

Mitigating berry cracking through modulation of berry skin elasticity

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Background

Methods

CONTENT

Results

Conclusion

A scenic view of a vineyard. In the foreground, rows of grapevines with green leaves stretch across the frame. The ground is covered with green grass and some fallen leaves. In the background, a valley is filled with a dense forest of trees, some of which are showing autumn colors. The overall atmosphere is peaceful and natural.

Background

Grape berry cracking



“Fruit cracking is a physical failure of the fruit peel that manifests as fractures in the peel or cuticle of certain fruits”

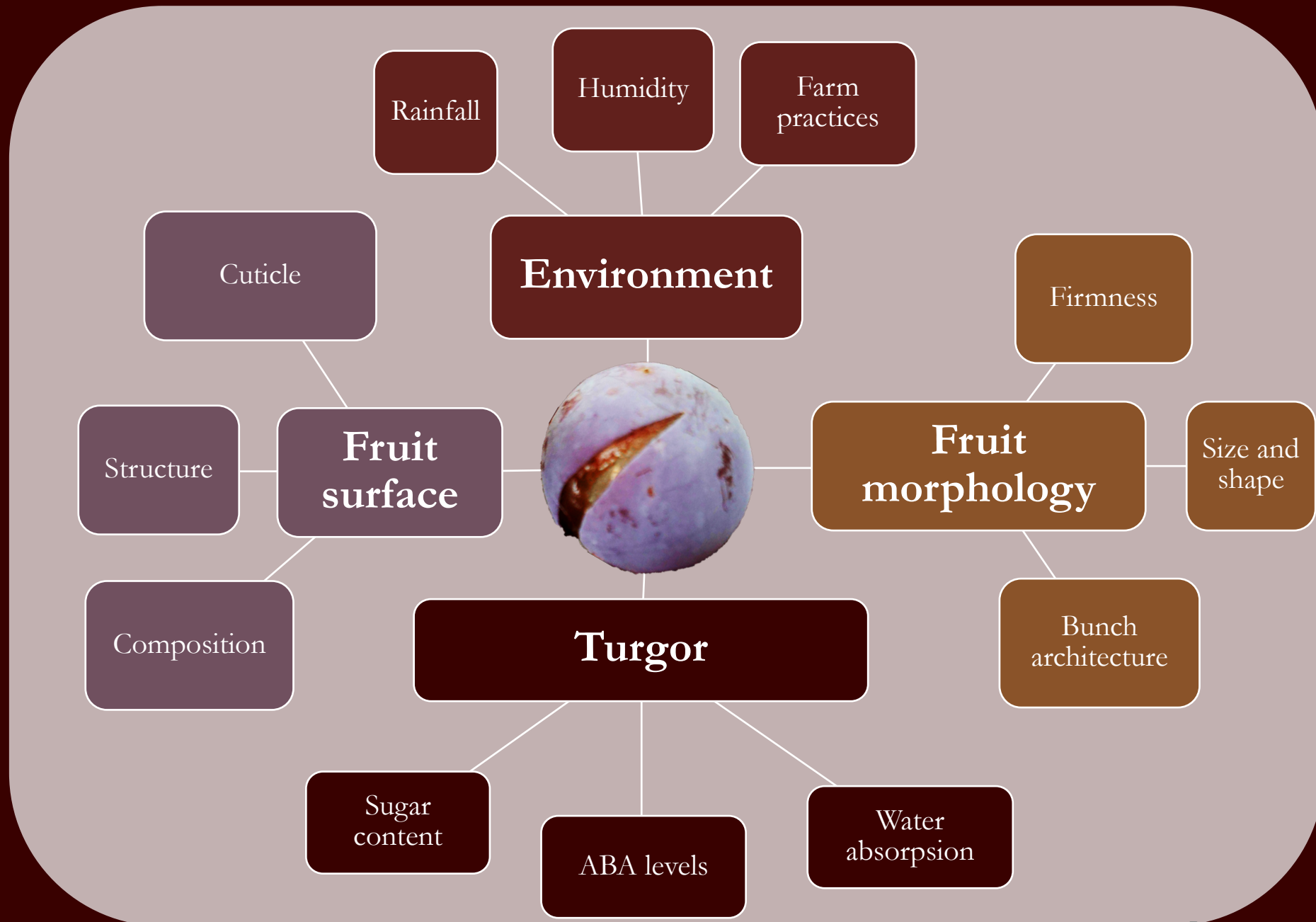


- Increased fungal infections
- Reduces shelf life
- Poor appearance

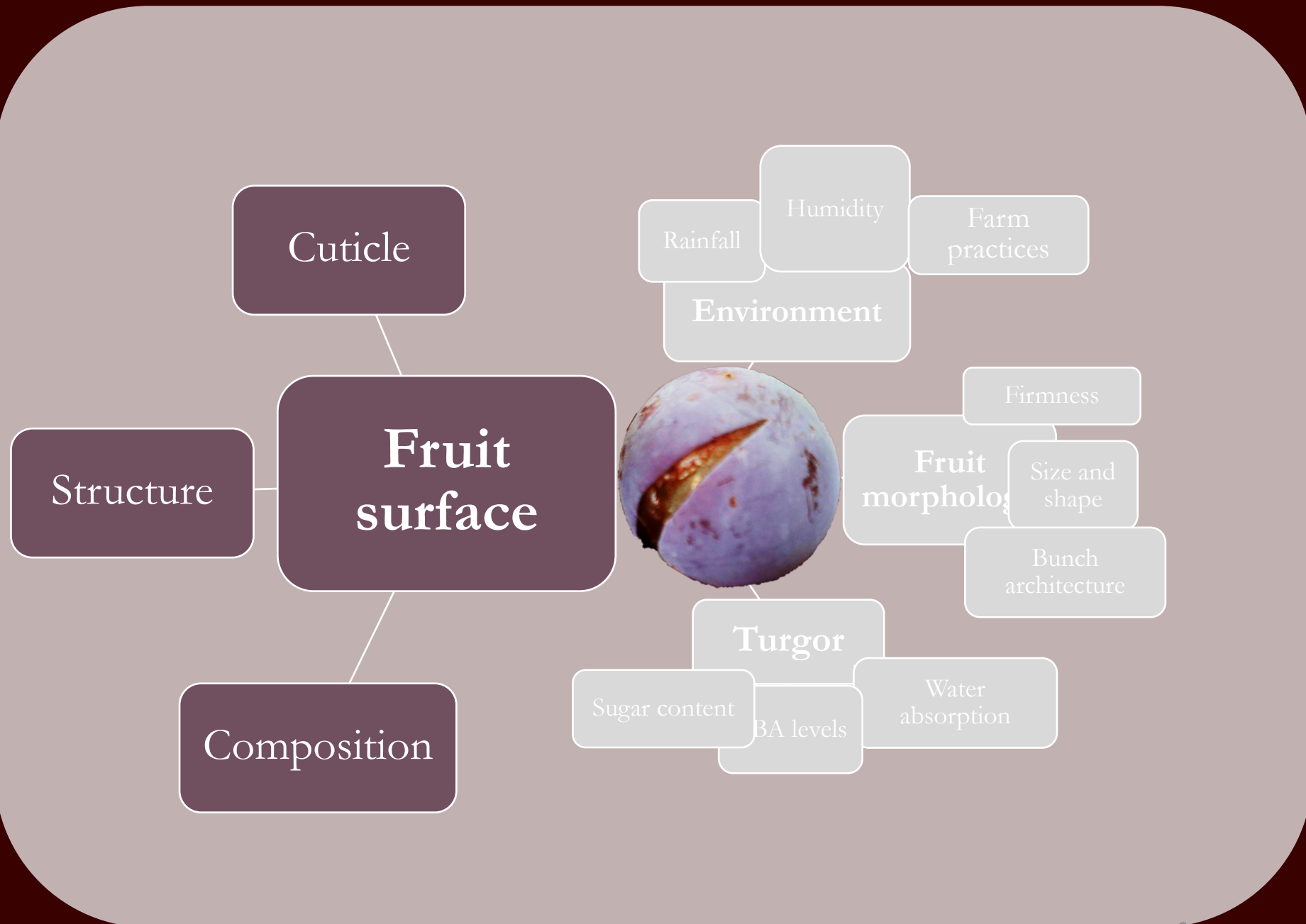


Reduced marketability leading to loss of income

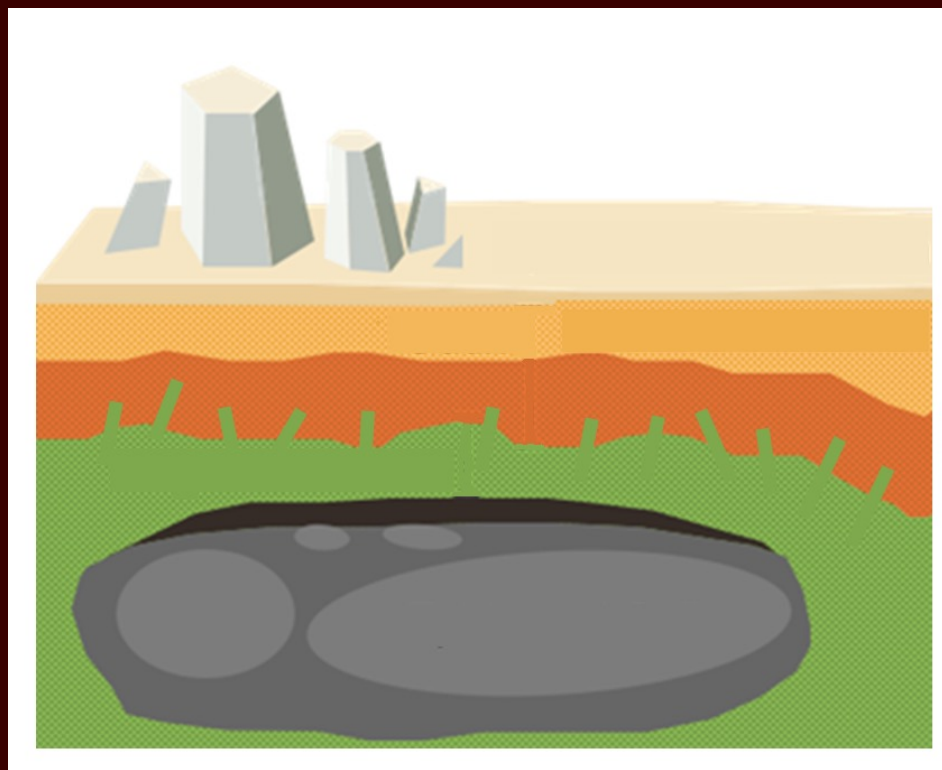
What causes fruit cracking?



What causes fruit cracking?



The structure and role of the fruit surface

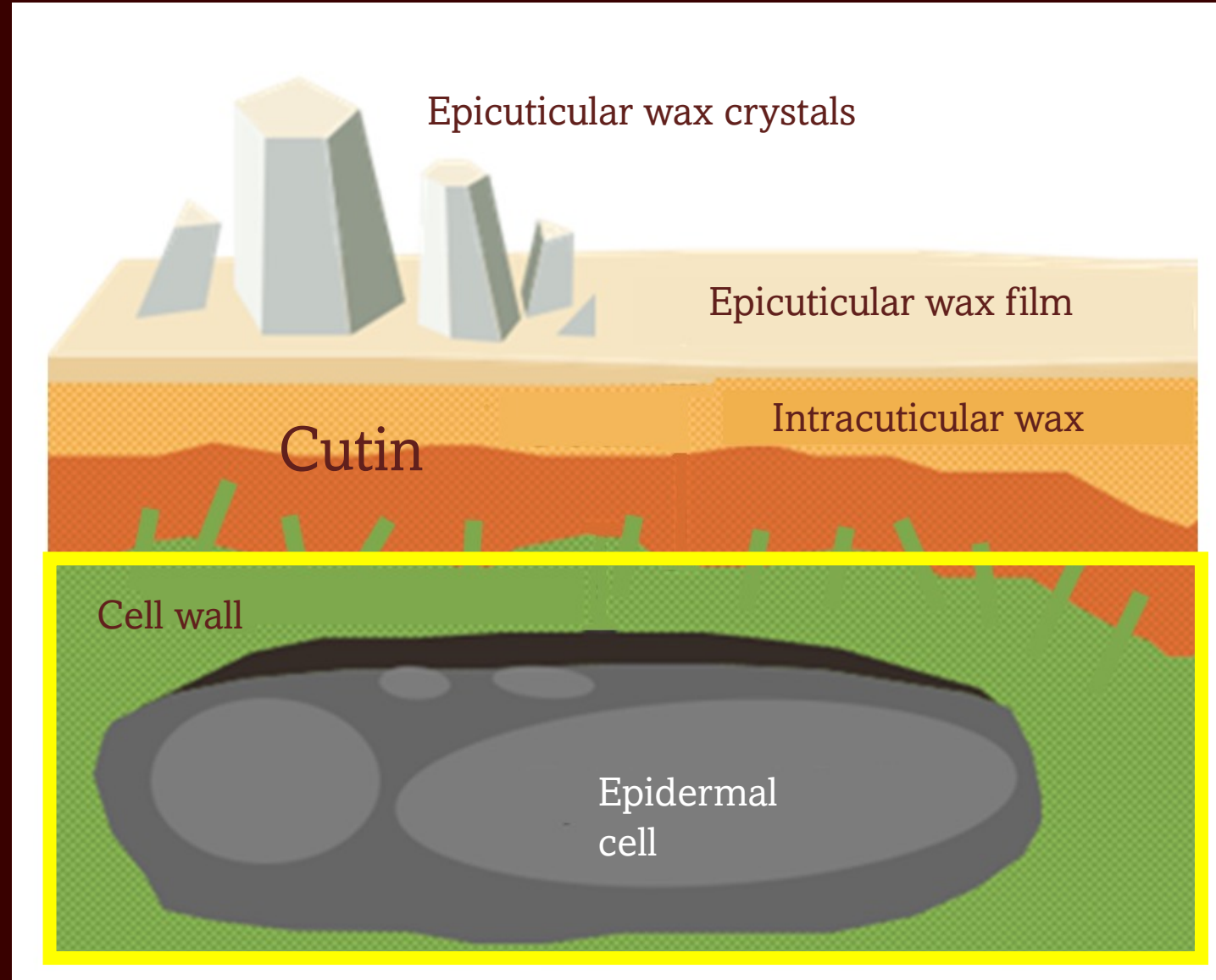


Cuticle

Epidermal cell layers

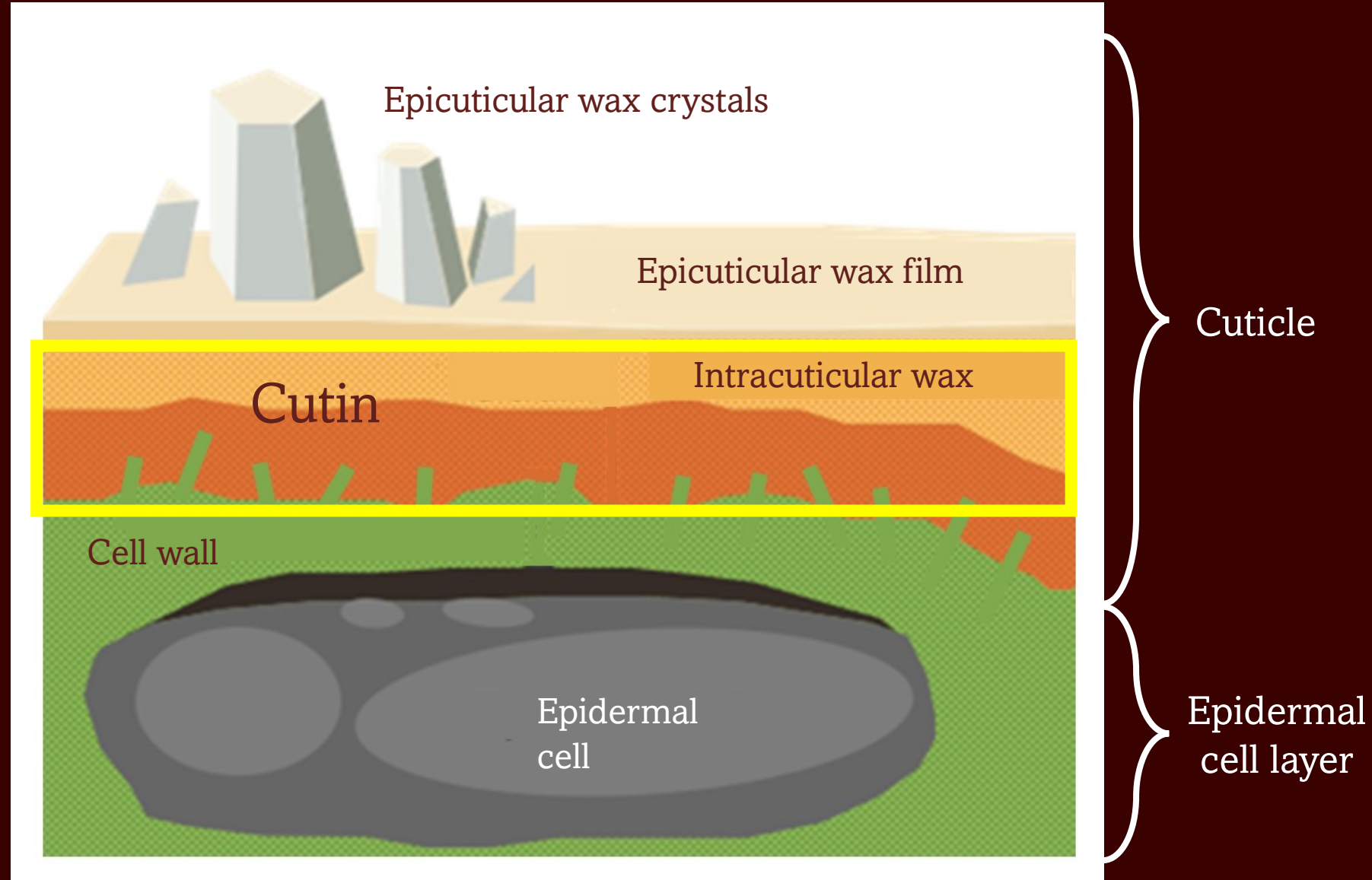
Epidermis

- Epidermal cells = skin
 - Increased cell division linked to cracking resistance
- Cell wall polysaccharides (shown in green)
 - Cellulose
 - Hemicellulose
 - Pectins
- Increased pectin content linked to cracking resistance



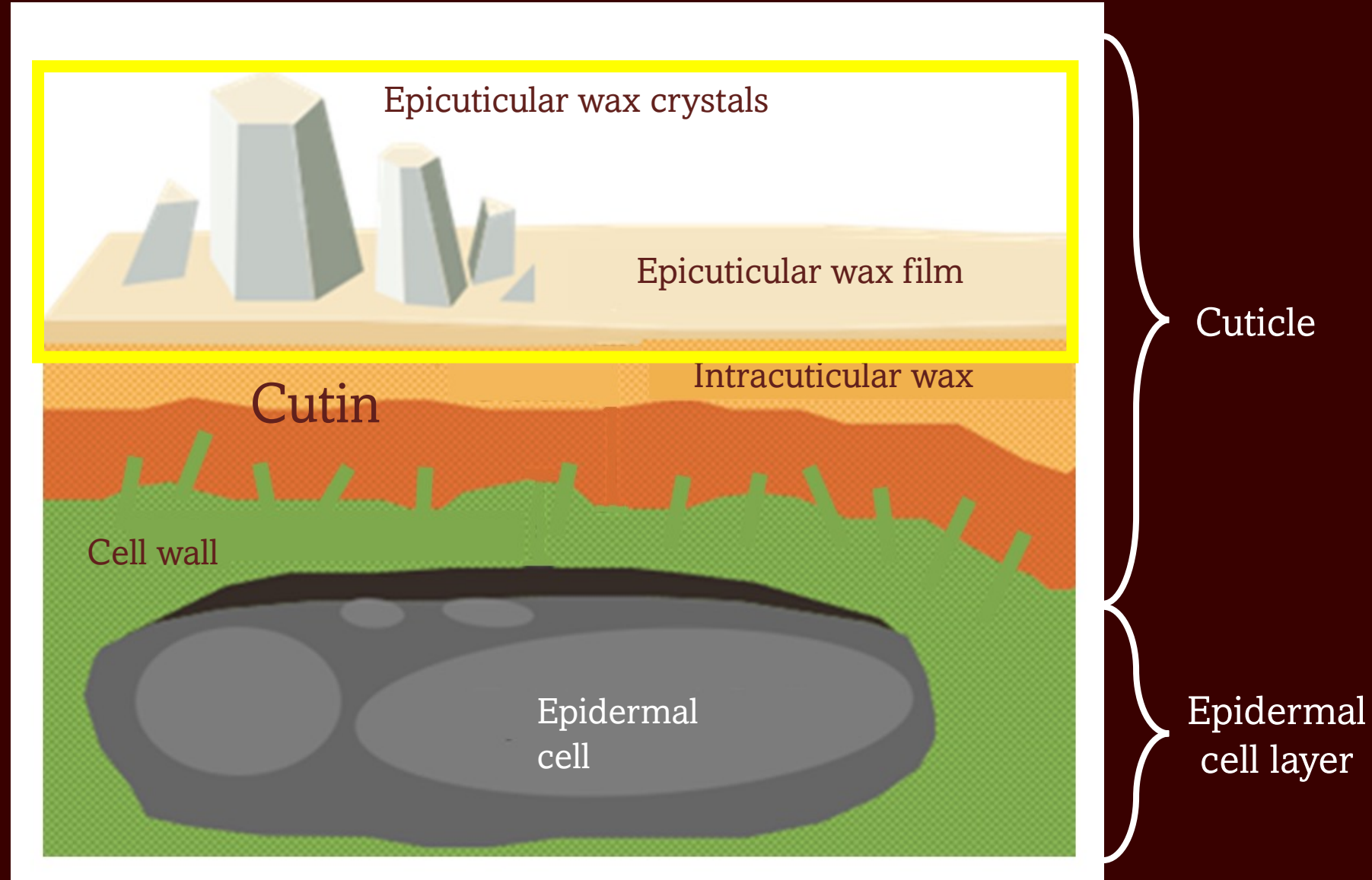
Cutin

- Polymer matrix
- C16 and C18 fatty acids + derivatives
- Cuticle thickness linked to cracking resistance



Wax

- Embedded in cutin
- Long chain fatty acids and derivatives
- Phenolics and triterpenoids





Project Aim

Investigate the influence of grape berry skin composition on berry skin elasticity and cracking susceptibility across diverse genotypes and after plant growth regulator application.



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A scenic view of a vineyard. In the foreground, rows of grapevines with green leaves and some yellowing foliage are visible. The vines are supported by wooden stakes. In the background, a valley is filled with a dense forest of trees, some of which are showing autumn colors. The overall scene is bright and natural.

Methods

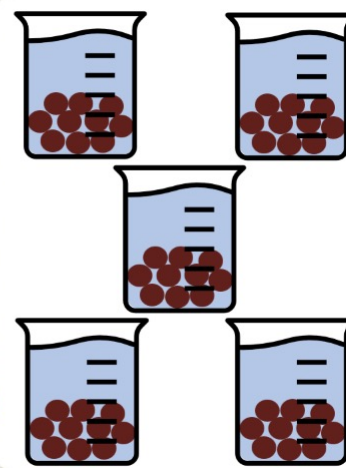
Ripeness

- Ten berries per cultivar
- Brix
 - 16-20 °Brix



Berry cracking score

- Ten berries per cultivar
- Submerged in dH₂O + 0,1% Tween
- 5 reps
- Score number of berries cracked after 24 hrs
- Measured mass at 0 hrs and 24 hrs

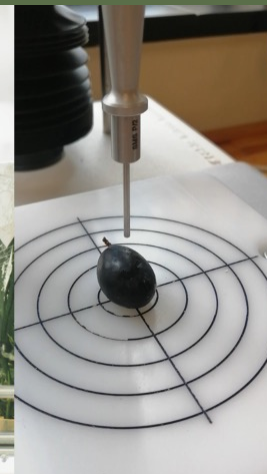


Cuticle composition

- Cuticle isolation (in-house method)
 - Enzyme digestion with cellulase and pectinase
- Cutin and wax analysis – GC-MS (Fernandez-Moreno *et al.*, 2016; Lashbrooke *et al.*, 2016)

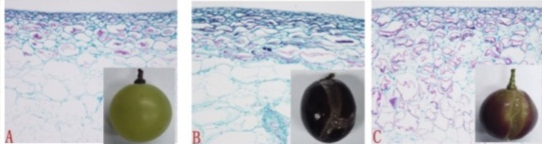
Compression measurements

- Used a food texture analyser
- Ten (10) berries
- Measure distance (mm) and force (N)
- Distance = skin elasticity
- Force = skin strength



Microscopy

- Light microscopy
 - Sudan IV, Toluidine blue
- Fluorescent microscopy
 - Calcofluor white, corophosphine O



Plant growth regulator treatment

- Five PGR treatments
 - Schalk Reynolds, PhilAgro
- Cracking resistant + Cracking susceptible cultivars
- Three reps per cultivar per treatment
- Two sprays
 - Veraison
 - Veraison + 1 week
- Sampled at harvest ripeness

ABA ProTone™ SG
GA3 ProGibb® 40%
Cytokinin MaxCel (6-Benzyl adenine; 6-BAP)
Cytokinin SITOFEX® 10EC (Forchlorfenuron; CPPU)
Control

Phenotypic analysis

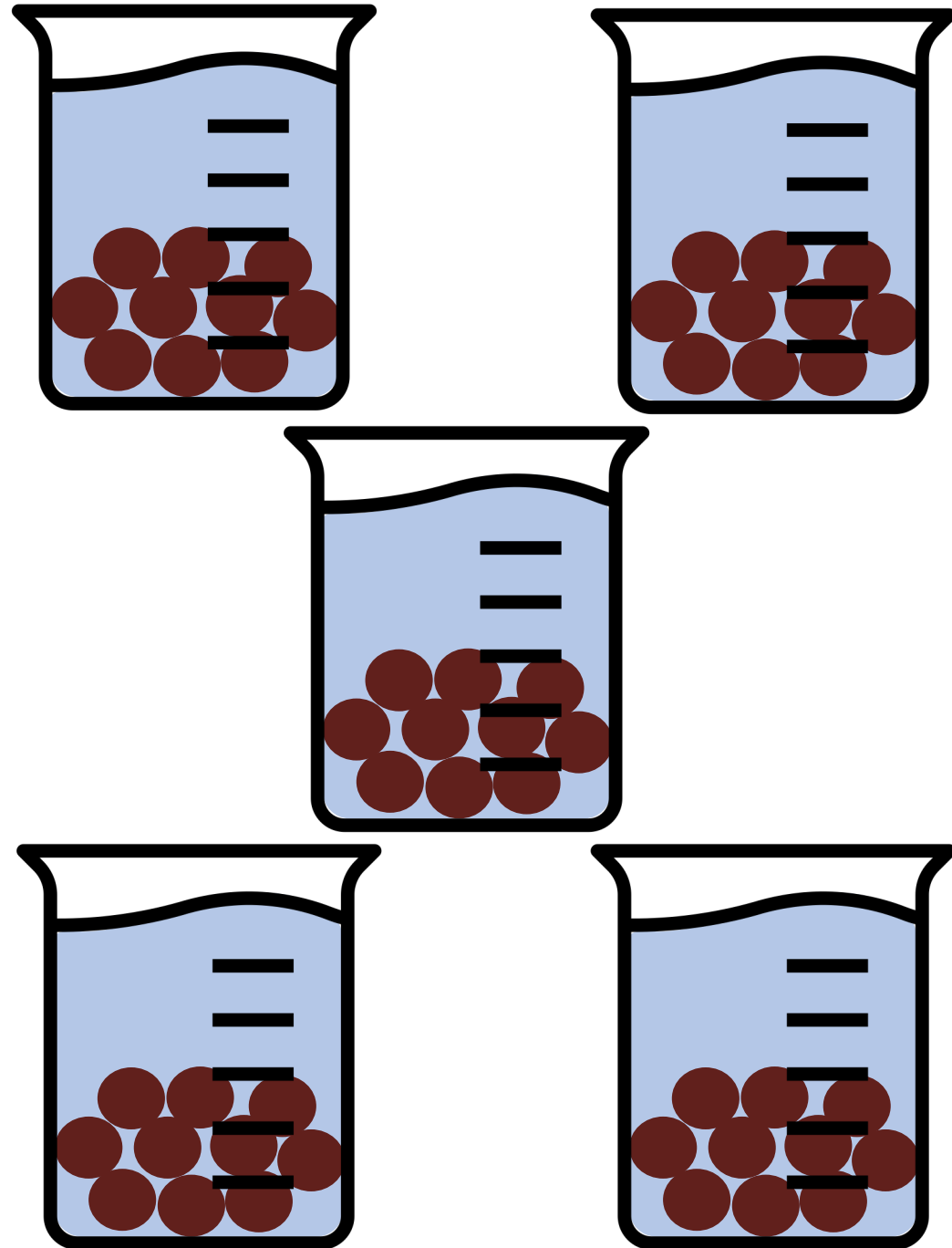
Ripeness

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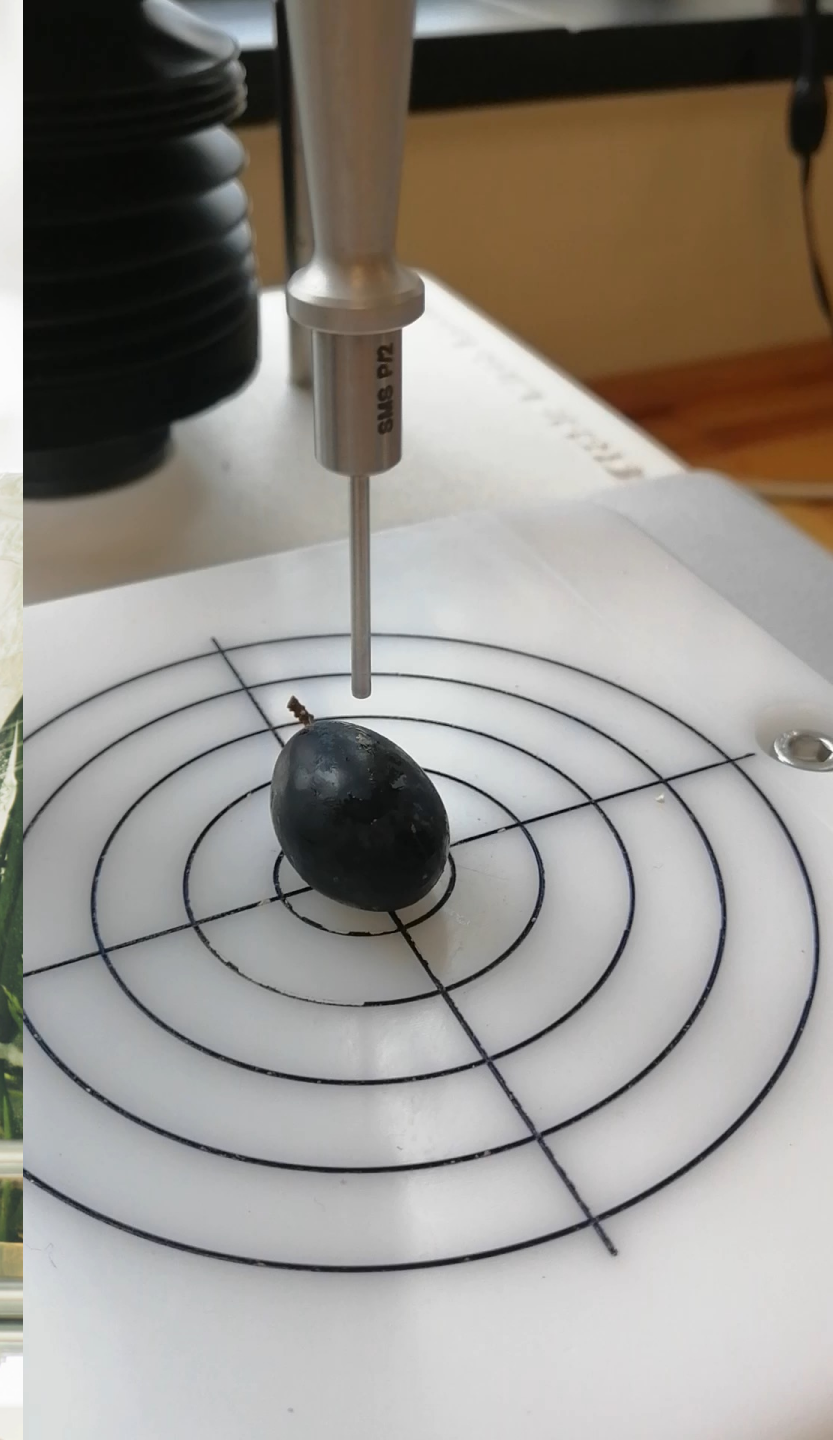
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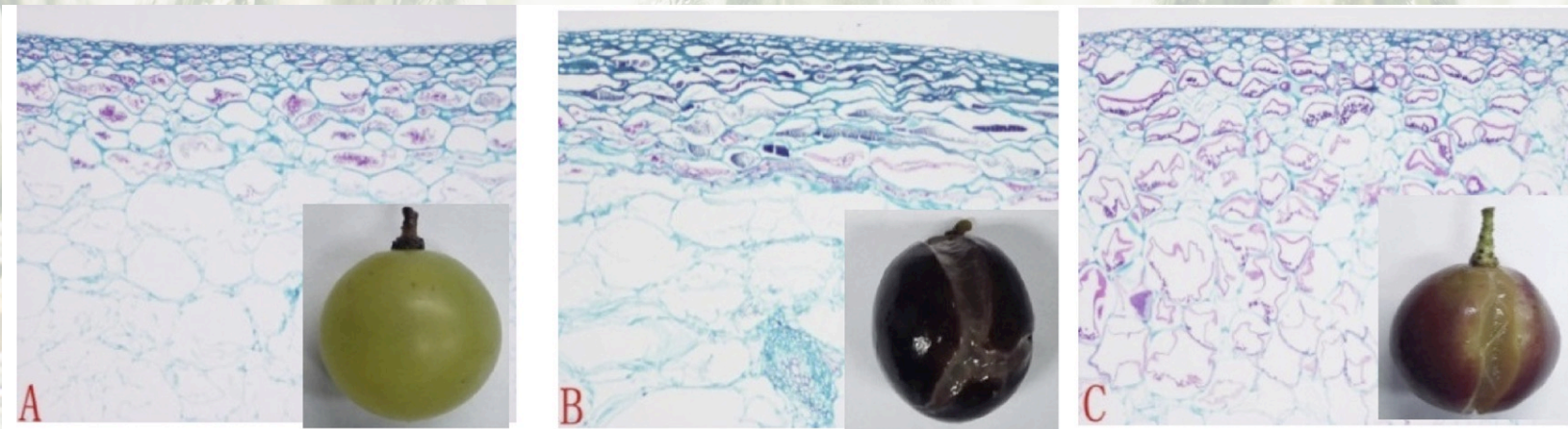


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ProTone™ SG

GA3
ProGibb® 40%

Cytokinin
MaxCel (6-Benzyl adenine; 6-BAP)

Cytokinin
SITOFEX® 10EC (Forchlorfenuron; CPPU)

Control



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Results

Overview

2022

**Pilot
study**

25 table grape
cultivars

2023

**PGR
treatment**

Three cultivars

2023

Genebank

220 table grape
cultivars

2023

**Mapping
population**

Deckrot
(wine grape)
x
G1-7720
(table grape)

Mapping population

Deckrot

G1 - 7720



Aroma

Colour

Seeded

Berry size

Bunch compactness



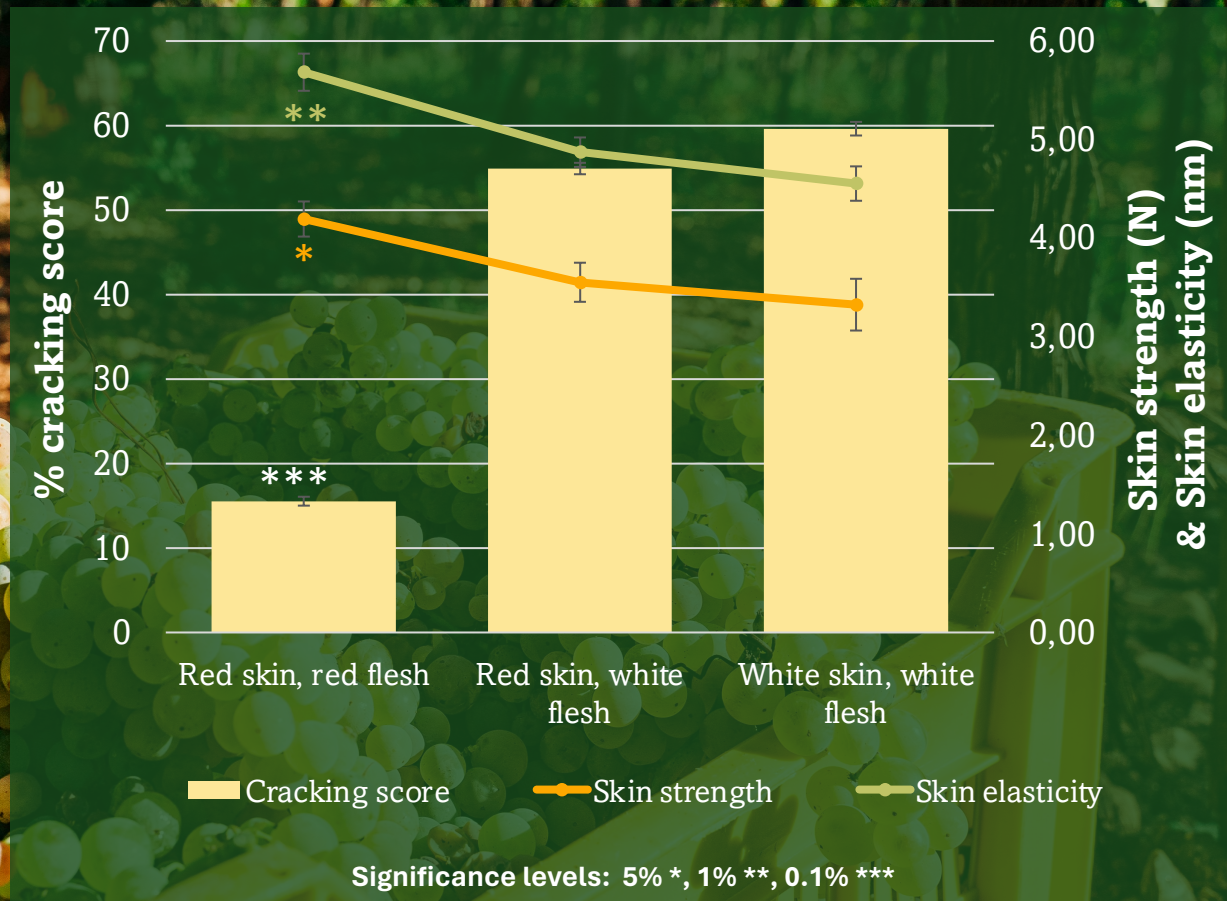
Mapping population

- Cracking score correlates with elasticity
- No permeability measured for this population

	Skin strength	Skin elasticity	Brix	Mass 0hrs	Cracking score
Skin strength	1				
Skin elasticity	0.45	1			
Brix	-0.12	0.02	1		
Mass 0hrs	-0.01	-0.09	-0.36	1	
Cracking score	-0.40	-0.78	-0.08	0.21	1

Mapping population

- Flesh colour seems to play a role in cracking, skin elasticity and skin strength
- Red flesh = juicier berries
 - Do anthocyanins play a role in flesh integrity?
 - Genetically linked traits?



2022 results

- 15 out of 25 table grape cultivars
 - Brix correlates with cracking score
- Cracking score correlates with **elasticity** and **permeability**
- Skin strength and berry size seems to play little role

	Skin strength	Skin elasticity	Brix	Cracking score	%mass change	Mass @0 hrs
Skin strength	1.00					
Skin elasticity	0.31	1.00				
Brix	-0.01	0.07	1.00			
Cracking score	-0.19	-0.65	0.24	1.00		
%mass change	-0.28	-0.44	-0.17	0.77	1.00	
Mass @0 hrs	-0.09	-0.25	0.41	0.33	0.15	1.00

2023 Genebank results

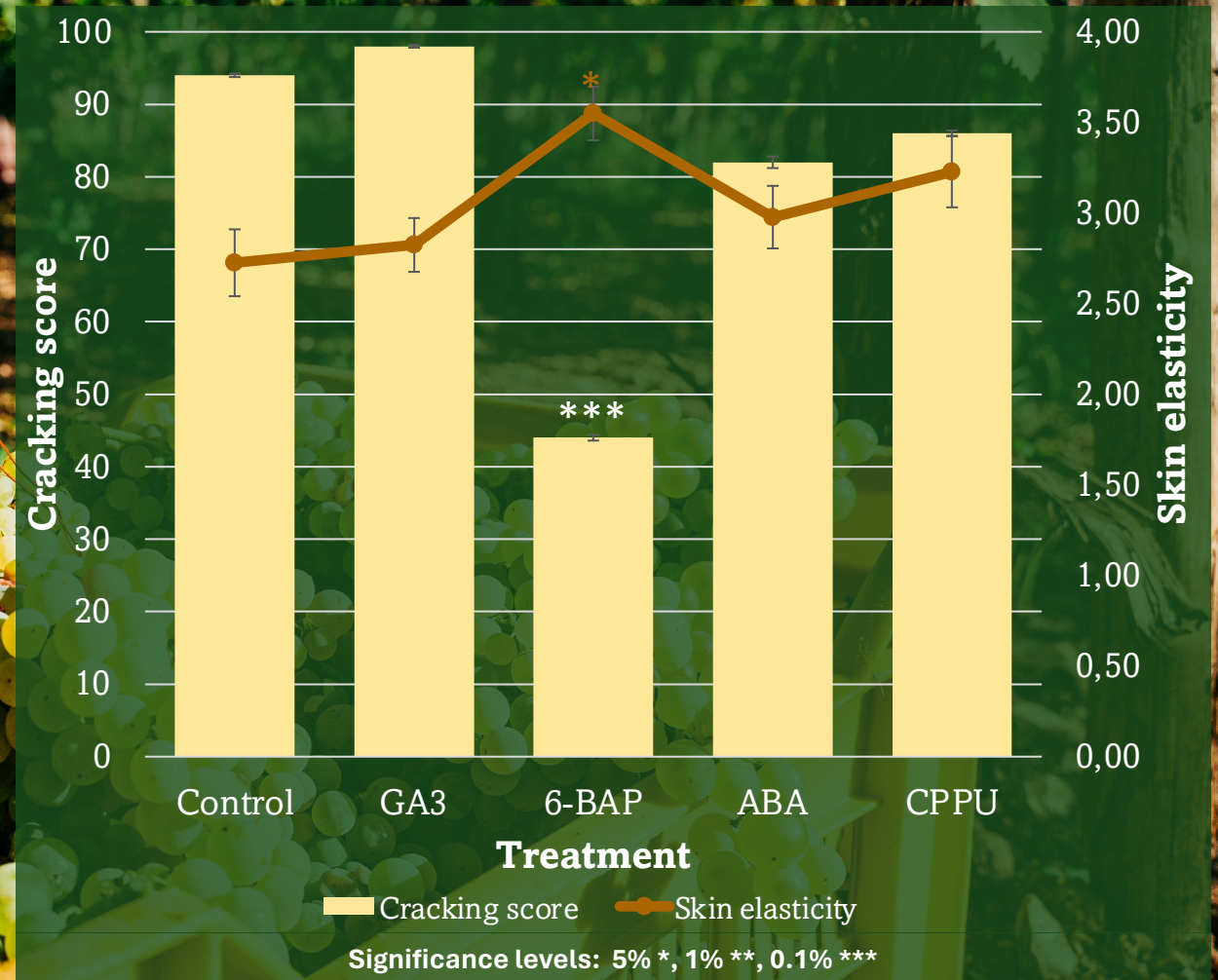
- 87 out of 220 cultivars measured for cracking score
- **Elasticity** plays bigger role than **permeability**
 - Increased sample size?
 - More uniform cultivars selected?
- Skin strength and berry size plays little role in cracking

	Skin strength	Skin elasticity	Brix	Cracking score	%Mass change	Mass @0hrs
Skin strength	1.00					
Skin elasticity	0.29	1.00				
Brix	-0.11	0.02	1.00			
Cracking score	-0.14	-0.70	-0.09	1.00		
%Mass change	-0.11	-0.37	0.08	0.43	1.00	
Mass @0hrs	0.11	0.04	-0.11	0.17	0.06	1.00

2023 PGR treatments

- Three cultivars
 - Kishmish L (susceptible)
 - Merbein sdl (susceptible)
 - Poloskei L (resistant)
- Kishmish L
 - Maxcel (6-BAP) decreased cracking significantly
 - Elasticity also increased

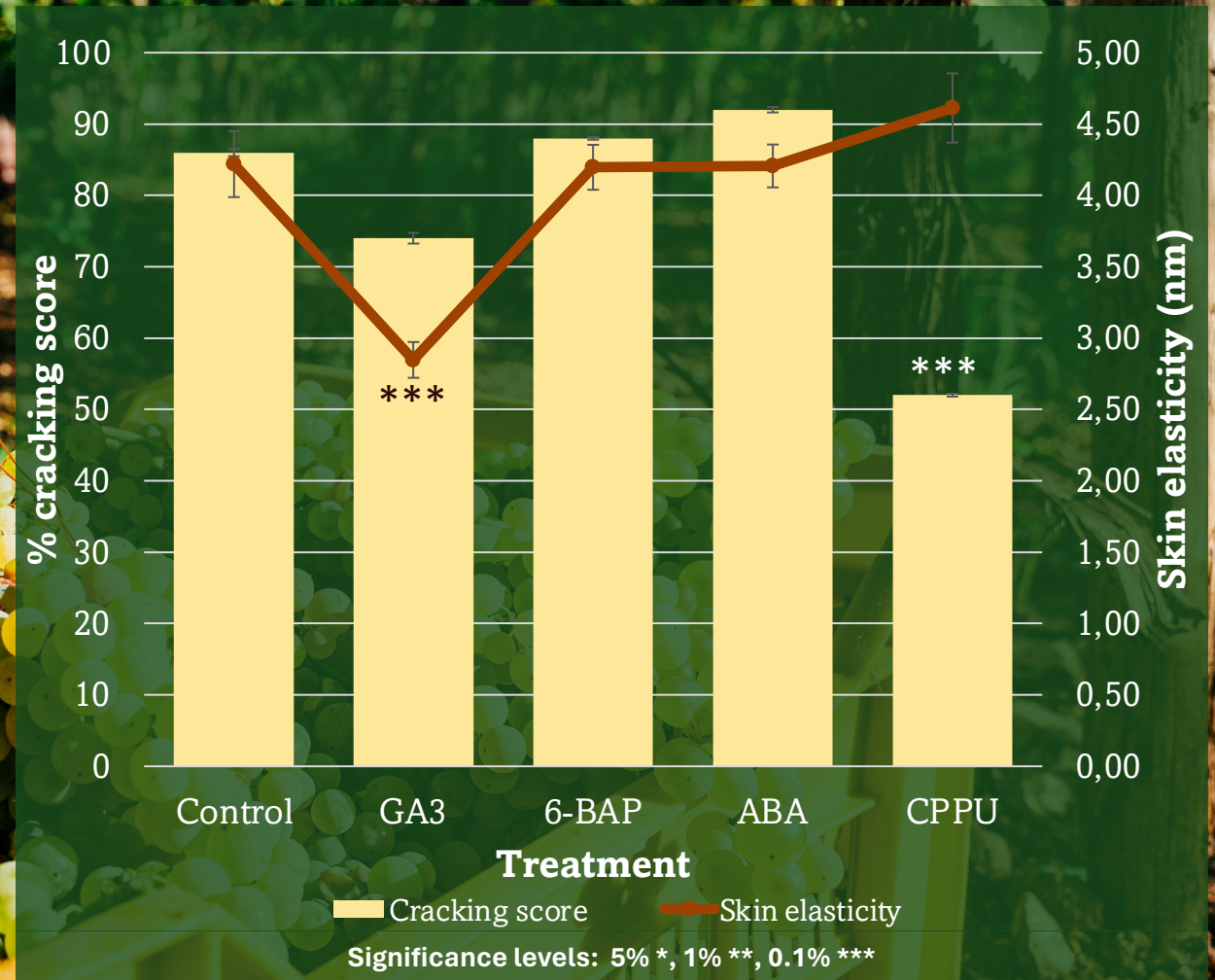
Kishmish L.



2023 PGR treatments

- Merbein sdl
 - Sitoflex (CPPU) significantly decreased cracking score
 - Elasticity did not increase significantly
 - Inverse not true
 - Decreased elasticity \neq increased cracking

Merbein sdl



Microscopy

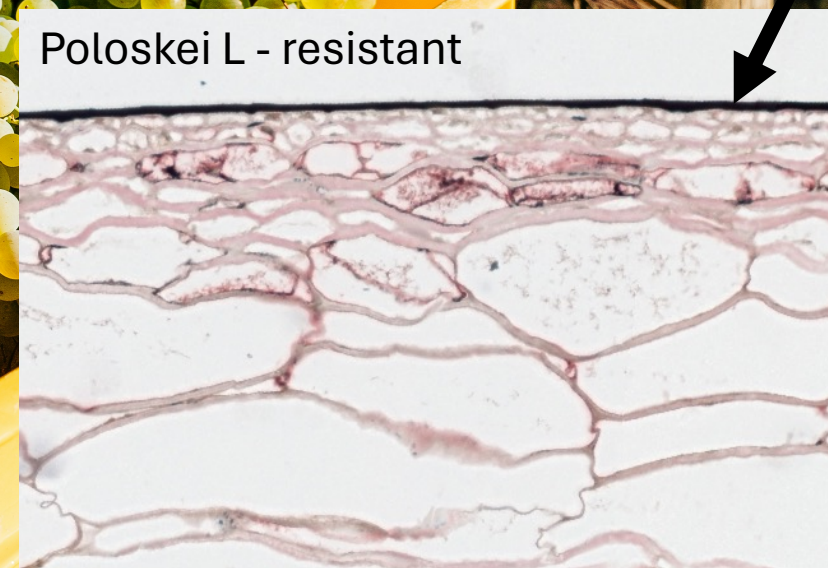
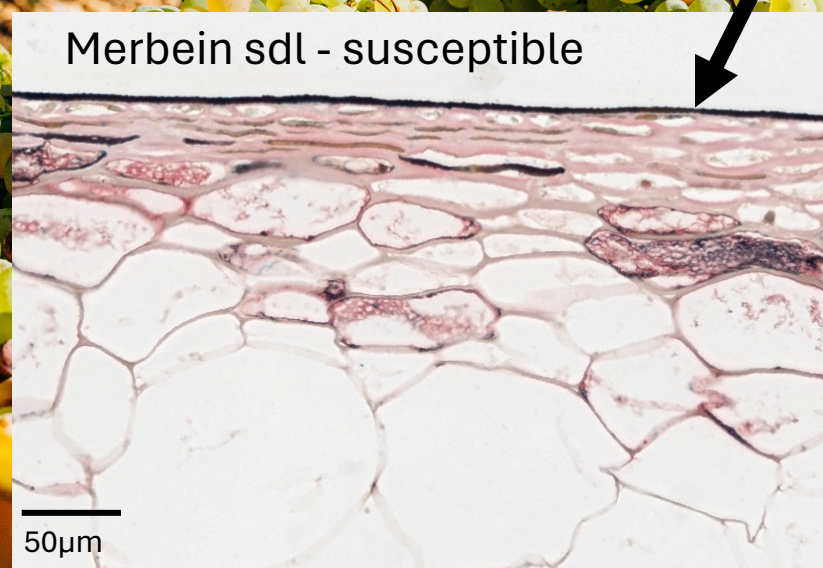
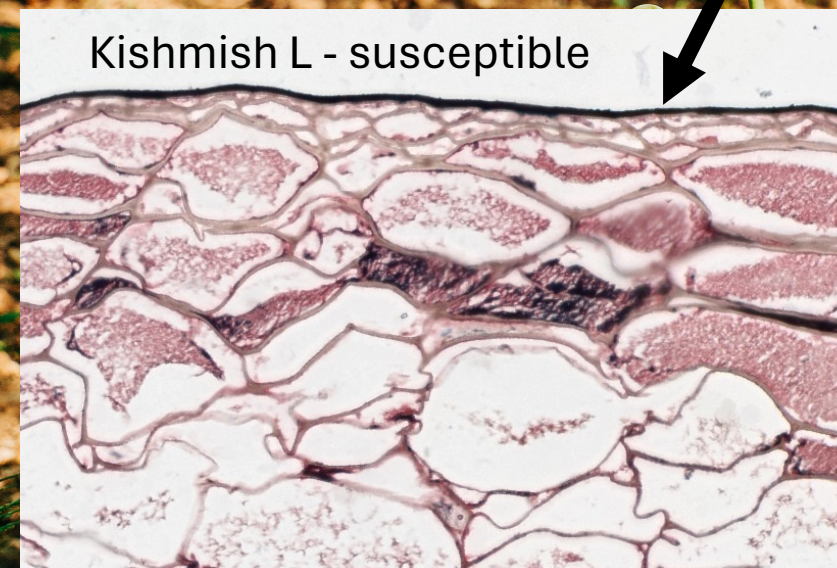
- Sudan Black stain for 2022 samples
- Cuticle clearly shown in black
- No obvious differences between cracking susceptible and resistant cultivars

Kishmish L - susceptible

Merbein sdl - susceptible

Poloskei L - resistant

50µm

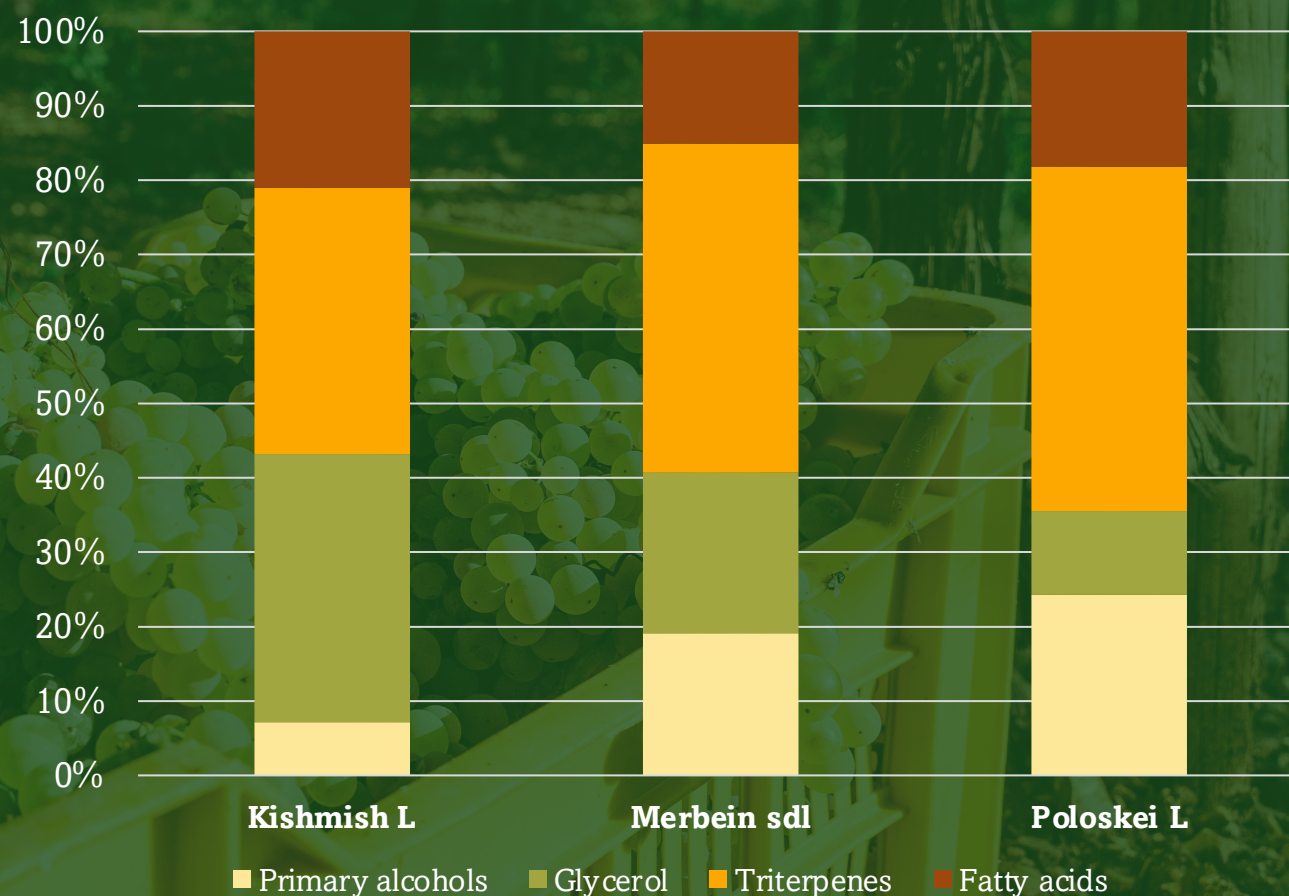


Cuticle composition

Waxes

- Fatty acids
 - Di-acids
 - Saturated and unsaturated fatty acids
- Triterpenes make up majority – oleanolic acid
- Glycerol content high in Kishmish L

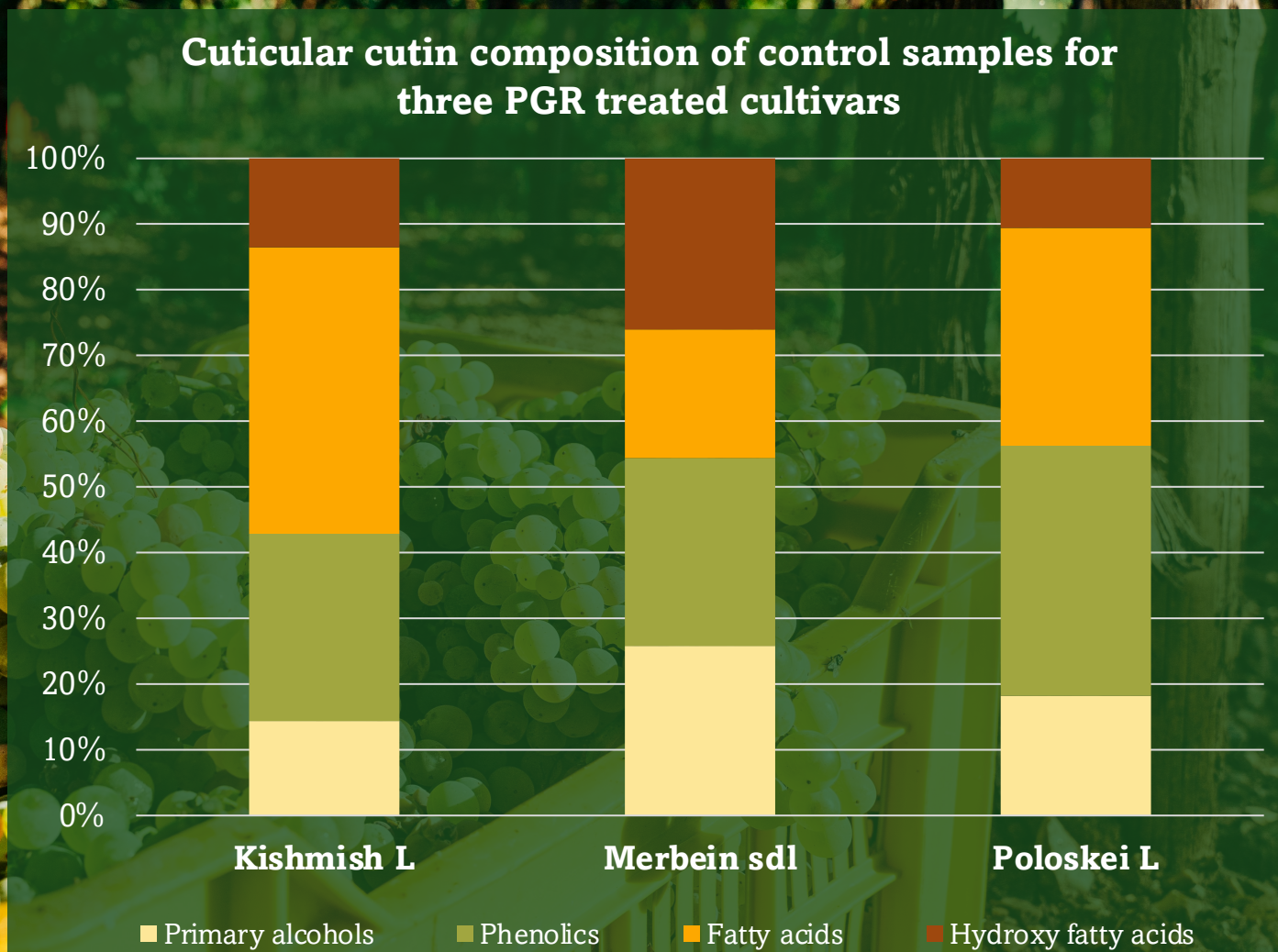
Cuticular wax composition of control samples for three PGR treated cultivars



Cuticle composition

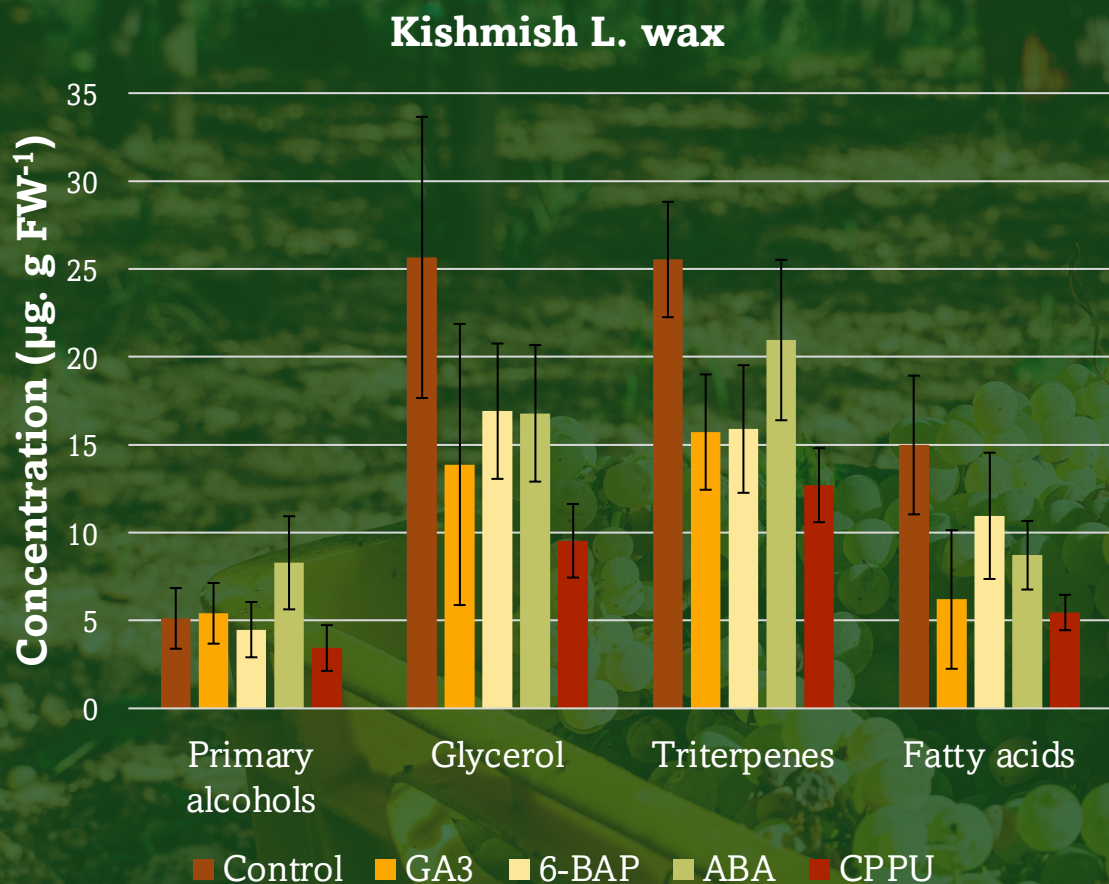
Cutin

- Fatty acids
 - Di-acids
 - Saturated and unsaturated fatty acids
- Hydroxy acids
 - Fatty acids with OH-groups



Cuticle composition Kishmish L.

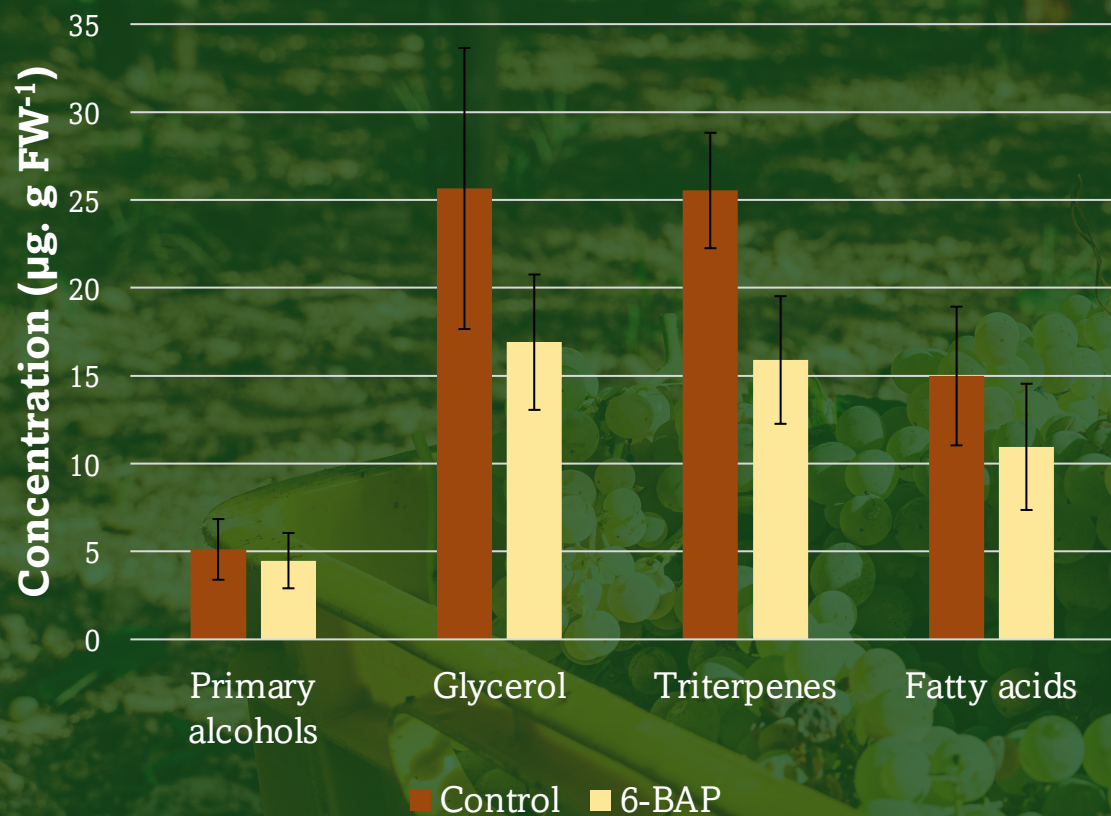
No significant
difference
between
treatments and
control



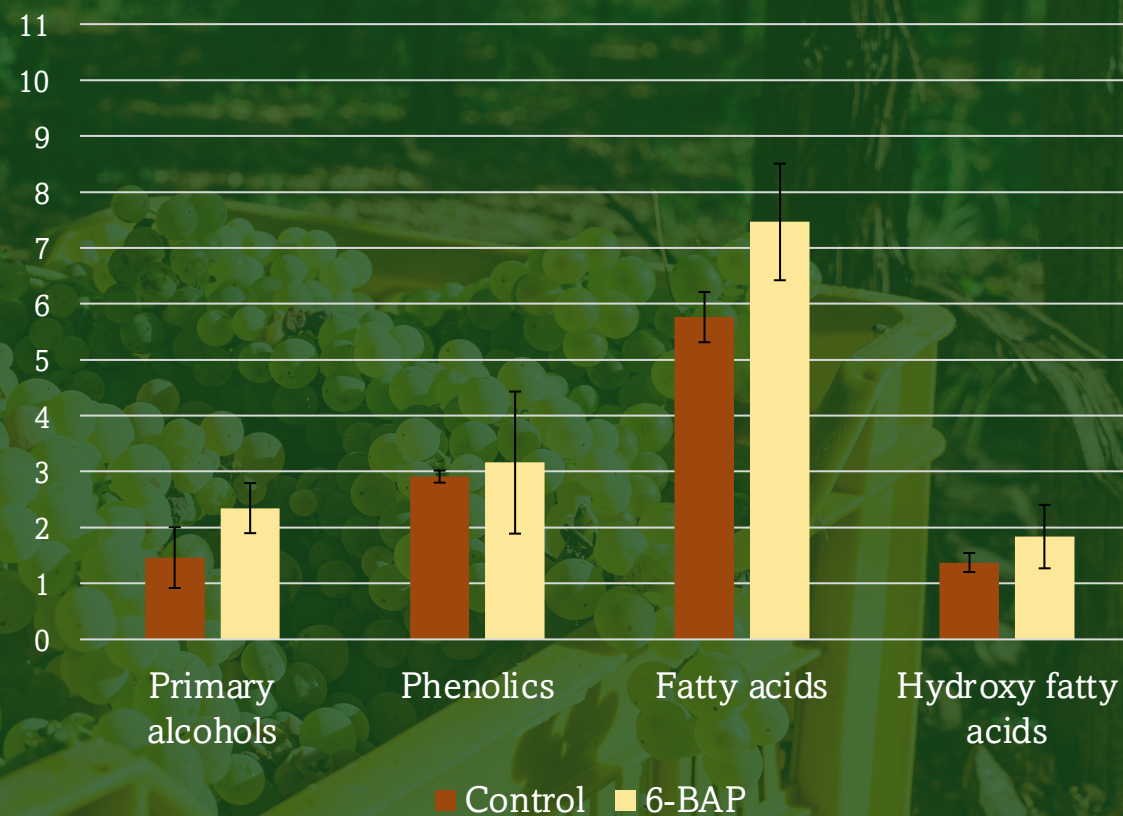
Cuticle composition Kishmish L.

Overall decrease
in waxes and
increase in cutin
content

Kishmish L. wax



Kishmish L. cutin





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A scenic view of a vineyard. In the foreground, rows of grapevines with green leaves are visible. The background shows a valley with a dense forest of trees, some with yellow and orange autumn foliage. The overall scene is bright and natural.

Conclusion

Concluding remarks

- Skin elasticity plays a role in berry cracking
 - Permeability may contribute as well
- Anthocyanin content may be linked
- Cytokinins improve cracking
 - Increase elasticity by cell division?



Future work



Repeat PGR
treatment and
phenotypic
analysis with
more cultivars



Gene expression
targeting genes
related to
cracking and
cuticle synthesis



QTL analysis
of DG
population

Thank you!

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Phyllis Burger, ARC-Nietvoorbij

Schalk Reynolds, PhilAgro

Hans Eyeghe-Bickong, Chemical analysis

lab SAGWRI

Justin Lashbrooke



10TH
INTERNATIONAL
TABLE GRAPE
SYMPOSIUM



Stellenbosch
UNIVERSITY
IYUNIVESITHI
UNIVERSITEIT



SATI
SOUTH AFRICAN TABLE
GRAPE INDUSTRY



SAGWRI
South African Grape and
Wine Research Institute

			Skin elasticity	Skin strength	Cracking score	Mass Ohrs	Mass change
Kishmish L	Control	Control	2.73	2.91	94	36.98	1.82
	GA3	GA3	2.82	2.73	98	50.58	1.34
	Maxcell	6-BAP	3.55	3.37	44	35.23	0.93
	Protone	ABA	2.98	2.16	82	28.46	-0.46
	Sitoflex	CPPU	3.23	2.85	86	37.06	1.88
Merbein Sdl	Control	Control	4.22	3.76	86	19.91	-0.78
	GA3	GA3	2.85	3.64	74	18.55	-0.12
	Maxcell	6-BAP	4.20	4.38	88	20.82	-0.04
	Protone	ABA	4.21	3.31	92	21.05	0.27
	Sitoflex	CPPU	4.61	3.81	52	21.99	0.40
Poloskei	Control	Control	6.08	5.99	4	35.90	0.37
	GA3	GA3	6.03	5.44	7	32.88	1.94
	Maxcell	6-BAP	5.52	5.54	2	35.84	1.12
	Protone	ABA	5.09	4.52	6	38.79	0.53
	Sitoflex	CPPU	5.02	5.12	0	32.77	0.56

2023 PGR treatments

- Merbein sdl
 - Sitoflex significantly decreased cracking score
 - Elasticity did not increase significantly
 - Inverse not true
 - Decreased elasticity \neq increased cracking
 - Mass change significantly increased
 - Negative values?
 - Higher rate of transpiration

Merbein sdl

