



Massimiliano Corso

Chargé de Recherche

IJPB-INRAE



SPS
Saclay Plant Sciences

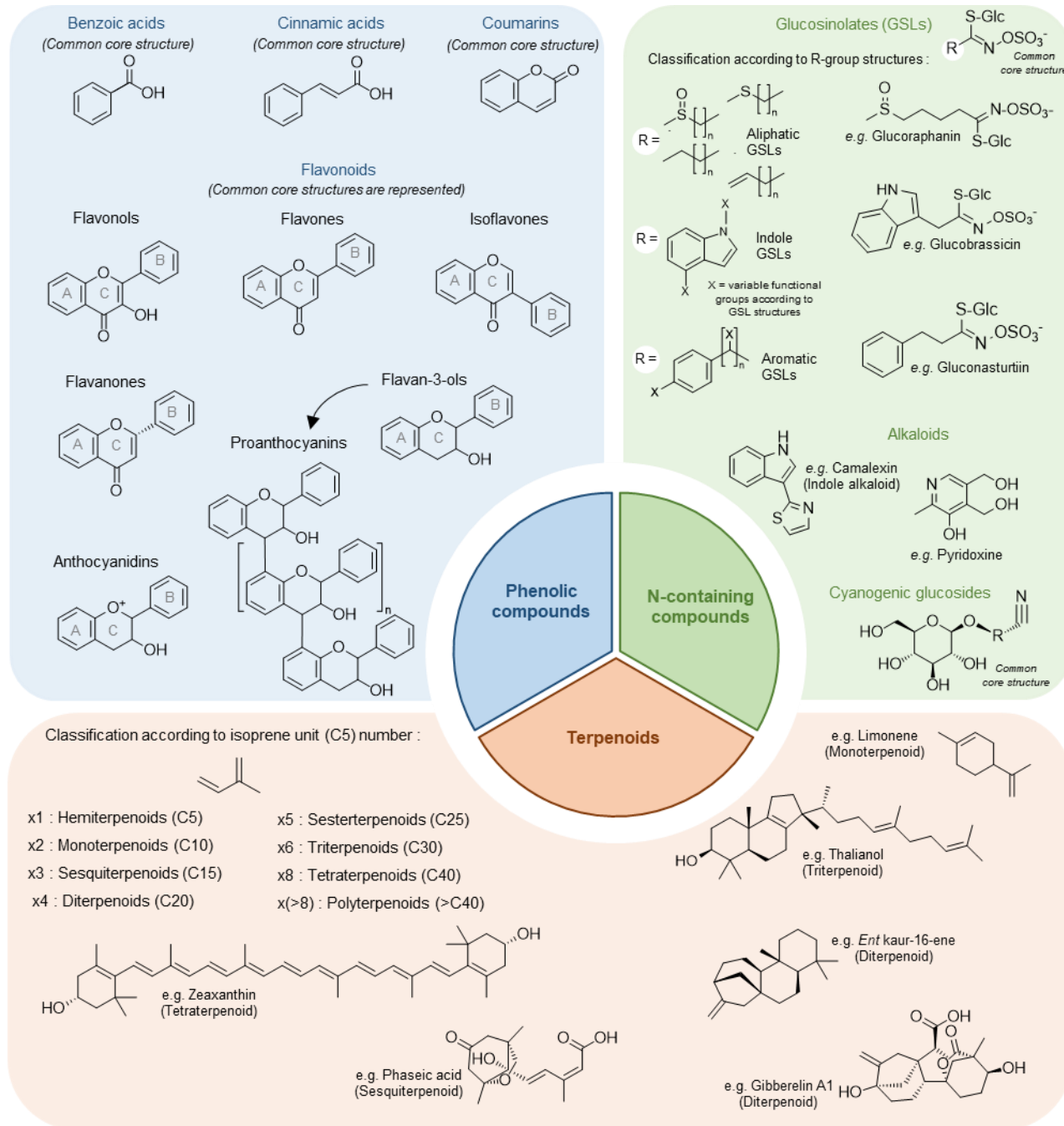
université
PARIS-SACLAY

AgroParisTech
Talents d'une planète soutenable

Seed Specialized Metabolites diversity and functions



Seed Specialized Metabolites



Arabidopsis thaliana



Camelina microcarpa



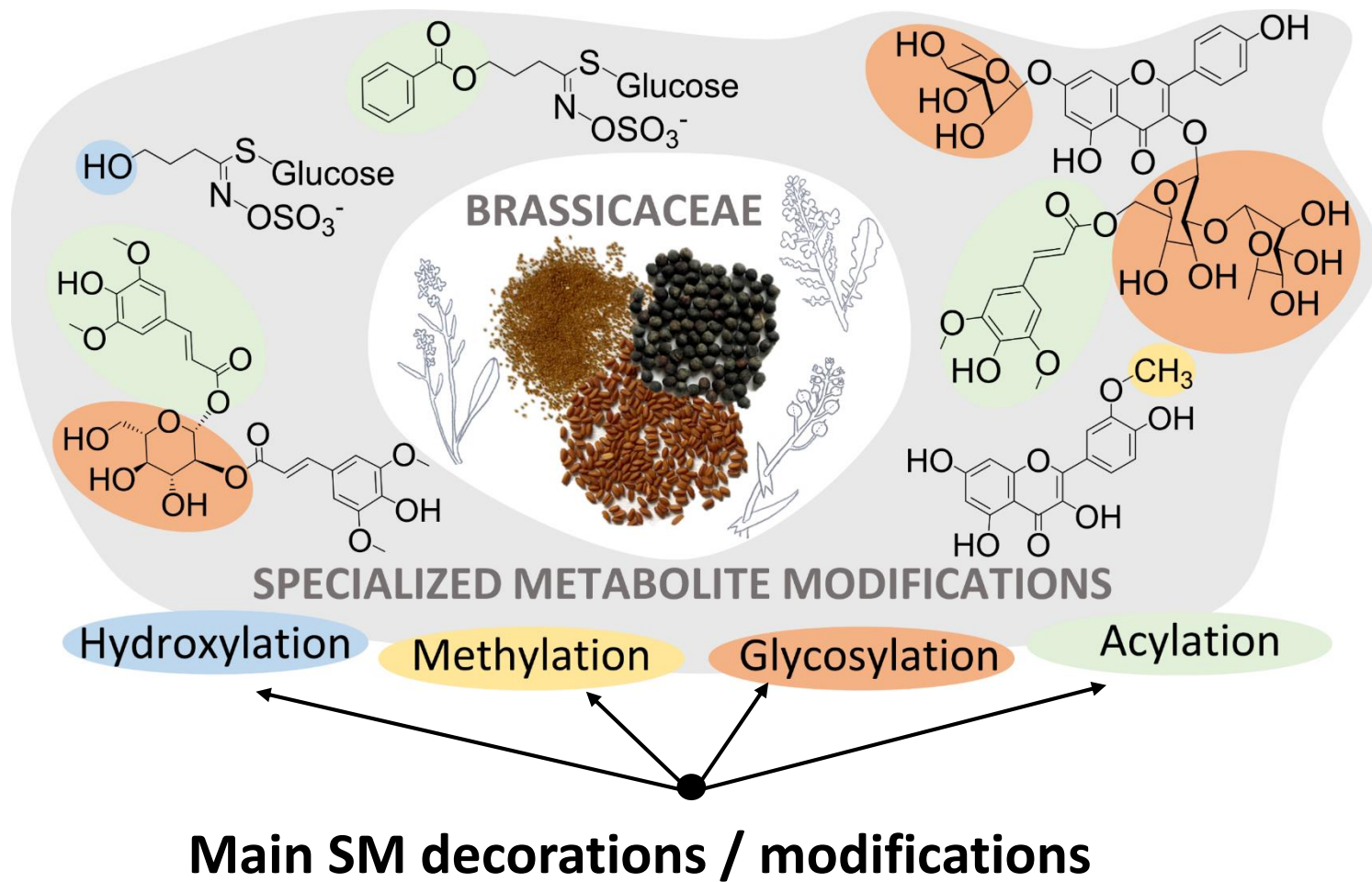
Camelina sativa



Brassica napus
(Rapeseed)

1 cm

Specialized metabolite decorations



Diversity of SMs

- Structural diversity
- Accumulation patterns diversity

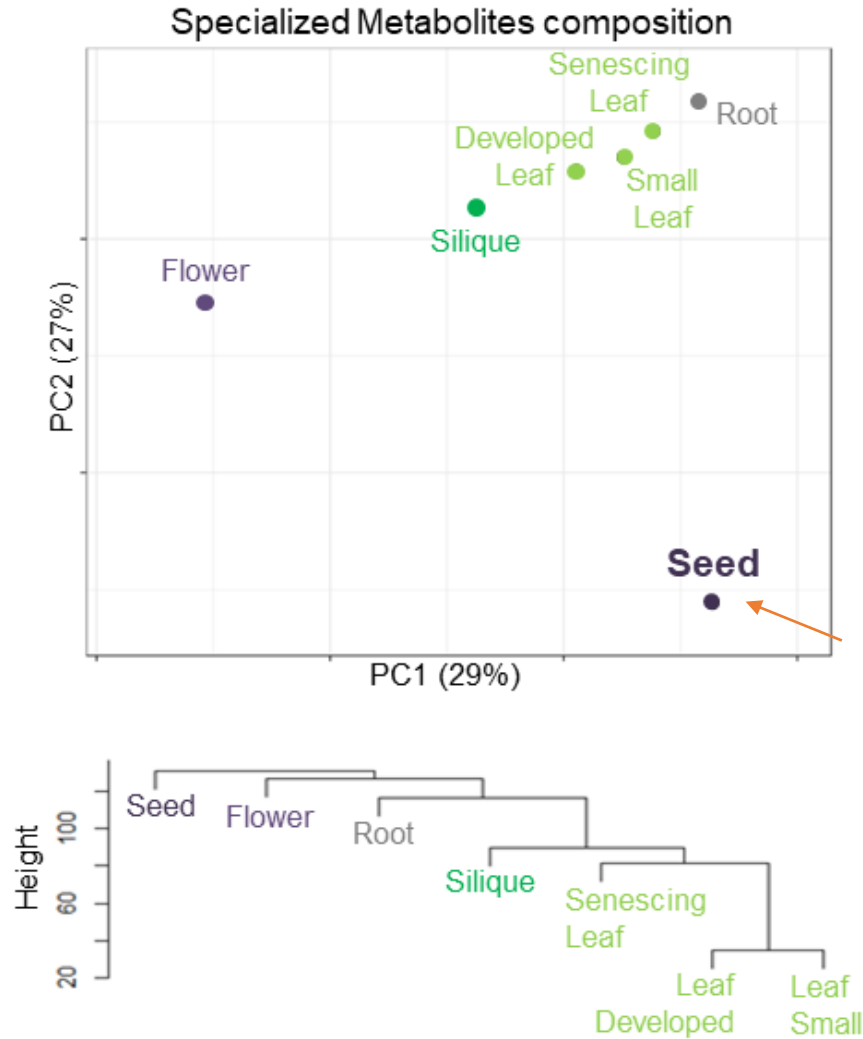
Effect on SMs functions

- Biological activities
- Localization (tissue/organ/subcellular)
- Solubility
- Storage

Why focussing on seed specialized metabolites?

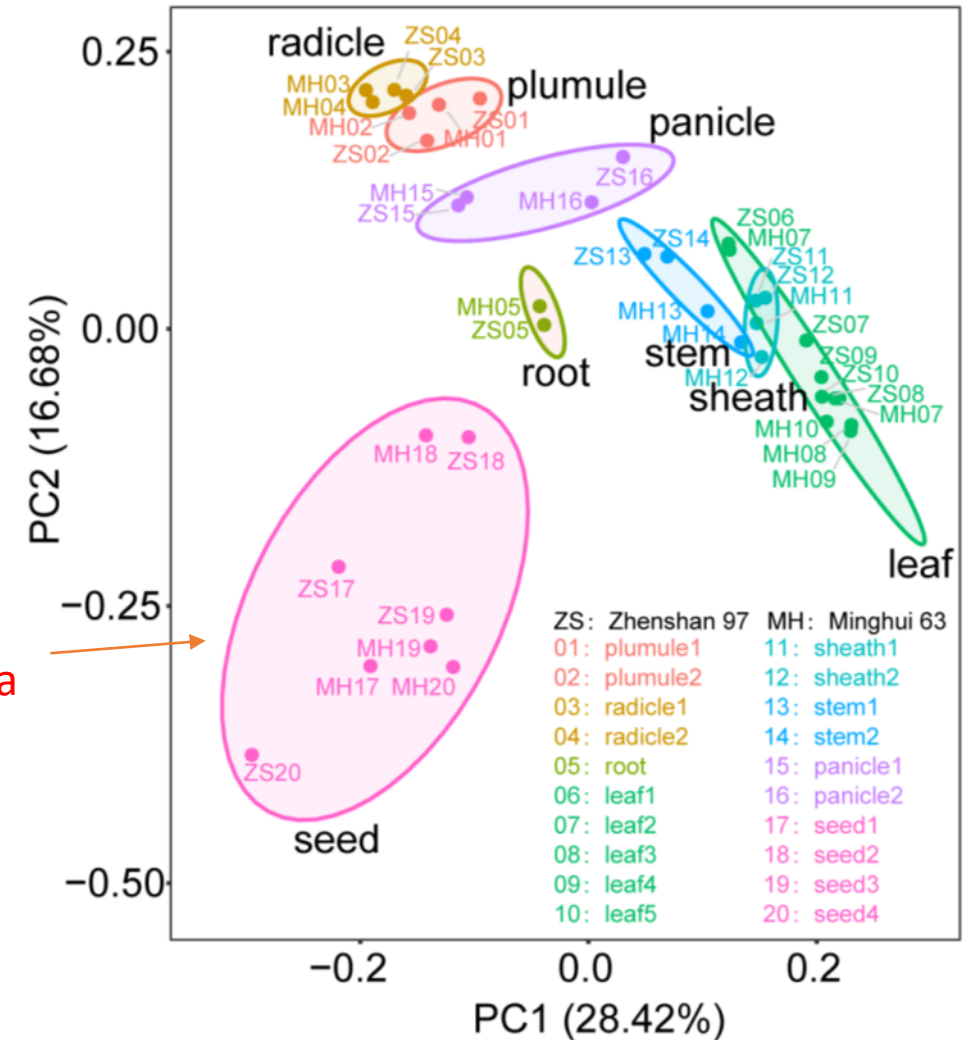
Major source of proteins, oils, starch, fibers, vitamins or minerals
 Around 70 % of calories consumed by humans derive from seeds

Arabidopsis thaliana

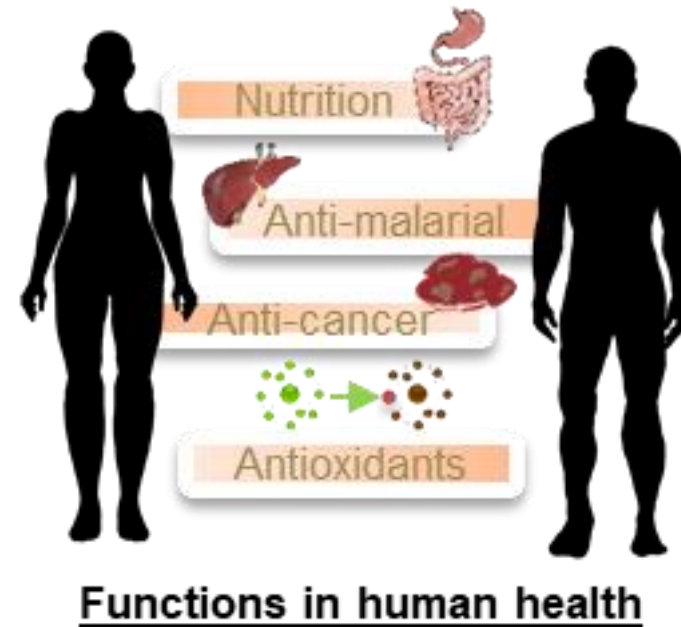
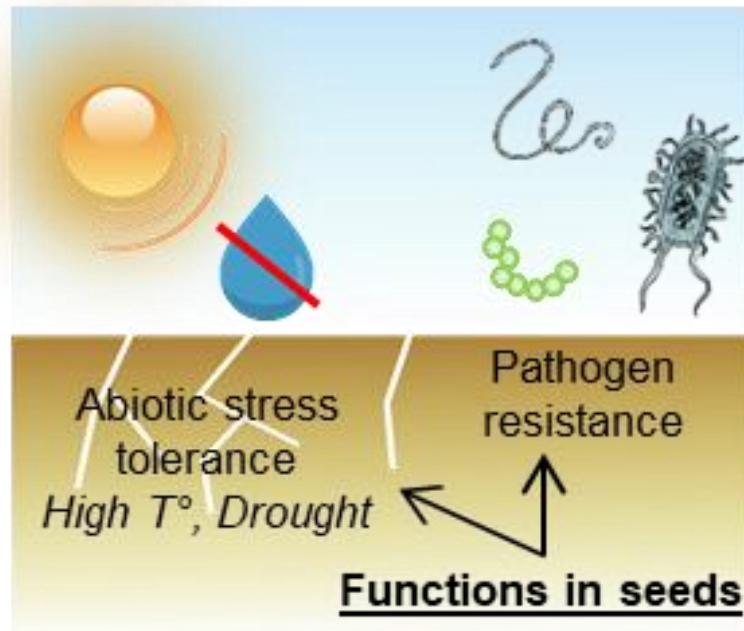
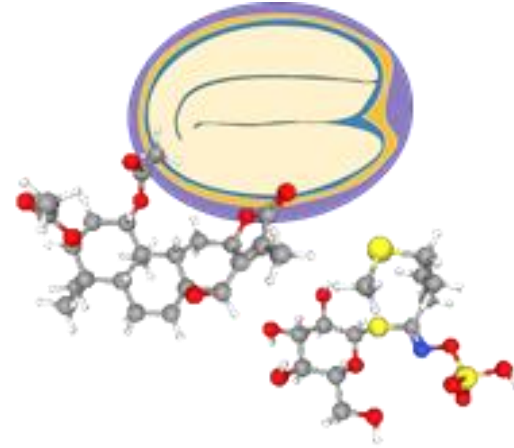


Seeds showed a specific specialized metabolome

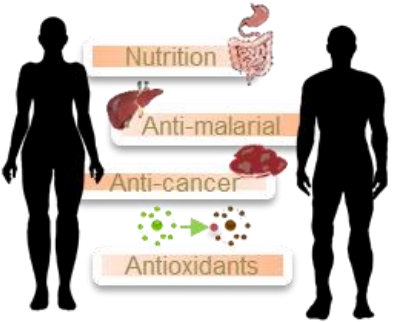
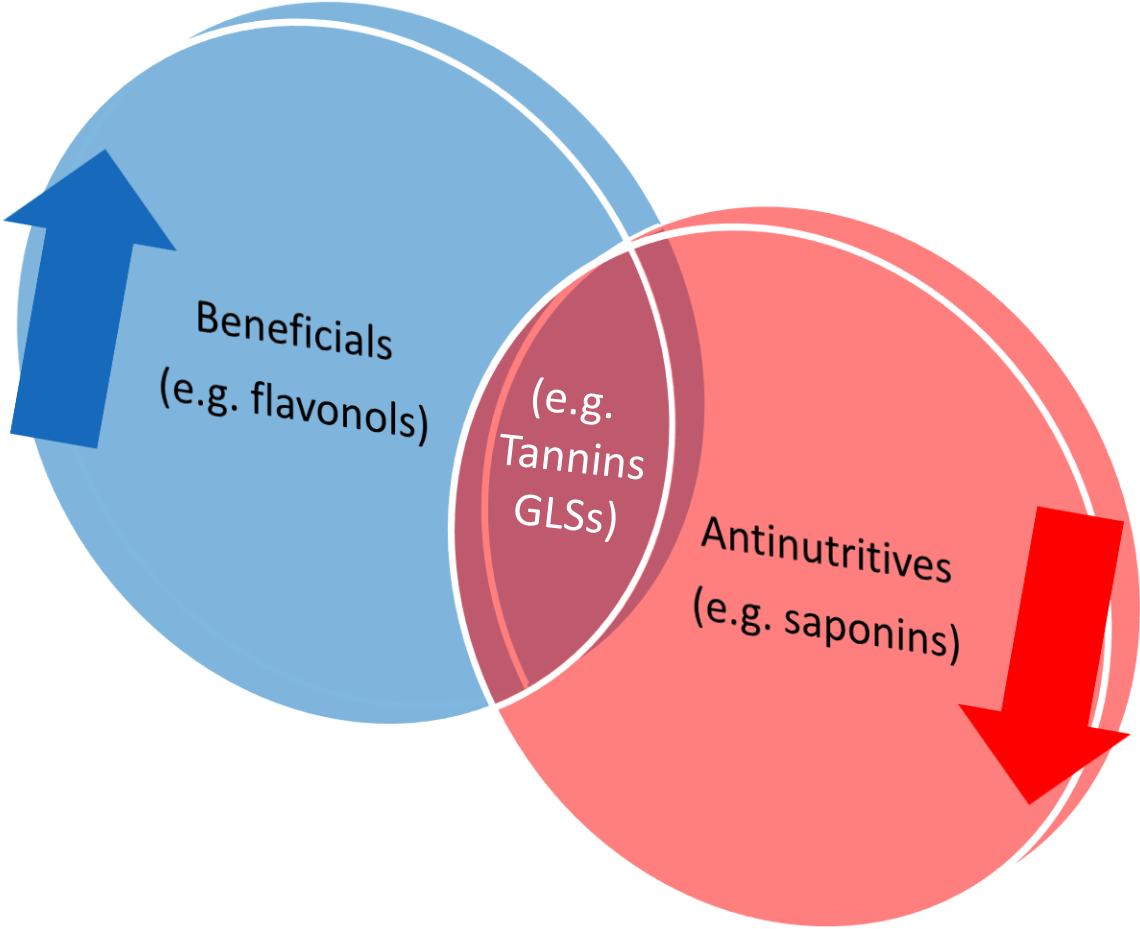
Oryza sativa



Seed Metabolites role and valorisation



It is important to have a good balance between beneficial and antinutritive specialized metabolites in seeds



Functions in human health

“C’est l’alimentation qui contribue à nous maintenir en bonne santé, pas la médecine, qui permet de soigner les maladies ”



Tansley review

Medicine is not health care, food is health care:
plant metabolic engineering, diet and human
health

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New Phytologist (2017) 216: 699–719
doi: 10.1111/nph.14730

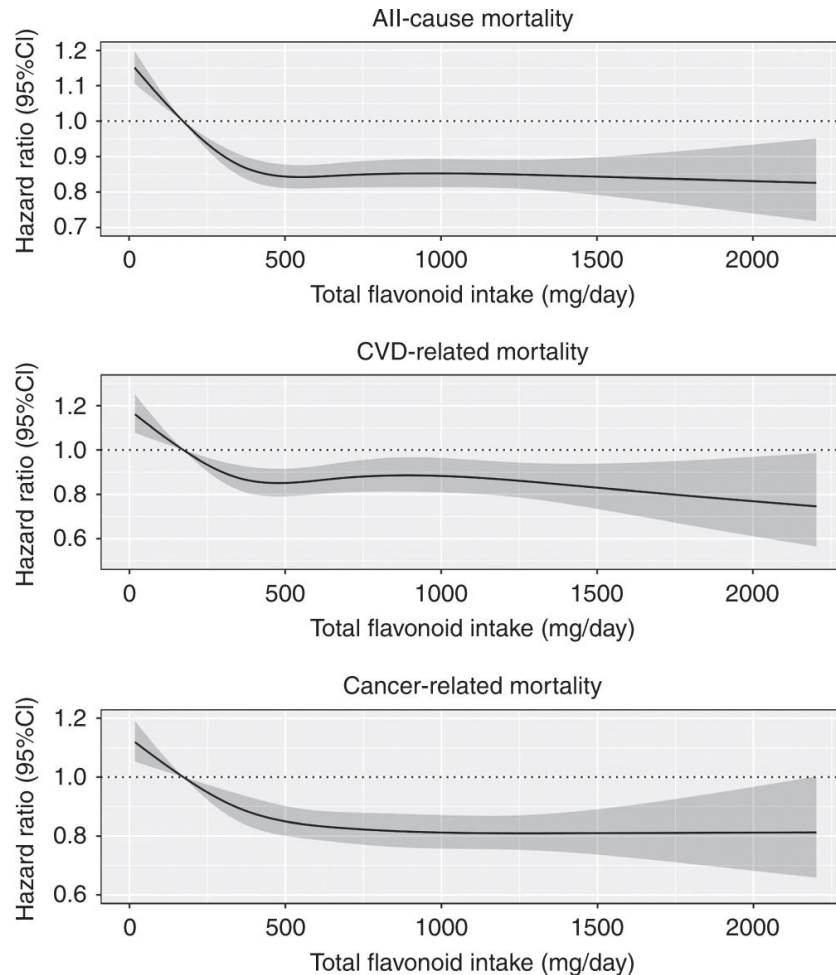
Cathie Martin and Jie Li

Department of Metabolic Biology, John Innes Centre, Norwich Research Park, Norwich, NR4 7UH, UK

There is an uncredited slogan on the internet stating: **‘Medicine is not health care, food is health care. Medicine is sick care’** which carries with it an important philosophical message reflecting how our ideas on protecting our health have increasingly emphasised medical solutions

Flavonoid function in human health

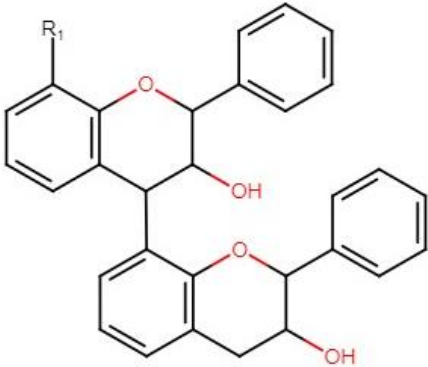
- 56 048 Danish were followed for 23 years (*Danish Diet Cancer and Health Cohort*)
- Information on dietary habits and diseases were collected for each person



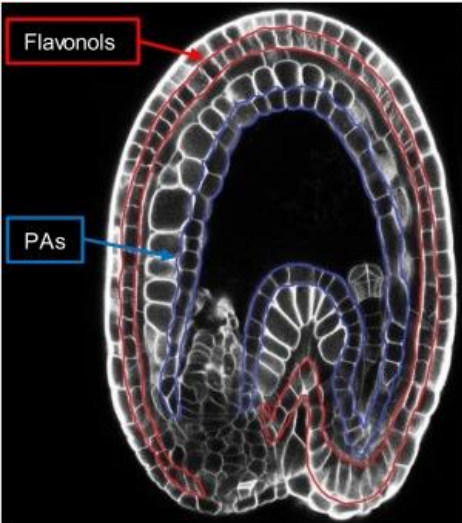
A moderate (>500 mg/day) habitual intake of flavonoids is associated with lower all-cause mortality, including cardiovascular- and cancer-related mortality.

The **Cox proportional-hazards model** (Cox, 1972) is essentially a regression model commonly used statistical in medical research for investigating the association between the survival time of patients and one or more predictor variables.

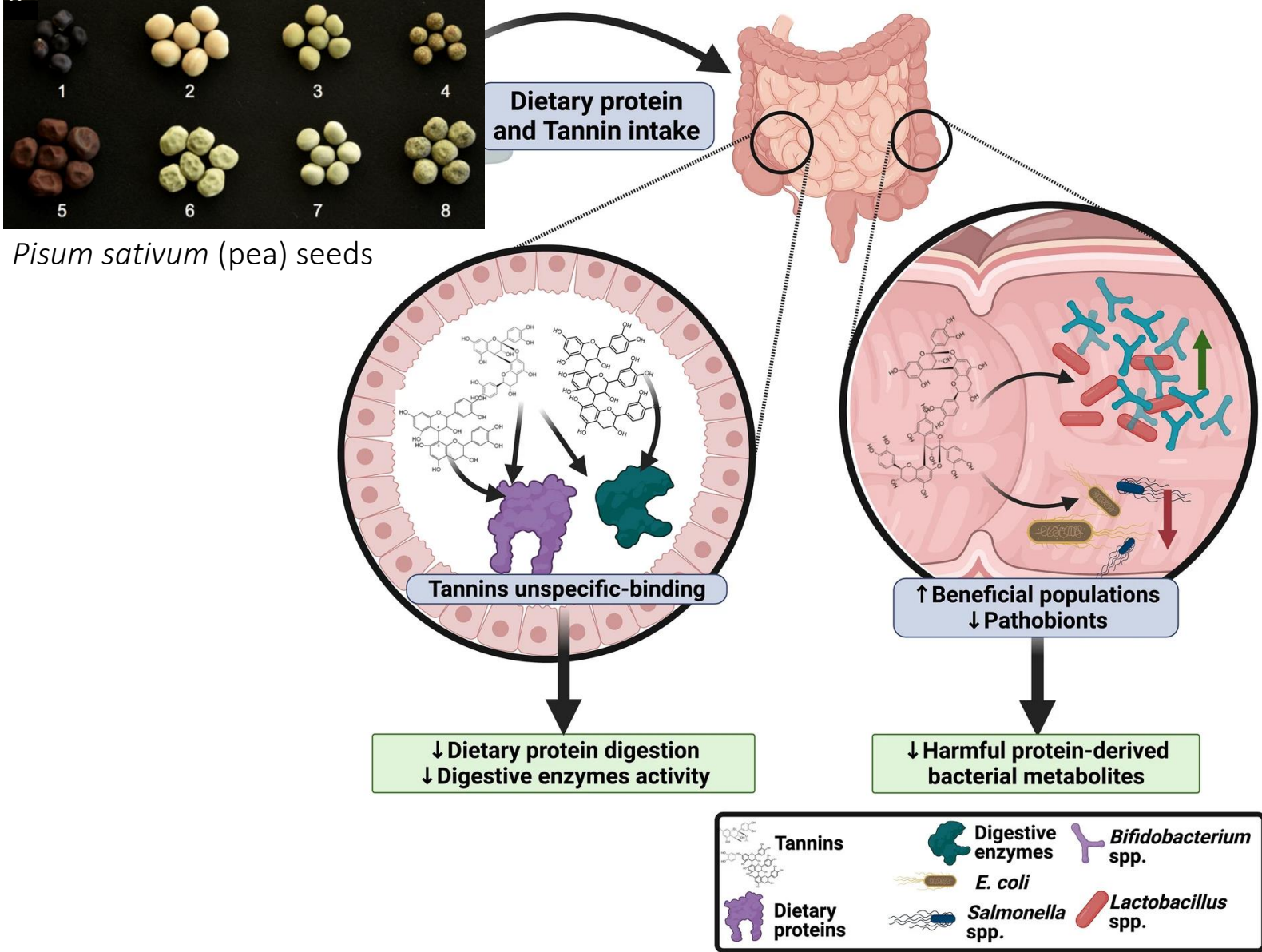
Tannins functions in human health



Proanthocyanidins PAs
(Condensed tannins)

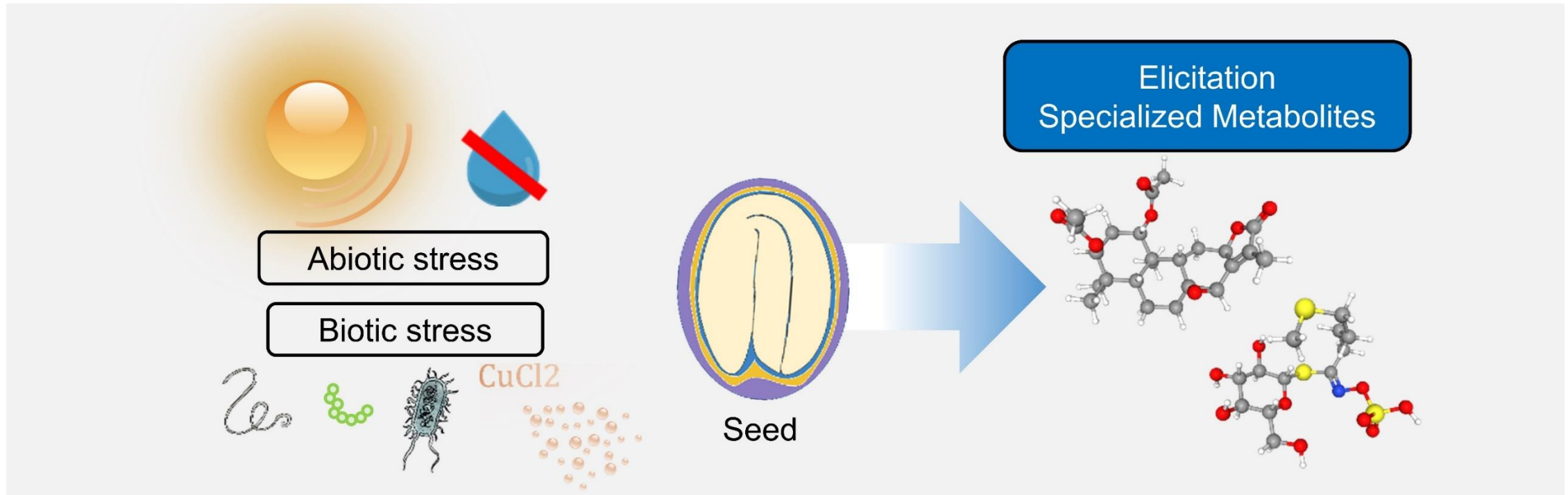


Corso et al., 2020 Plant Science 296:110471



Modified from: Gasaly and Gotteland, 2022. Amino Acids 54(3):311-324. doi: 10.1007/s00726-021-03034-3

Specialized Metabolites Plasticity and functions in seeds



Can the environmental stresses shape the seed specialized metabolome ?

Do specialized metabolome play a role in seed resistance to stresses?

1

Untargeted metabolomic analyses reveal the diversity and plasticity of the specialized metabolome in seeds of different *Camelina sativa* genotypes



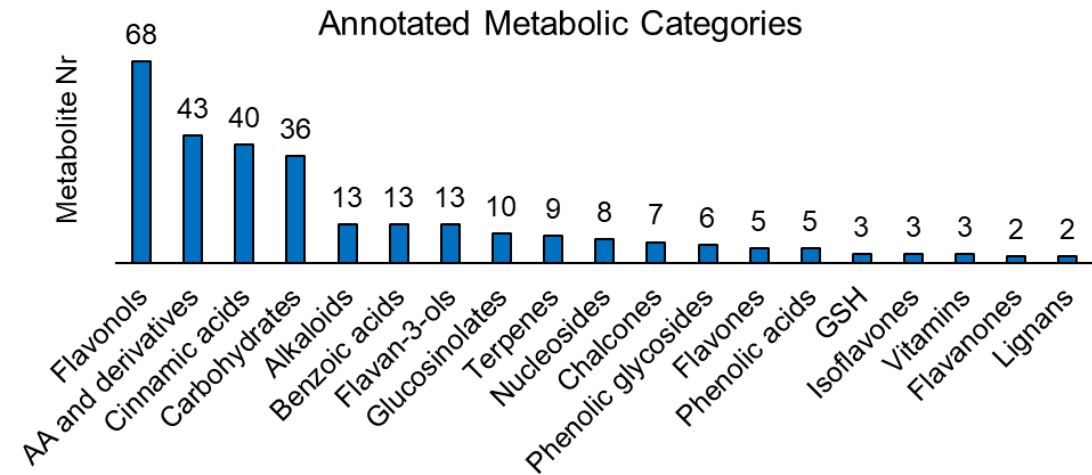
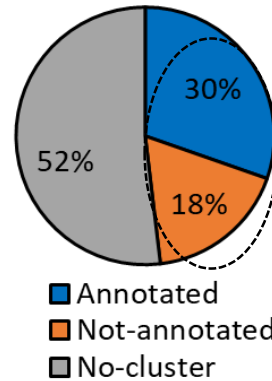
Brassicaceae
High omega-3



Camelina sativa

- 6 genotypes
- 5 years of culture

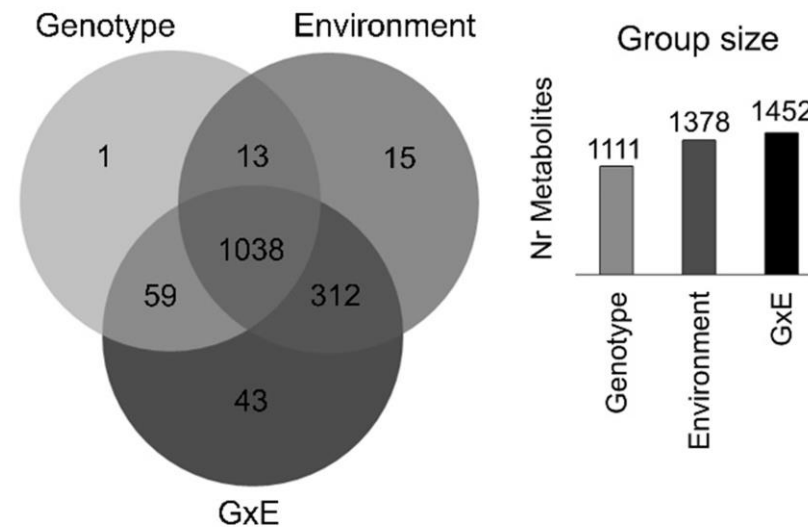
Molecular network cluster annotation



LC-MS/MS QTOF
untargeted
metabolomics

1. Boutet, Barreda, et al., 2022. The Plant Journal 110: 147–165.
2. Alberghini et al., 2022. Industrial Crops & Products 182:114944

(a) Differentially accumulated Metabolic features (DAMf)



The environment have a strong impact on seed specialized metabolites diversity

Seed specialized metabolites, oil and proteins plasticity

1

Phenotypic plasticity : Ability of a genotype to adapt to environmental changes by regulating one or more phenotypic traits

Boutet* & Barreda* et al., *The Plant Journal* 110(1):147-165 (2022)

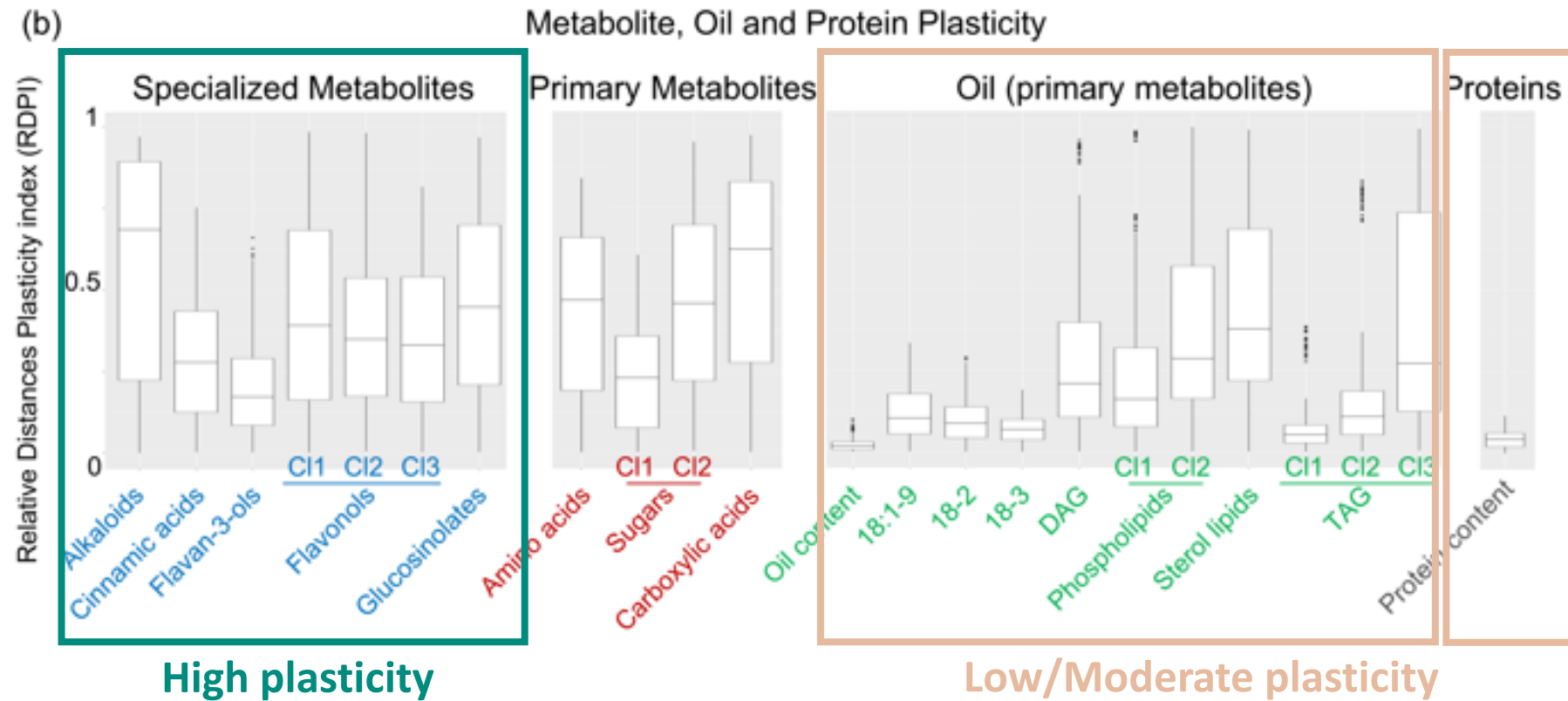
→ Untargeted metabolomics
(LC-MS/MS QTOF)

→ Untargeted lipidomics
(LC-MS/MS QTOF)

→ GC-MS

RDPI = 1 → highly plastic category

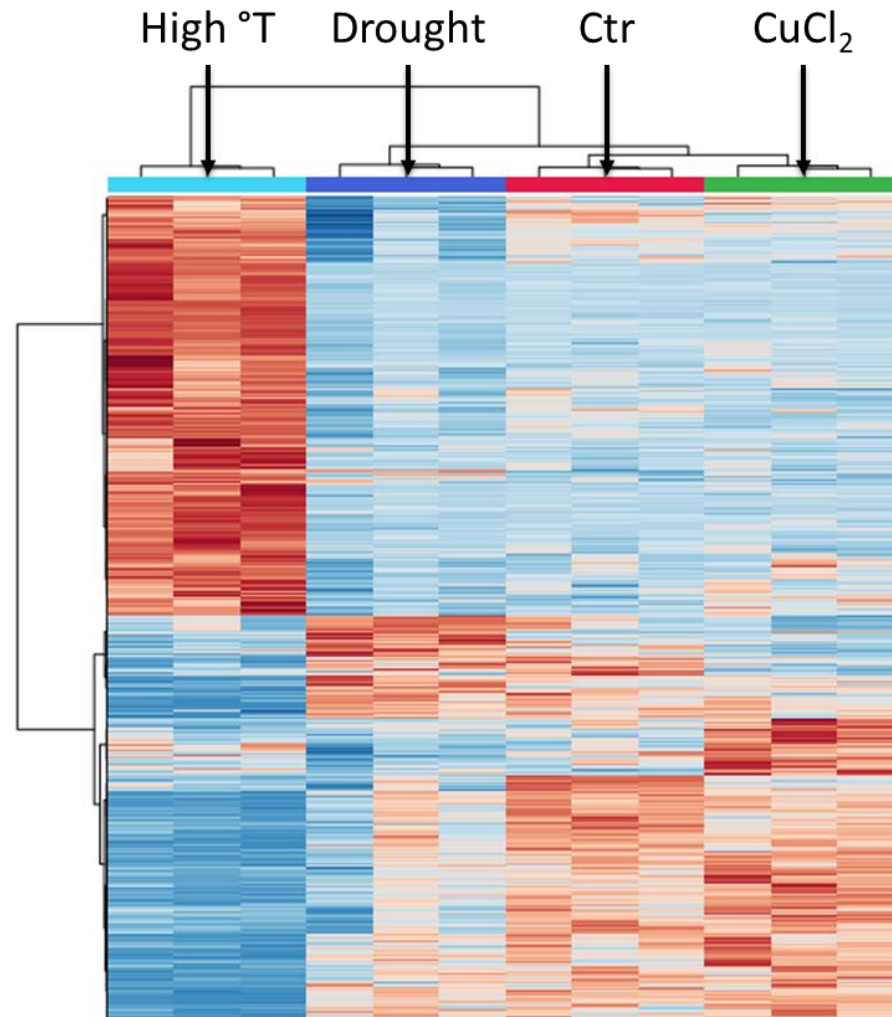
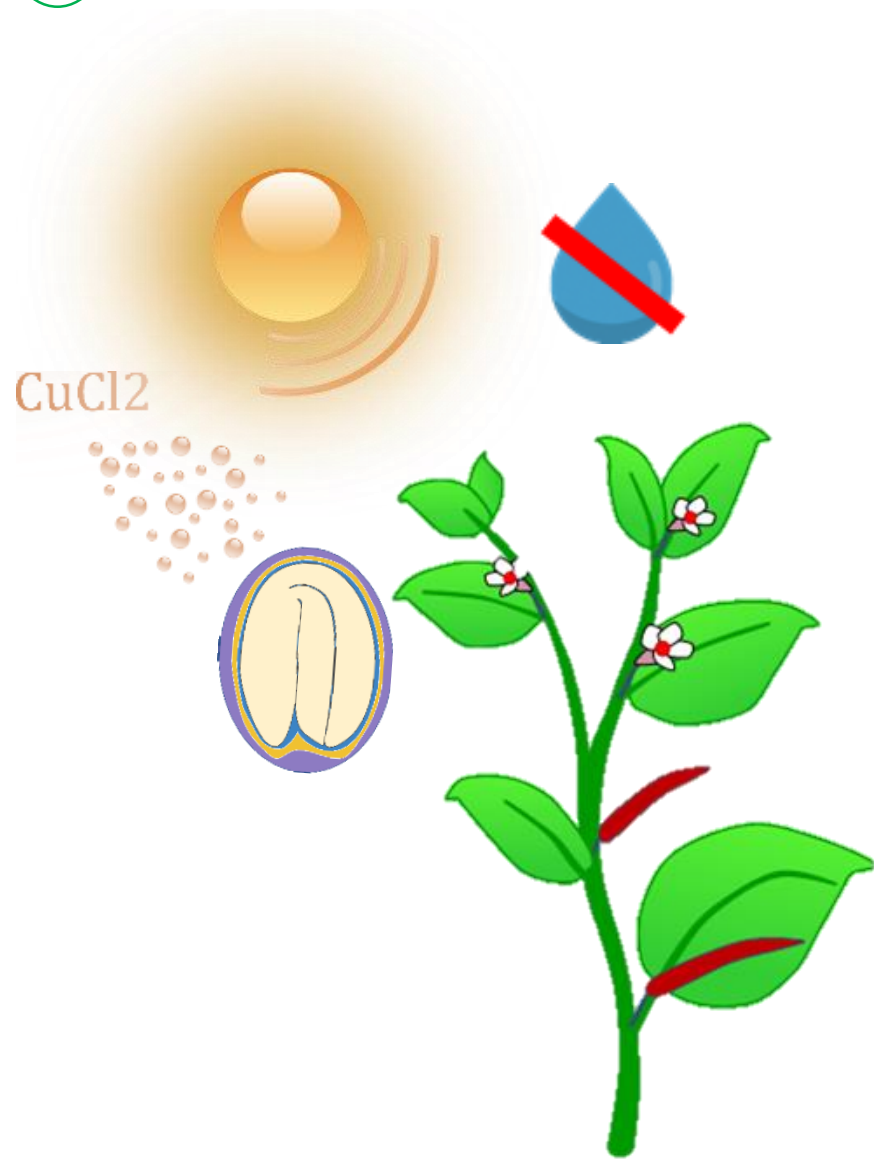
RDPI = 0 → no plastic category



Specialized metabolites are more impacted by the environment (i.e. have higher plasticity) than most seed reserve compounds

2

Seed specialized metabolome is regulated by abiotic stresses

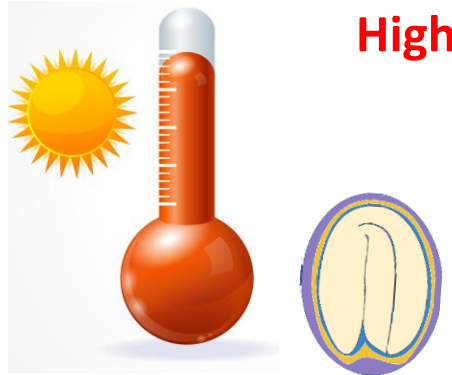


Major effect of high temperature stress on the accumulation of specialized metabolites in seeds

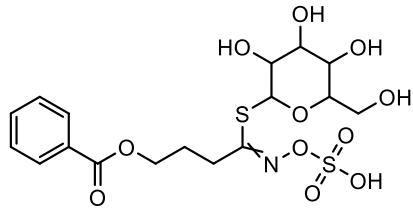
2

High and low temperatures increases the accumulation of glucosinolates and flavonoids in seeds

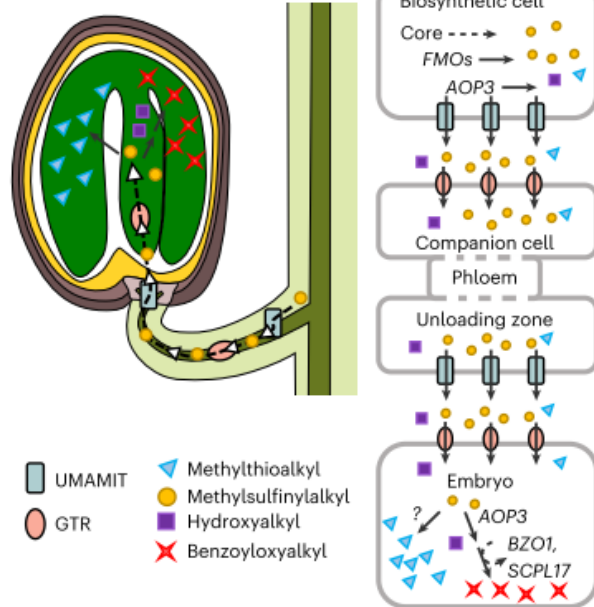
High temperature



Glucosinolates



Barreda et al., unpublished



Sanden et al. Nature Plant, 1-8 (2024)

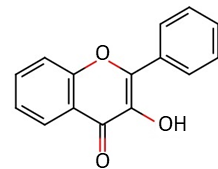
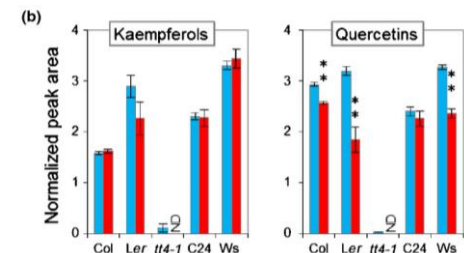
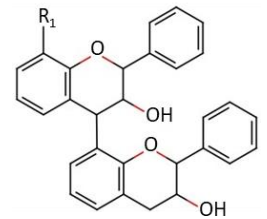
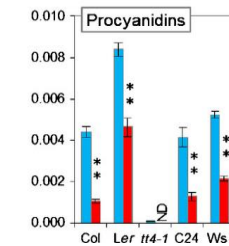
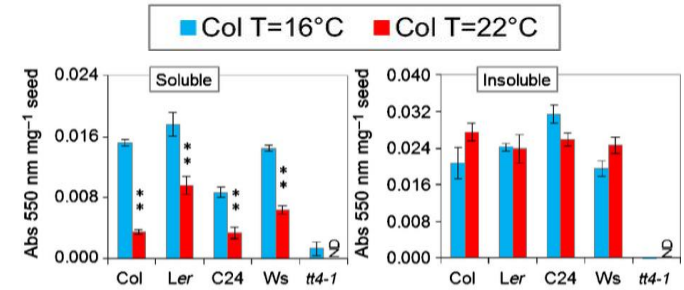
Low temperature



Flavonoids



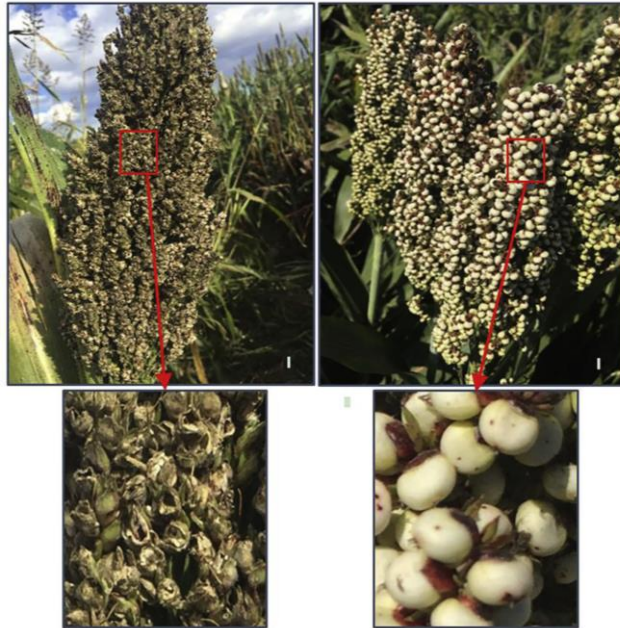
Macgregor et al., 2015.
New Phyt 205(2):642-652



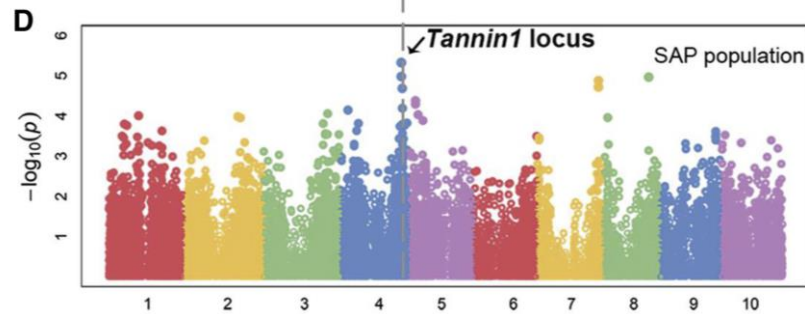
Flavonoids accumulation reduce seed bird feeding

bird-preference

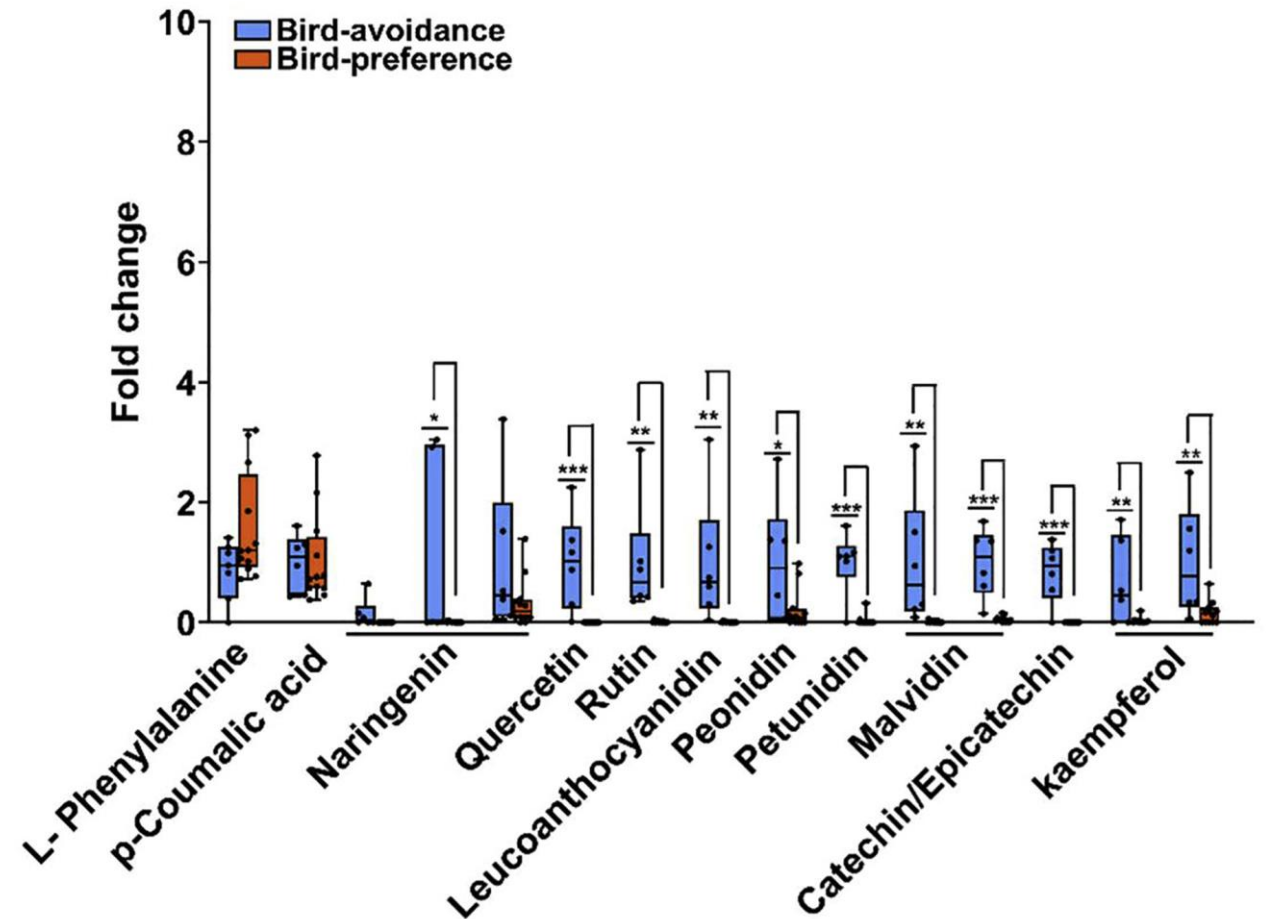
bird-avoidance



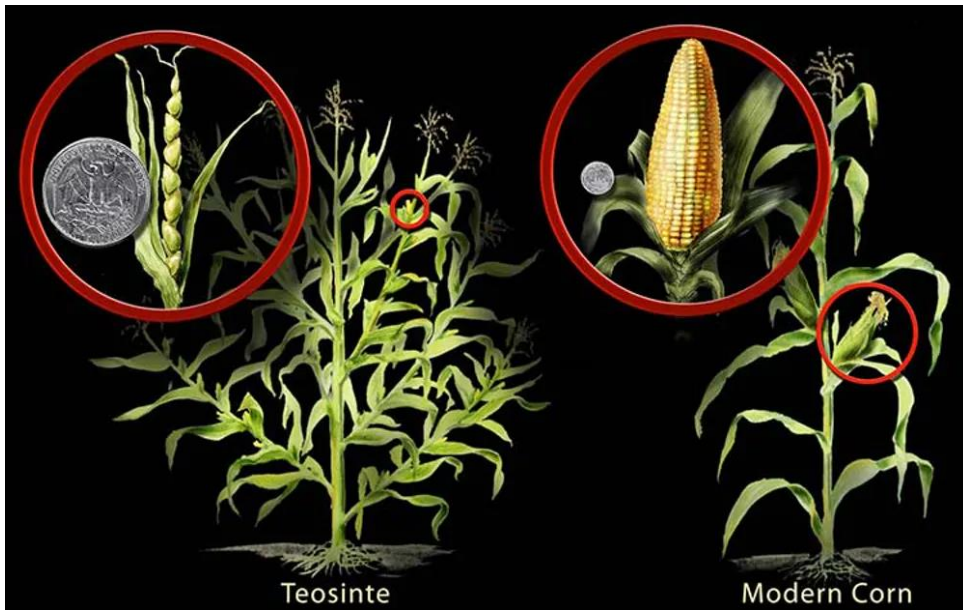
Sorghum



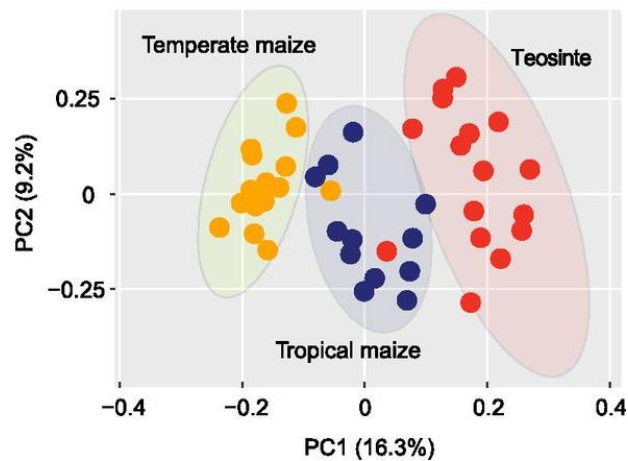
Condensed tannin content in the SAP population. Arrows indicate the SNPs most strongly associated with bird feeding behavior and condensed tannin content.



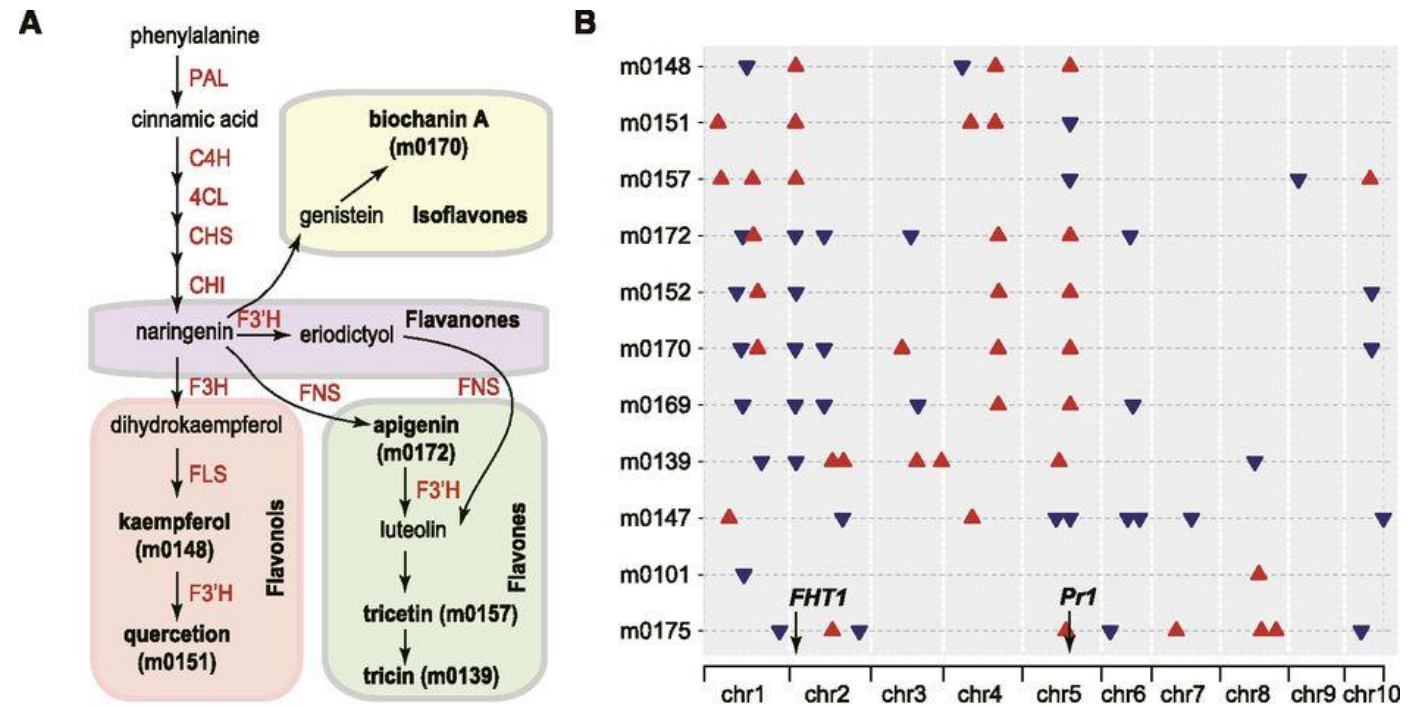
Impact of domestication on specialized metabolites in maize kernels



Nicolle Rager Fuller, National Science Foundation



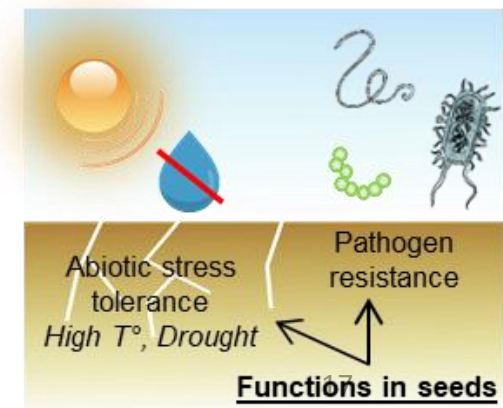
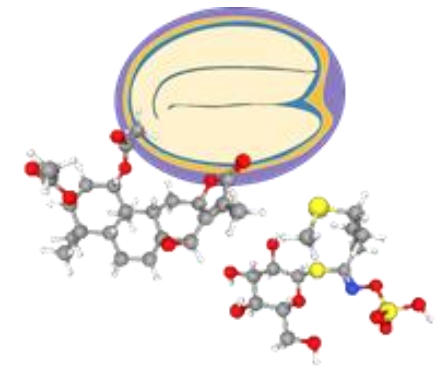
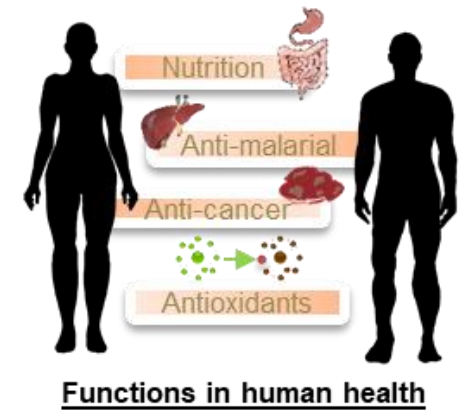
Metabolome
Divergence
between Maize and
Teosinte



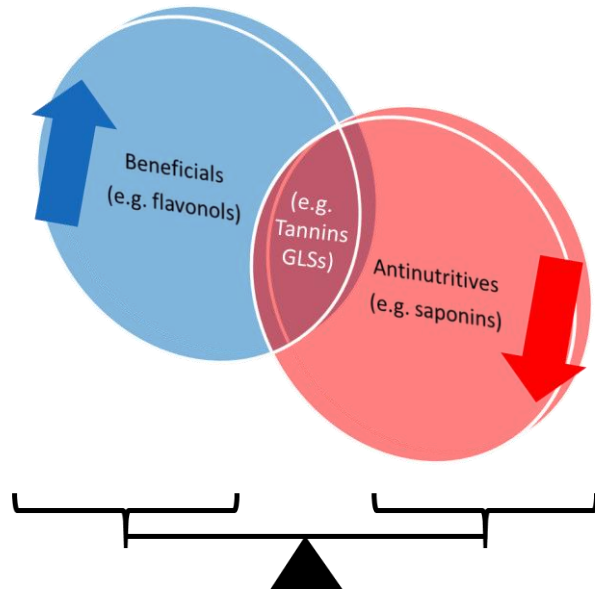
Pr1 Contributed to the Metabolic
Divergence in the Flavonoid Pathway
F3'H (PR1), flavanone 3'-hydroxylase

Conclusions and take-home messages

- Seed are characterized by large specialized metabolites diversity
- Specialized metabolites impact human health as antinutritional and/or beneficial (examples of flavonoids and glucosinolates)
- Seed specialized metabolites are strongly modulated by the environmental conditions (i.e. are highly plastic compounds)
- Seed glucosinolates and flavonoids are modulated by temperature (warm and/or cold)
- Flavonoids accumulation reduce seed bird feeding
- Domestication had a strong impact on seed specialized metabolite composition



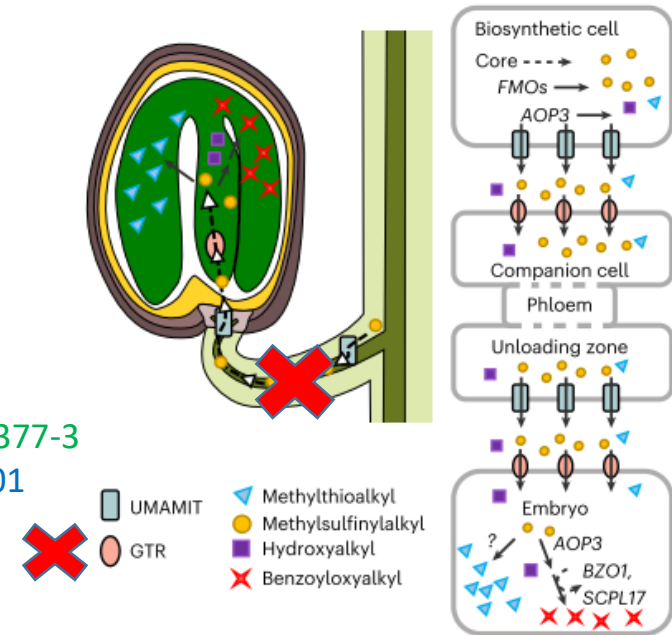
Find a good balance between stress-related / antinutritional and beneficial compounds: the example of glucosinolates



A

Biotechnology
Mutants for *GTR1* and *2*
genes accumulated
reduced amount of
glucosinolates in the
seeds

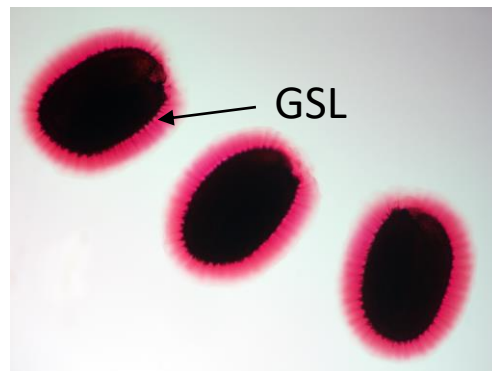
Rapeseed: Nour-Eldin et al. 2017 *Nature Biotech* 35:377-3
Camelina: Hölzl et al., 2023 *Plant Biotech J* 21:189-201



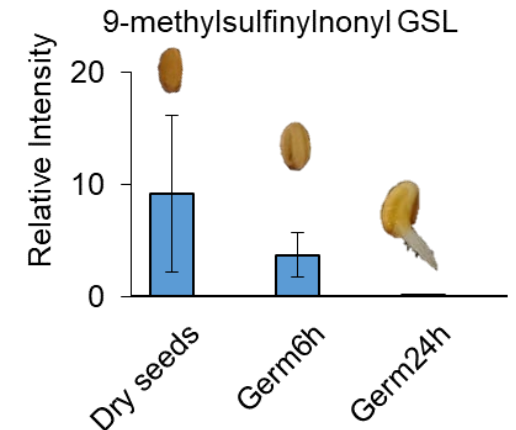
B

Reduction of Glucosinolates (GSL) content after seed harvest in Camelina seeds *M. Corso (unpublished)*

Extraction / fractionation
Glucosinolates
accumulated in the seed
coat and in the mucilage



Seed physiology
Glucosinolates are
degraded during
germination





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Bertrand DUBREUCQ (embryogenesis)

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