

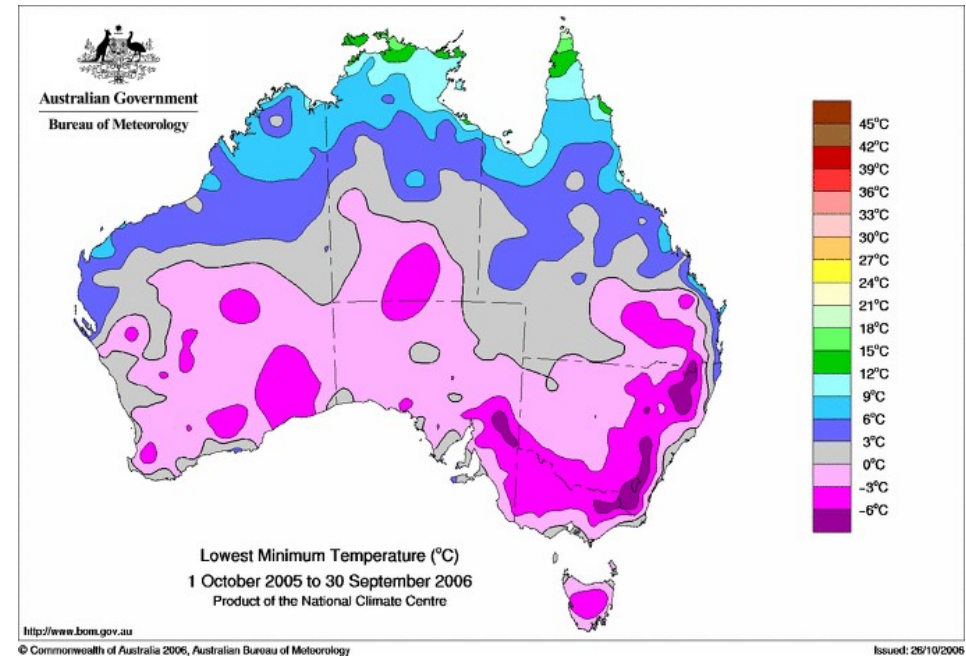
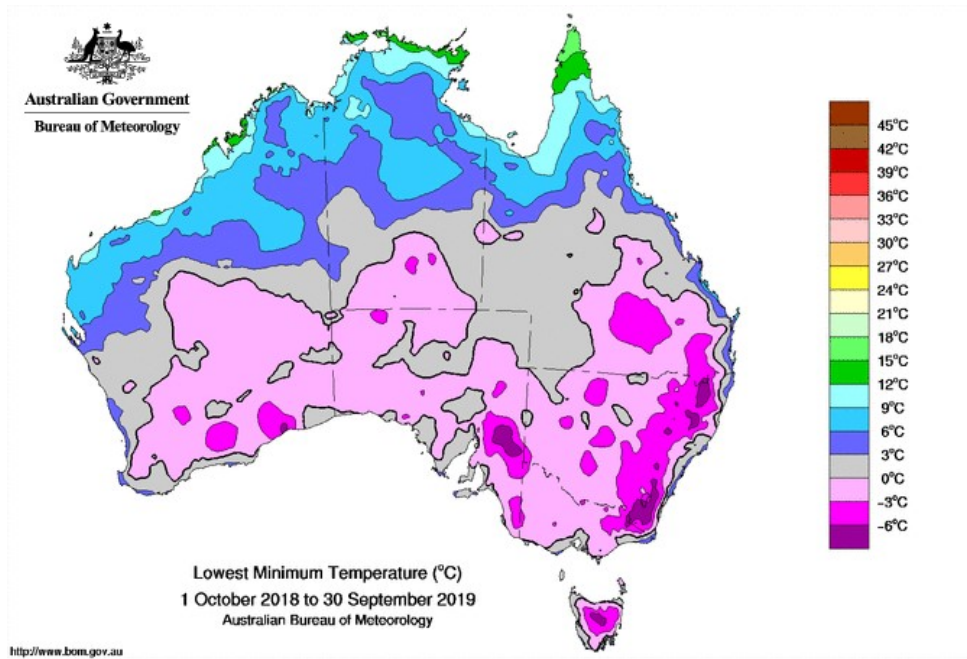
Impact of Frost Damage on EVOO Quality Parameters

by Claudia Guillaume

17th October 2019



2019 Lowest temperatures



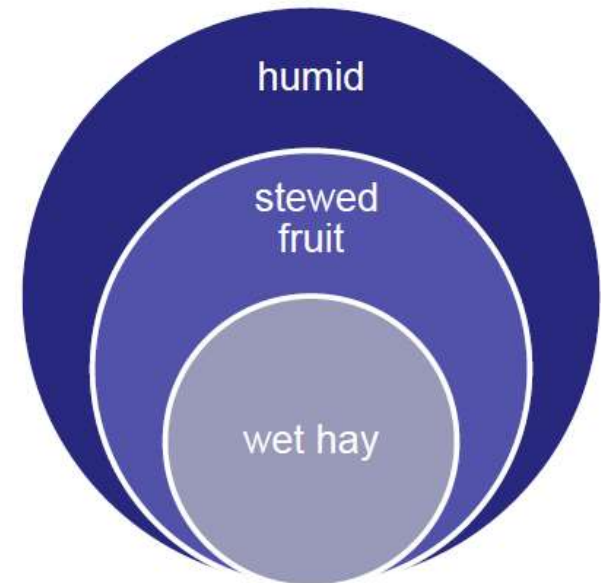
Degree of Frost damage

- Frost damage occurs when ice forms inside the plant tissue and injures the plant cells.
- Frost damage may have a drastic effect upon the entire plant or affect only a small part of the plant tissue, which reduces yield and product quality.
- The frost damage varies according to the specific temperature at ground level around the tree, the duration of the cold, the olive variety, the age of the tree, and whether the trees have had a chance to harden off.
- Frost occurs at inland sites on clear, cold nights without wind or at higher altitudes and is less likely to occur in coastal areas.
- Frost is a local condition and rarely affect the entire plant.

Type of Frost damage

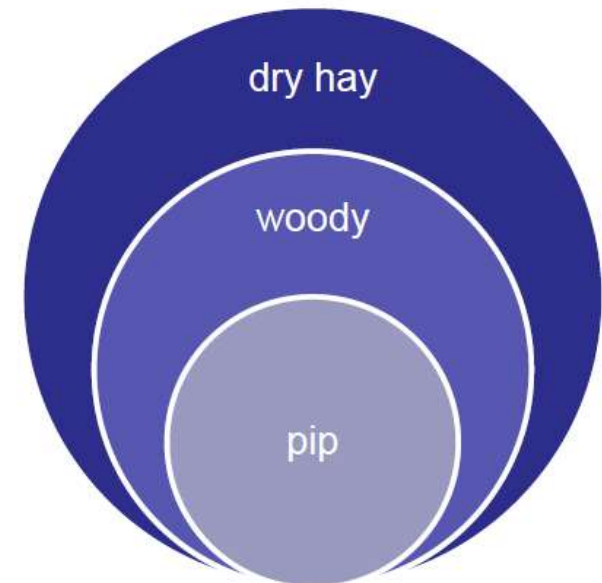
- **Wet frost**

- Damage of intracellular tissue by 'overcooling' (air temperature of 0 °C or lower). Water within cells may or may not freeze. Olives start freezing at -1.4 °C
- Normally occur when the temperature drops slowly (about 1-5°C per h) and/or heavy winds following the cold weather
- Fruits show brownish spot in the skin with 'soggy/watery' consistency, falling off the tree occasionally
- Quality of the product affected



Type of Frost damage

- **Dry frost**
 - Damage of extracellular (and/or intracellular) tissue
 - Formation of ice crystals (either by freezing of dew or an intracellular phase change from liquid to ice).
 - Normally occur when the temperatures drop rapidly and are maintain for a period of time (i.e temp. maintained below 1 for more than 20 h)
 - Fruits are dehydrated/shriveled and remain on the tree until harvested



Evolution of Quality Parameters

- Fruit was processed with an Abencor® system.
- Three Varieties: Frantoio, Barnea and Picual.
- Four treatments: Before frost, immediately after frost event, two weeks after frost event and four weeks after frost event.
- The tests carried out were:
 - Quality parameters, as FFA, PV, UV coefficients, IND, Biophenols profile by HPLC and Sensory analysis.



Evolution of Quality Parameters

Quality and Organoleptic Parameters¹ obtained from oil
before, immediately after, 2 and 4 weeks after frost damage processed

	BF		AF		2W		4W		Std. error	F ²	Signific.
FFA	0.25	a	0.29	a	0.47	b	0.72	c	0.047	9.098	0.000
PV	12.50	a	12.91	a	15.63	b	18.76	c	0.822	3.586	0.018
K232	1.42	a	1.40	a	1.61	b	1.65	b	0.053	1.617	0.200
K270	0.10	a	0.09	a	0.10	a	0.12	b	0.005	2.752	0.059
IND	22.09	b	20.94	b	13.97	a	14.68	a	1.201	3.763	0.020
PPH	83.00	b	73.44	b	34.22	a	35.78	a	4.927	14.540	0.000
BIT	0.07	c	0.07	c	0.05	b	0.04	a	0.004	5.900	0.003
Defects	0.00	a	2.08	b	3.14	c	4.08	d	0.270	102.400	0.000
P.TEST	7.17	d	5.25	c	4.11	b	3.44	a	0.250	107.000	0.000
GQI	7.34	d	5.59	c	4.14	b	2.99	a	0.300	56.430	0.000

¹Mean sample size = 36. Means followed by the same roman letter within each row do not present significant differences

(Duncan's multiple range test $\alpha = 0.05$).

²F tests the effect of time between frost damage and processing

Evolution of Quality parameters for Picual

	BF	AF	2W	4W
→ FFA	0.17	0.22	0.27	0.48
PV	11.47	10.40	10.10	13.97
K232	1.11	1.16	1.10	1.17
K270	0.06	0.07	0.07	0.10
DK	0.00	0.00	0.00	0.00
→ IND	31.77	27.00	21.90	24.27
→ TOTAL PHENOLS	273.53	148.56	119.66	69.01

- FFA increased 2.8 times after 4 weeks the frost event
- IND decreased 7 months after 4 weeks the frost event
- PPH decreased 4 times after 4 weeks the frost event

Evolution of Quality parameters for Frantoio

	BF	AF	2W	4W
→ FFA	0.33	0.34	0.74	1.20
→ PV	14.63	15.00	21.67	23.37
K232	1.61	1.52	1.92	1.88
K270	0.11	0.09	0.12	0.13
DK	0.00	0.00	0.00	0.00
→ IND	18.83	16.63	12.23	9.00
→ TOTAL PHENOLS	336.90	301.83	163.67	86.09

- FFA outside spec after 4 weeks the frost event and duplicate in 2 weeks
- PV outside spec after 2 weeks the frost event
- IND decreased 9 months after 4 weeks the frost event
- PPH decreased 4 times after 4 weeks the frost event

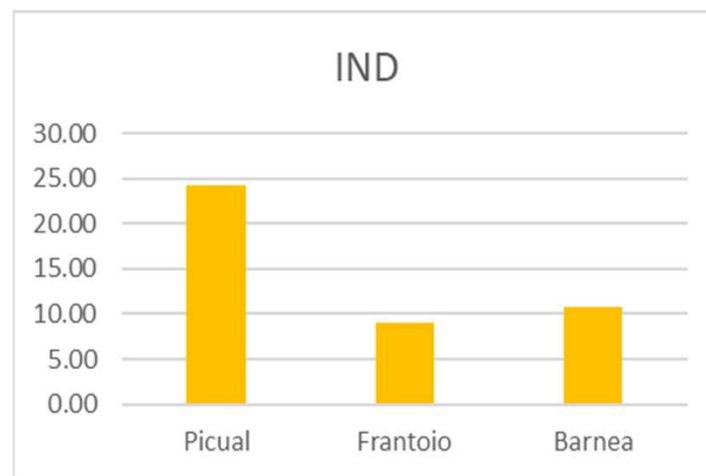
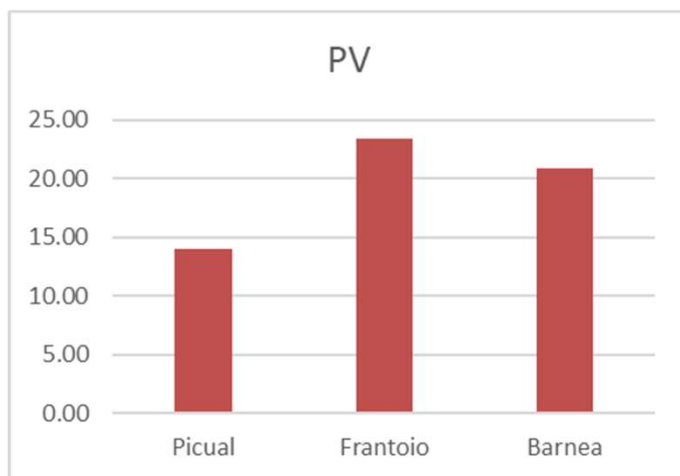
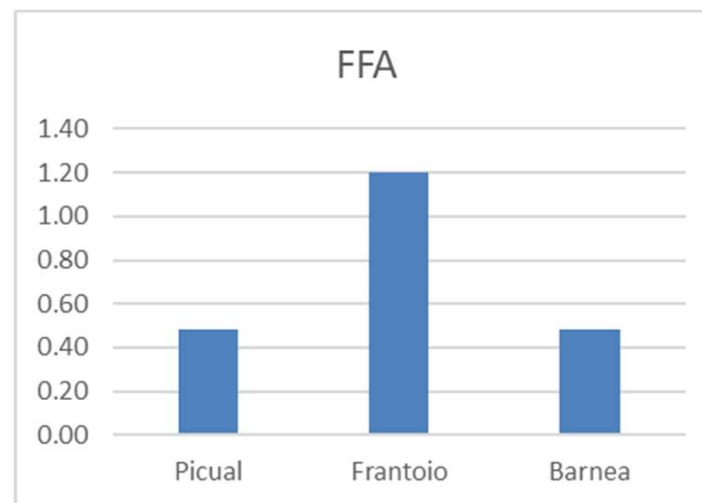
Evolution of Quality parameters for Barnea

	BF	AF	2W	4W
→ FFA	0.25	0.31	0.41	0.48
→ PV	11.40	13.33	15.13	20.93
K232	1.54	1.51	1.81	1.91
K270	0.12	0.11	0.12	0.13
DK	0.00	0.00	0.00	0.00
→ IND	17.67	15.20	11.77	10.77
→ TOTAL PHENOLS	338.31	232.60	81.65	63.98

- FFA duplicate after 4 weeks the frost event
- PV outside spec after 4 weeks the frost event
- IND decreased 7 months after 4 weeks the frost event
- PPH decreased 5 times after 4 weeks the frost event

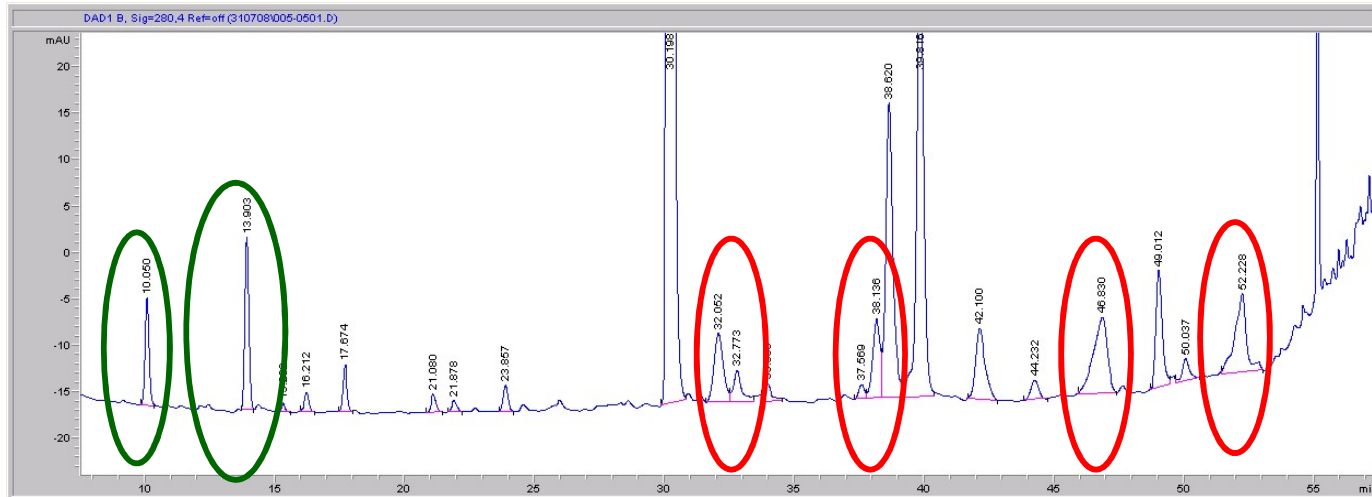
Evolution of Quality parameters

	Picual	Frantoio	Barnea
FFA	0.48	1.20	0.48
PV	13.97	23.37	20.93
K232	1.17	1.88	1.91
K270	0.10	0.13	0.13
DK	0.00	0.00	0.00
IND	24.27	9.00	10.77
TOTAL PHENOLS	69.01	86.09	63.98

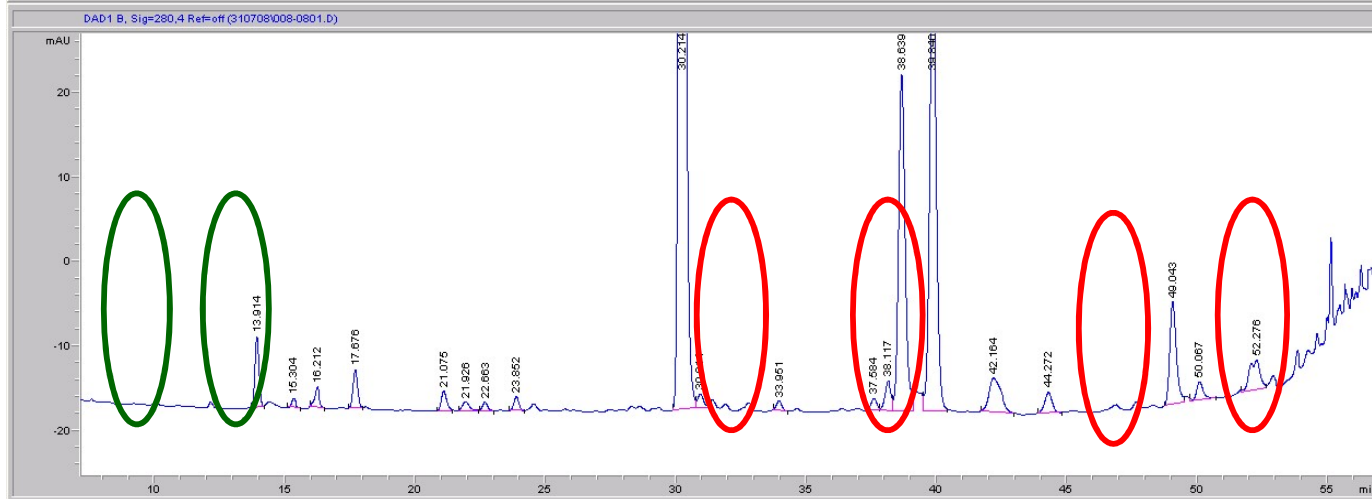


Evolution of Phenol profile

**before
frost oil**



**4 weeks
after frost**



- 1.Hydroxytyrosol;
- 2.Tyrosol; 3.Vainillic acid;
- 4.Vanillin; 5.p-coumaric acid;
- 6-Hydroxytyrosyl acetate; 7.DDOA; 8.DAO;
9. DLA; 10. Pinoresinol;
- 11.Cinnamic acid; 12. Luteolin; 13. AOA; 14. Apigenin; 15. ALA

Evolution of Phenol profile

Polyphenols¹ (in ppm) obtained from oil processed
before, immediately after, 2 and 4 weeks after frost damage

	BF	AF	2W	4W	Std. error	F ²	Signific.
Hydroxytyrosol	8.94 b	10.84 b	3.05 a	1.22 a	1.065	7.125	0.001
tyrosol	16.69 c	23.48 b	10.30 a	7.32 a	1.578	8.512	0.000
Vainillic acid	1.09 b	1.04 b	1.02 b	0.76 a	0.079	0.855	0.470
Vainillin	0.72 a	0.79 b	0.93 c	0.81 d	0.049	0.776	0.520
p-cumaric	0.68 c	0.61 c	0.43 b	0.19 a	0.054	6.023	0.002
HtyAc	22.98 c	13.29 b	3.58 a	1.58 a	2.218	7.804	0.001
DDOA	39.18 c	22.48 b	3.63 a	1.62 a	3.472	13.310	0.000
DAO	0.76 d	0.46 c	0.29 b	0.18 a	0.057	7.800	0.001
DDLA	40.69 c	26.97 b	15.04 a	22.67 a	4.116	1.831	0.160
Pinoresinol	9.86 b	9.02 b	7.09 a	5.67 a	0.806	1.423	0.250
Cinamic acid	8.51 a	10.94 a	8.04 a	5.26 a	1.399	0.674	0.570
1-acetoxipinoresinol	2.36 a	4.64 b	2.67 a	3.33 a	0.879	0.310	0.820
Luteonin	27.22 c	34.32 d	20.33 b	9.99 a	2.650	5.198	0.005
AOA	41.31 c	33.91 b	10.63 a	5.22 a	3.168	20.420	0.000
Apigenin	18.03 c	17.04 c	12.46 b	8.13 a	1.252	4.222	0.013
ALA	43.87 b	17.84 a	15.48 a	5.75 a	6.563	1.622	0.200
TOTAL	282.91 c	227.66 b	114.99 a	79.69 a	17.966	15.980	0.000

HtyAc: Hydroxytyrosil Acetate. DDOA: Dialdehydic form of decarboxymethyl oleuropein aglycone. DOA: Dialdehydic form of oleuropein aglycone. DDLA: Dialdehydic form of decarboxymethyl ligstroside aglycone. AOA: Aldehydic form of oleuropein aglycone.

ALA: aldehydic form of ligstroside aglycone

¹Mean sample size = 36. Means followed by the same roman letter within each row do not present significant differences

(Duncan's multiple range test $\alpha = 0.05$).

²F tests the effect of time between frost damage and processing

Evolution of Phenol profile

Polyphenols¹ (as % of total polyphenols) obtained from oil processed before, immediately after, 2 and 4 weeks after frost damage

	BF	AF	2W	4W	Std. error	F ²	Signific.
Hydroxytyrosol	3.14 c	4.06 d	1.79 b	0.82 a	0.401	4.018	0.016
Tyrosol	4.60 a	6.86 b	4.88 a	4.68 a	0.426	1.694	0.190
Vainillic acid	1.20 a	1.25 a	2.13 b	2.52 b	0.248	1.854	0.160
Vainillin	1.37 a	1.89 b	3.14 c	3.38 c	0.244	5.494	0.004
p-cumaric	1.46 b	1.61 c	1.62 c	1.22 a	0.192	0.228	0.880
HtyAc	6.46 c	4.21 b	1.81 a	0.70 a	0.664	5.048	0.006
DDOA	6.44 c	3.55 b	0.92 a	0.65 a	0.485	21.310	0.000
DAO	1.66 b	1.13 a	0.99 a	1.17 a	0.163	0.776	0.520
DDLA	4.76 a	3.28 a	3.25 a	7.85 b	0.974	1.257	0.310
Pinoresinol	11.51 a	12.39 a	16.88 b	18.08 b	1.637	0.983	0.410
Cinamic acid	28.77 a	29.86 a	35.20 a	34.86 a	3.920	0.168	0.920
1-acetoxipinoresinol	0.36 a	0.20 a	0.85 a	1.96 b	0.341	1.482	0.240
Luteonin	6.96 a	7.64 a	8.32 a	6.89 a	0.710	0.208	0.890
AOA	11.46 b	11.54 b	4.98 a	3.74 a	0.877	9.883	0.000
Apigenin	4.71 a	4.97 a	6.07 b	6.56 b	0.465	0.884	0.460
ALA	5.12 a	5.55 a	7.16 b	4.92 a	0.532	0.904	0.450

HtyAc: Hydroxytyrosil Acetate. DDOA: Dialdehydic form of decarboxymethyl oleuropein aglycone. DOA: Dialdehydic form of oleuropein aglycone. DDLA: Dialdehydic form of decarboxymethyl ligstroside aglycone. AOA: Aldehydic form of oleuropein aglycone.

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¹Mean sample size = 36. Means followed by the same roman letter within each row do not present significant differences

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²F tests the effect of time between frost damage and processing

Evolution of Sensory Defect

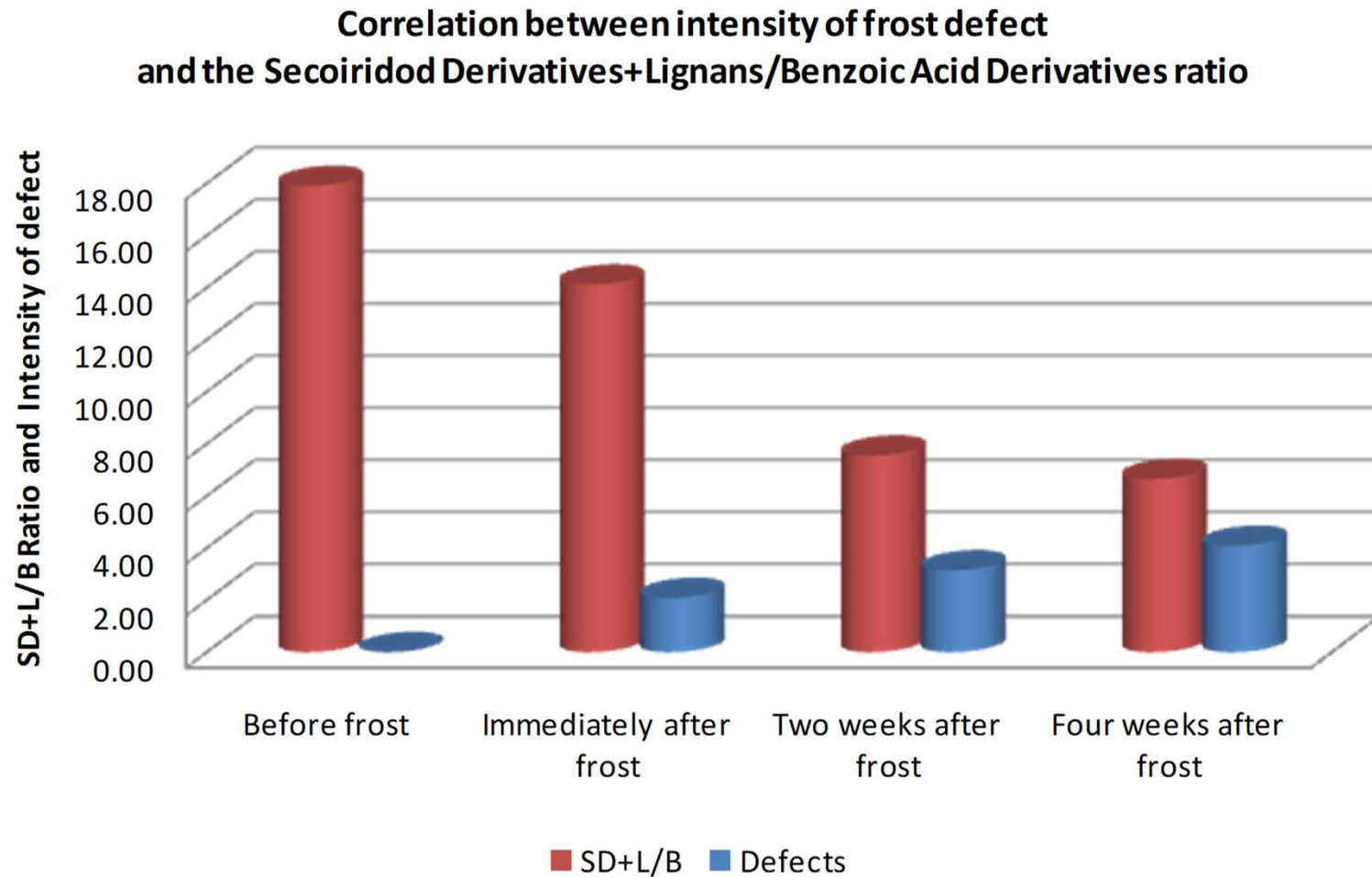
Picual	BF	AF	2W	4W
Defects	0.00	1.33	2.83	3.67

Frantoio	BF	AF	2W	4W
Defects	0.00	2.42	3.50	4.42

Barnea	BF	AF	2W	4W
Defects	0.00	2.50	3.08	4.17

All the oils after 2 weeks of the frost event were classified as **Lampante** (not fit for human consumption)

Evolution of Sensory Defect



Correlation between 'Wet frost' Defect and other quality parameters

Correlations between analysis and defects per variety

Parameter	Picual	Frantoio	Barnea	Average
→ FFA	0.89	0.83	0.94	0.89
PV	0.44	0.85	0.87	0.72
K232	0.40	0.72	0.78	0.63
K270	0.81	0.45	0.37	0.54
DK	0.55	0.06	0.54	0.38
→ IND	-0.89	-0.74	-0.83	-0.82
→ PPH	-0.96	-0.84	-0.77	-0.86
→ BIT	-0.92	-0.86	-0.75	-0.84
Defects	1.00	1.00	1.00	1.00
P.TEST	-0.99	-1.00	-1.00	-1.00
→ GQI	-0.99	-0.99	-0.99	-0.99

Conclusions



- Harvest and process the fruit as soon as possible after the frost event helps with the quality of the oil. The longer the time between the frost damage and the harvest the lowest the category of the oil.
- Immediately after frost damage the oil became defective decreasing the oil category, while the chemical parameters almost do not change. The intensity of the defect clearly increases according to the time of frost event is increasing, showing a significant relationship between “frost defects” and delays between frost event and harvest/process (F: 102.400).
- The shelf life of the oil is compromised significantly after the frost event.



Conclusions

- The simple phenols such as hydroxytyrosol and tyrosol, which normally increase their concentration with time, show an opposite behaviour when oil is produced from fruits affected by frost. These simple phenols are strongly linked with stability of the oil decreasing the potential shelf life, according to the time of processing increases.
- The main group of phenols that remarkably decreases immediately after the freeze injuries is the secoiridoid derivatives. That significant decrease in the concentration continues when the oil is processed two and four weeks after the frost event. This group is strongly linked with the bitterness and pungency of the oil.

Conclusions

- Hydroxybenzoic acid derivatives, particularly vanillin, were the only components that significantly increase as percentage of total phenols according to the frost damage increases in all the varieties.
- Oil produced with fruit damaged of extracellular tissue where the formation of ice crystals inside the cells have been originated, most of the time, do not show change in the category of the oil.





Thank you for your attention

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