

Raspberry
134 genotypes

Source: Absalom Shank

Metabolite Diversity Study in Strawberry, Cooperation HB-JKI-UMA-Luke-FZJ

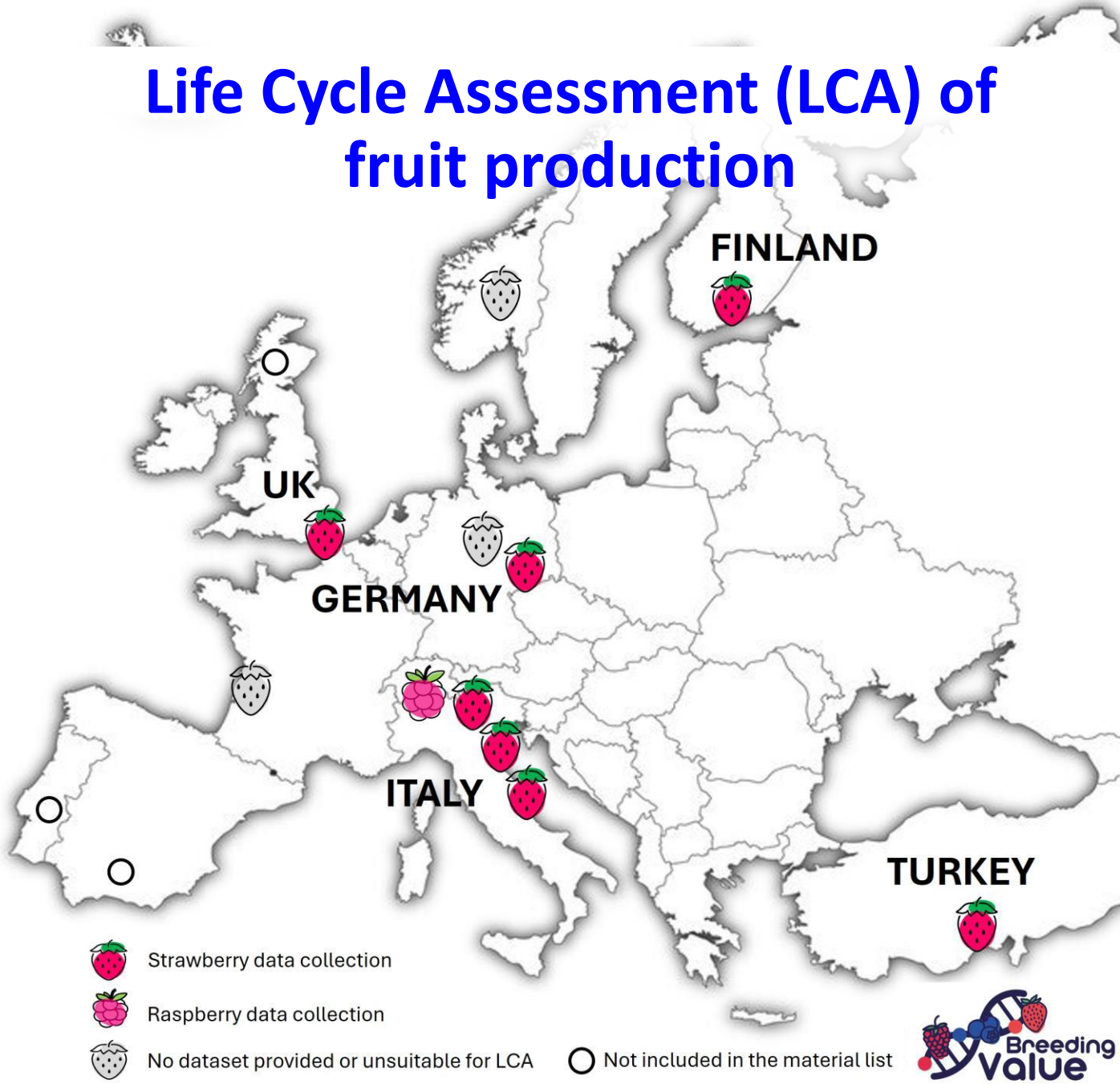


Life Cycle Assessment (LCA) of fruit production

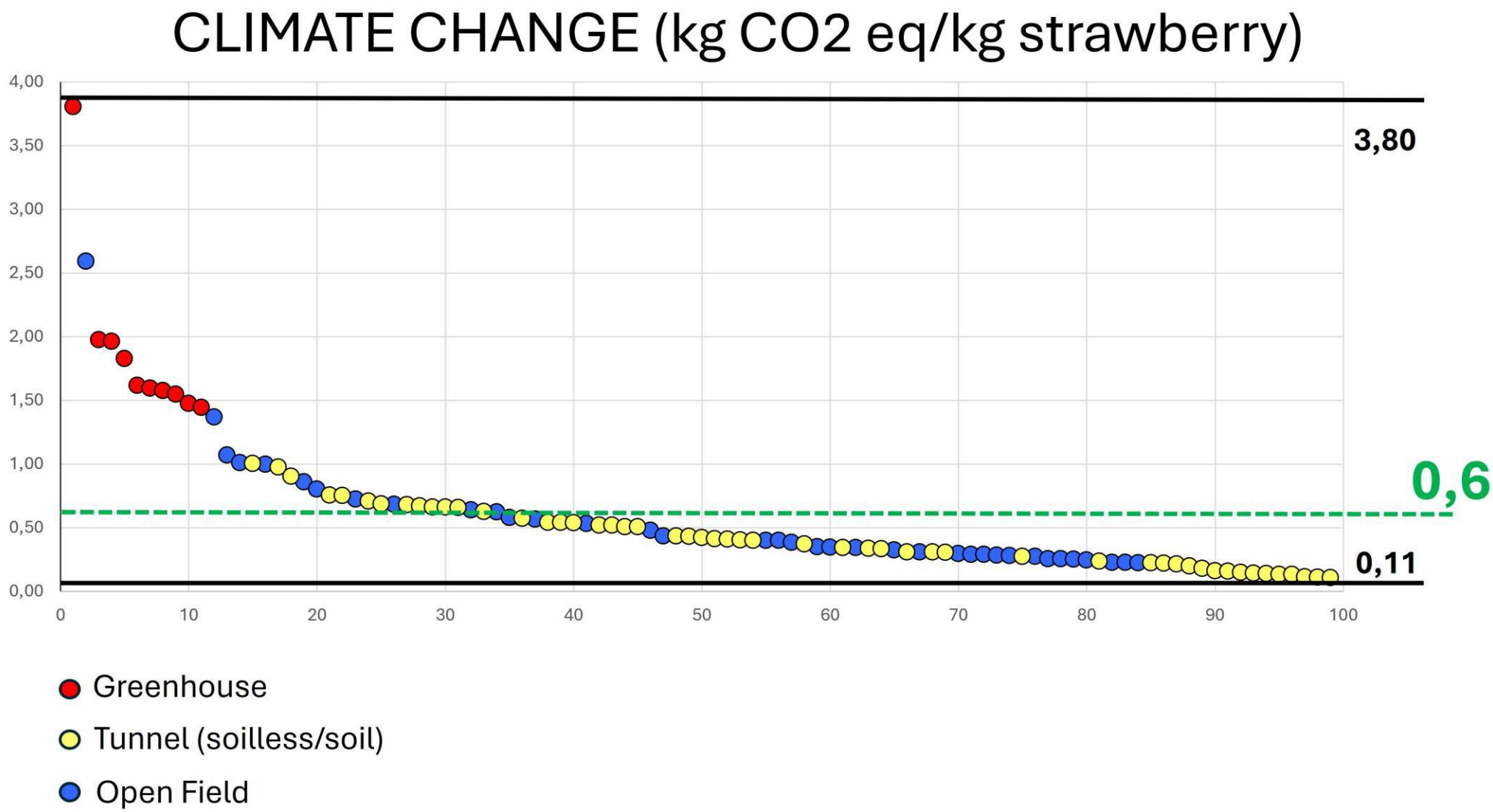
Partner	Country	Geo-Localization
UPM	ITALY	Agugliano, Marche
LUKE	FINLAND	Piikkiö, South-West
NIAB	UK	East Malling, Kent
HANSABRED	GERMANY	Saxony, Dresden
S'O	ITALY	Trento
CIV	ITALY	Comacchio
YALTIR/UCUK	TURKEY	Adana
JKI	GERMANY	Dresden
NIBIO	NORWAY	Ridabu
INVENIO	FRANCE	Bordeaux
IFAPA	SPAIN	Seville
FNM	SPAIN	Huelva
JHI	UK	Scotland

13 dataset provided (12 suitable for LCA)
26 field trials provided
53 genotypes
- 18 control cultivars
- 35 new genotypes

106 cultivation cycles
3 cultivation systems

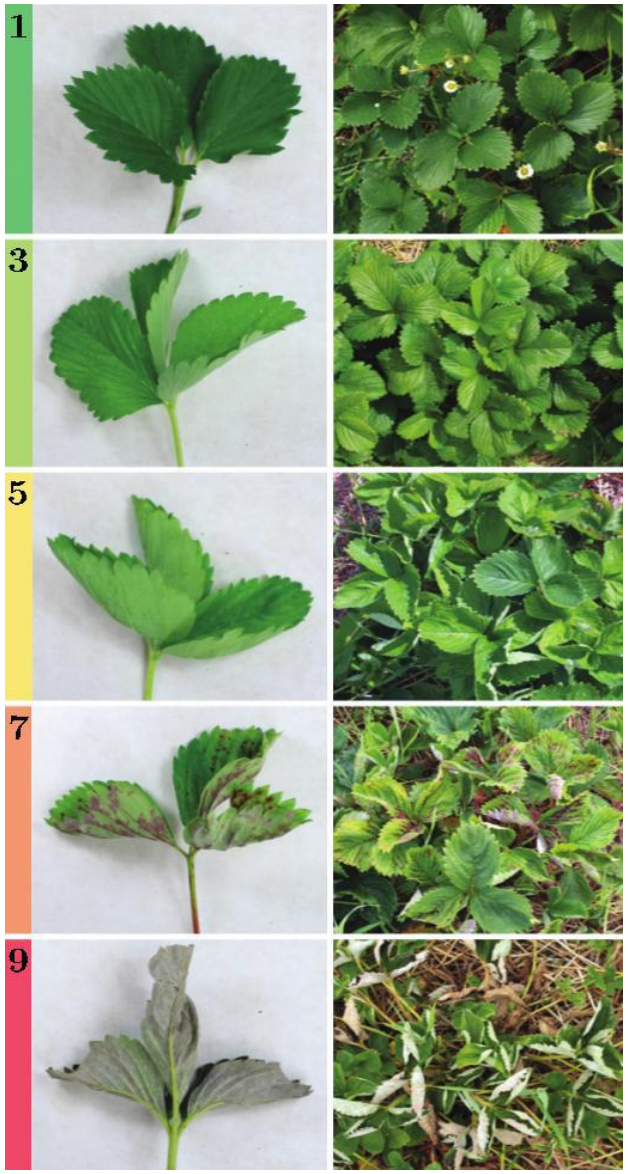


Strawberry BV benchmark



Evaluation for disease resistance

N°	Partner	Species	Disease
4	LUKE	Strawberry	Podosphaera aphanis; Phytophthora cactorum
7	JHI	Blueberry	Botryosphaeria; Dasineura oxycoccana
8	NIBIO	Strawberry	Podosphaera aphanis
10	JKI	Strawberry	Botrytis cinerea; Xanthomonas fragariae
			Mycosphaerella fragariae; Diplocarpon earlianum
12	INVENIO	Strawberry	Podosphaera aphanis
13	NIAB-EM	Strawberry	Botrytis cinerea
17	Hansabred	Strawberry	Podosphaera aphanis, Mycosphaerella fragariae, Diplocarpon earlianum, Xanthomonas fragariae
18	S'O	Strawberry	Podosphaera aphanis
		Raspberry	Phragmidium rubi-idaei



Wild species introgression alters aroma profiles: Do consumers accept new strawberry aroma types?

K. Olbricht[1,2], V. Waurich[1], H. Wagner[1], D. Pinzinger[3], M. Höfer[3], D. Ulrich[3], Predieri[4], S. Karhu[5], B. Usadel, E. Senger[6], and S. Osorio[7]

[1]Hansabred GmbH & Co. KG, Dresden, Germany,

[2]Humboldt-Universität zu Berlin, Faculty of Life Sciences, Albrecht Daniel Thaer-Institute of Agricultural and Horticultural Sciences, Berlin, Germany

[3]Julius Kühn-Institute, Dresden and Quedlinburg, Germany

[4]Institute for BioEconomy, National Research Council (CNR), Bologna, Italy

[5]LUKE, Turku, Finland

[6]Forschungszentrum Juelich GmbH, Bioeconomy Science Center (BioSC), CEPLAS, Institute of Bio- and Geosciences, IBG-4 Bioinformatics, Juelich, Germany

[7]Departamento de Biología Molecular y Bioquímica. Campus de Teatinos, Instituto de Hortofruticultura Subtropical y Mediterránea 'La Mayora', Universidad de Málaga-Consejo Superior de Investigaciones Cientıficas, Málaga, Spain

[a]E-mail: k.olbricht@hansabred.org

Material

Characterized by highly diverse aroma and wide ranges of sugar acidity values due to wild species introgressions

CV, Clone selection	Taxonomical background	Species background
90897	*F.* ×*vescana*	*F.* ×*ananassa*, *F. vesca*
90999	F1 after hybridization of *F.* ×*ananassa* × with *F. chiloensis*	*F.* ×*ananassa*, *F. chiloensis*
140564	F4 after hybridization of *F.* ×*ananassa* × with *F. chiloensis*	*F.* ×*ananassa*, *F. chiloensis*
150292	*F.* ×*ananassa* selection	*F.* ×*ananassa*
180810	F? after hybridization of *F.* ×*ananassa* × with *F. nilgerrensis*	*F.* ×ananassa, *F. nilgerrensis*
190361	F5 after hybridization of *F.* ×*ananassa* × with *F. chiloensis*	*F.* ×*ananassa*, *F. chiloensis*
Allegro	modern cultivar (*F.* ×*ananassa*)	*F.* ×*ananassa*
Honeoye	modern cultivar (*F.* ×*ananassa*)	*F.* ×*ananassa*
Lola	modern cultivar (*F.* ×*ananassa*)	*F.* ×*ananassa*
Mieze Schindler	old cultivar (*F.* ×*ananassa*)	*F.* ×*ananassa*, *F. chiloensis*
Renaissance	F3 after hybridization of *F.* ×*ananassa* × with *F. chiloensis*	*F.* ×*ananassa*, *F. chiloensis*
Rendezvous	F4 after hybridization of *F.* ×*ananassa* × with *F. chiloensis*	*F.* ×*ananassa*, *F. chiloensis*
Senga Sengana	old cultivar (*F.* ×*ananassa*)	*F.* ×*ananassa*

Hypotheses

• Humans have gathered and consumed strawberries for millennia, leading to a co-evolutionary relationship with *Fragaria* species.











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• Consumers may have an innate attraction to the characteristic aromas of wild strawberries.

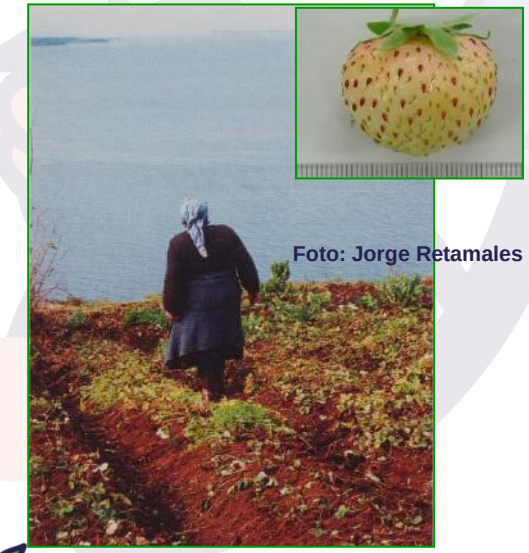

Foto: Jorge Retamales

Chile
Fragaria chiloensis

Fotos: Detlef Ulrich

Altai
Fragaria viridis

Fotos: Francesco Casalini

Piemont, Italy
Fragaria moschata
`Profumata di Tortona´

Hypotheses

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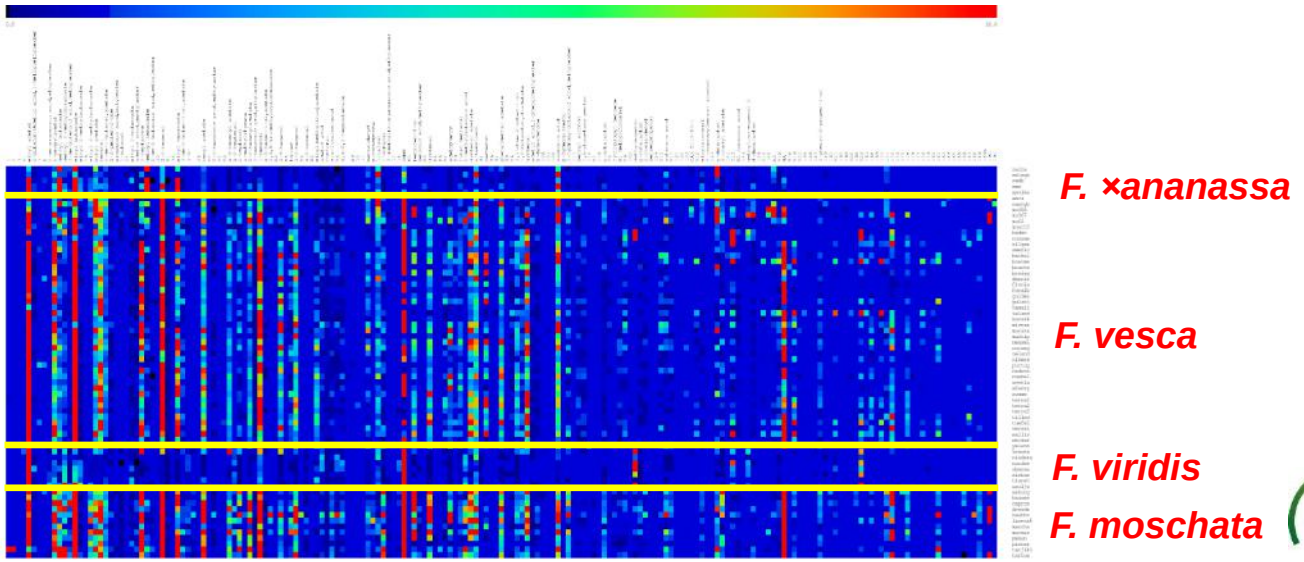
- Consumers may have an innate attraction to the characteristic aromas of wild strawberries.

- Breeding history has influenced dietary preferences, favoring a well-balanced flavor profile



Ulrich and Olbricht, 2013, Berry Journal

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- Humans have gathered and consumed strawberries for millennia, leading to a co-evolutionary relationship with *Fragaria* species.
- Consumers may have an innate attraction to the characteristic aromas of wild strawberries.
- Breeding history has influenced dietary preferences, favoring a well-balanced flavor profile.
- Modern breeding focused on productivity resulted in poor aroma patterns.
- The ability to perceive and appreciate diverse aroma compositions from wild species remains a fundamental aspect of human sensory perception.

Methods

Fruit sample preparation

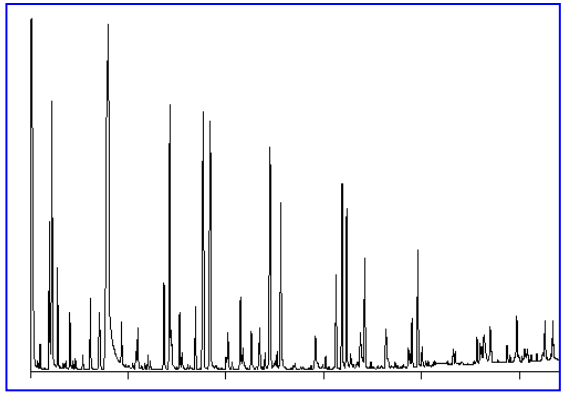
- 6-7 kg fruit per genotype cut into quarters and mixed
- representative sample batch ensured

Sensory study by consumers

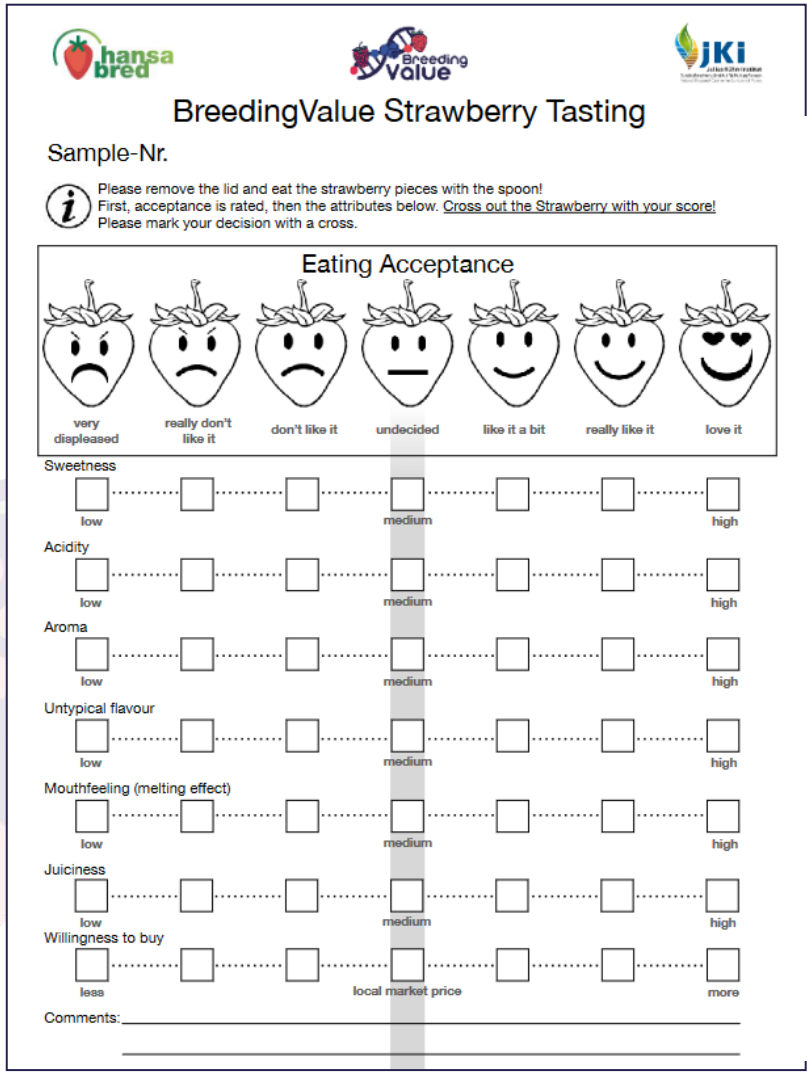
- Location: Dresden, Germany
- June11th and 18th 2022
- Participants: 94 and 86 persons (age from 8 to 79)

Measurement of Brix and TTA

VOC analysis by HS-SPME coupled with GC-MS



Sensory Study by Consumers



BreedingValue Strawberry Tasting

Sample-Nr.

Please remove the lid and eat the strawberry pieces with the spoon!
First, acceptance is rated, then the attributes below. Cross out the Strawberry with your score!
Please mark your decision with a cross.

Eating Acceptance

very displeased | really don't like it | don't like it | undecided | like it a bit | really like it | love it

Sweetness — low — medium — high

Acidity — low — medium — high

Aroma — low — medium — high

Untypical flavour — low — medium — high

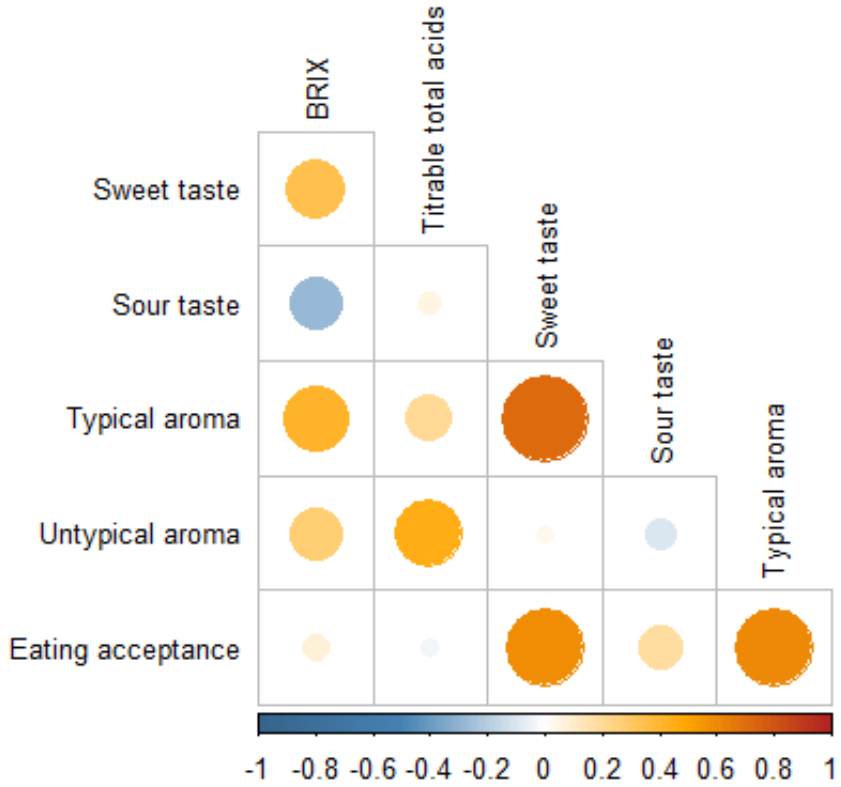
Mouthfeeling (melting effect) — low — medium — high

Juiciness — low — medium — high

Willingness to buy — less — local market price — more

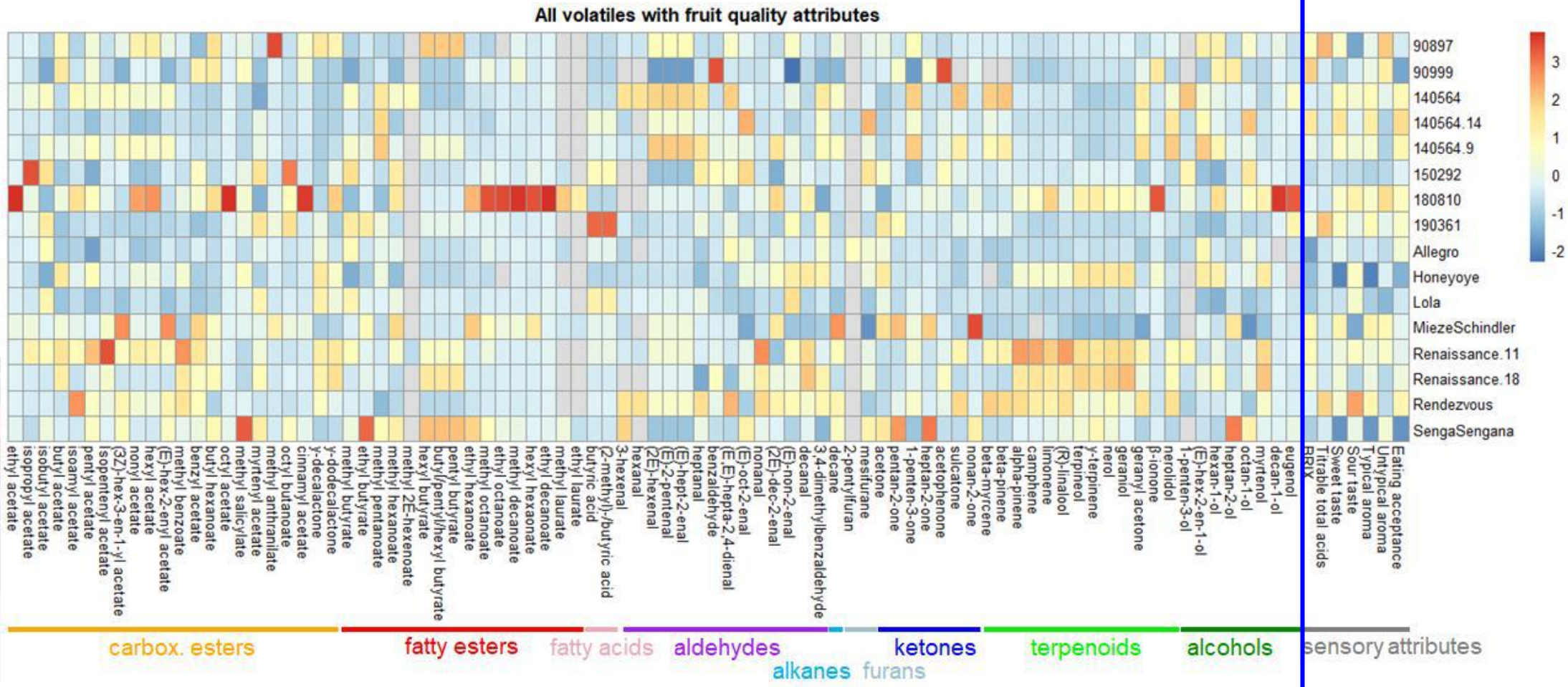
Comments:

Introduced by an explanatory lecture on the BreedingValue project and on the aim of the consumer

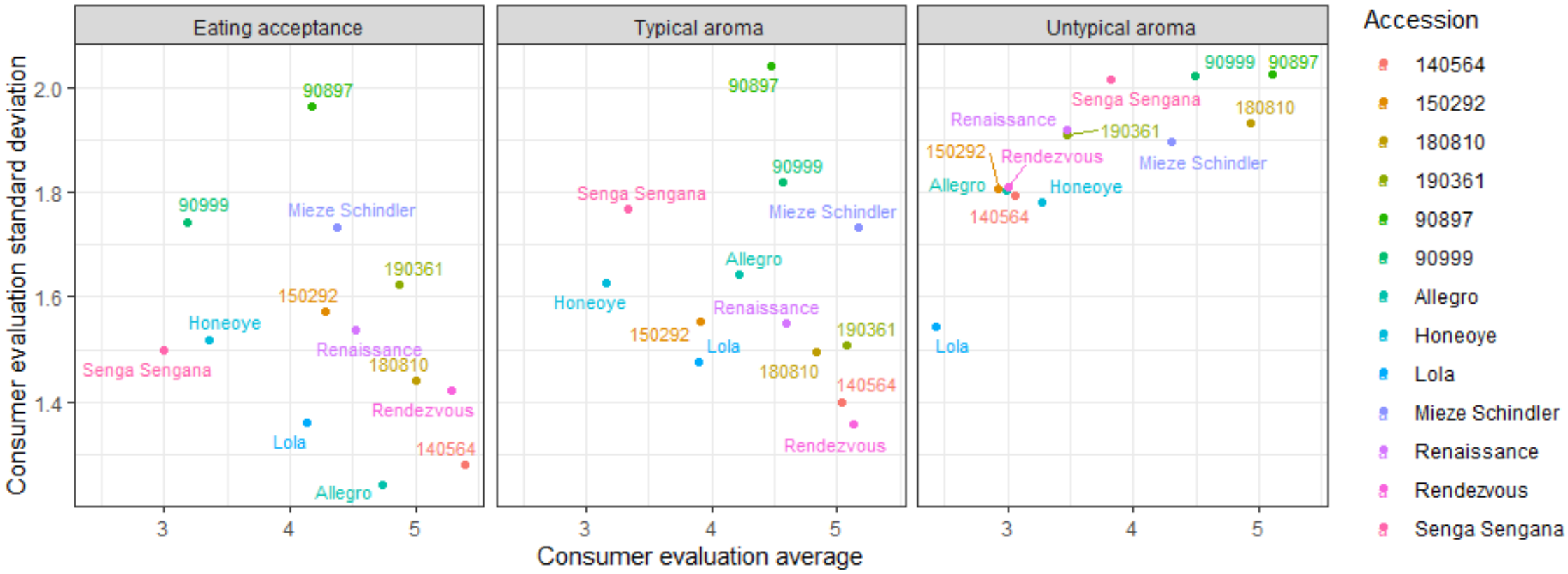


Correlations between Sensory Traits, Brix and TTA

Results and Discussions



Results and Discussions



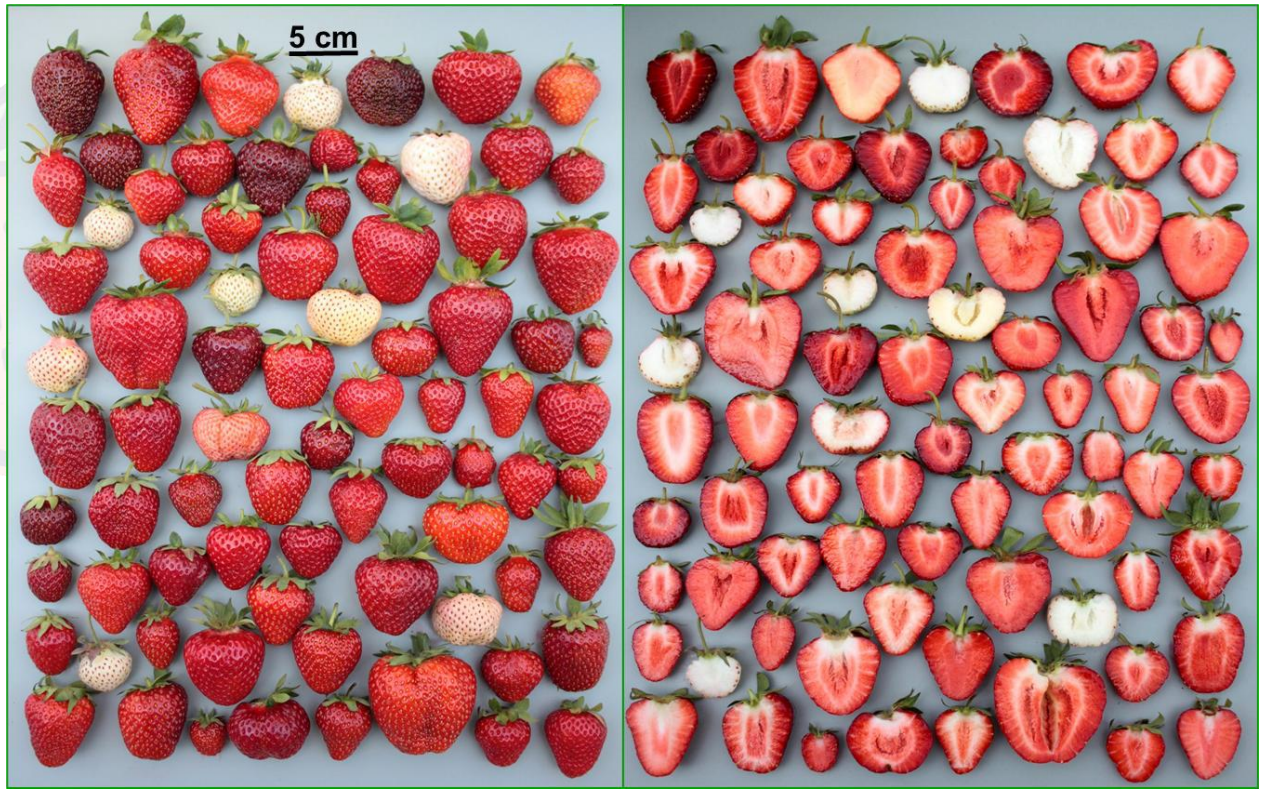
Conclusions

- **Variation NonVocs:** High diversity in soluble solids content (Brix) and total titrable acids (TTA). High acceptance highly correlates with sweet taste.
- **Volatile Compounds:** 87 VOCs detected by SPME. provides critical insights into the aroma profiles of different genotypes.
- **Modern Cultivars:** Lower VOC concentrations correlate with reduced consumer acceptance.
- **Wild Species Introgression:** *F. chiloensis* introgressions (e.g., F4 generation) show the highest acceptance. Specific VOCs influence consumer preference, enhanced by interspecific genetics.
- **Methyl Anthranilate Effect:** Good acceptance of Mieze Schindler but reduced acceptance for excessive amounts (*F. ×vescana*).
- **Lactone Effect:** selections after *F. nilgerrensis* introgression with peach-like notes were well accepted in Germany.
- **Aroma Balance:** VOC interactions play a crucial role in perceived aroma. High acceptance correlates with typical aroma but untypical aroma does not mean low acceptance.
- **Breeding Strategy:** Incorporating wild species' aroma complexity enhances sensory appeal and market success.

Hypothesis accepted: The ability to perceive and appreciate diverse aroma compositions from wild species remains a fundamental aspect of human sensory perception.

Uniformity

United in Diversity



Thank you for your Interest!