SUPPLEMENTARY DATA
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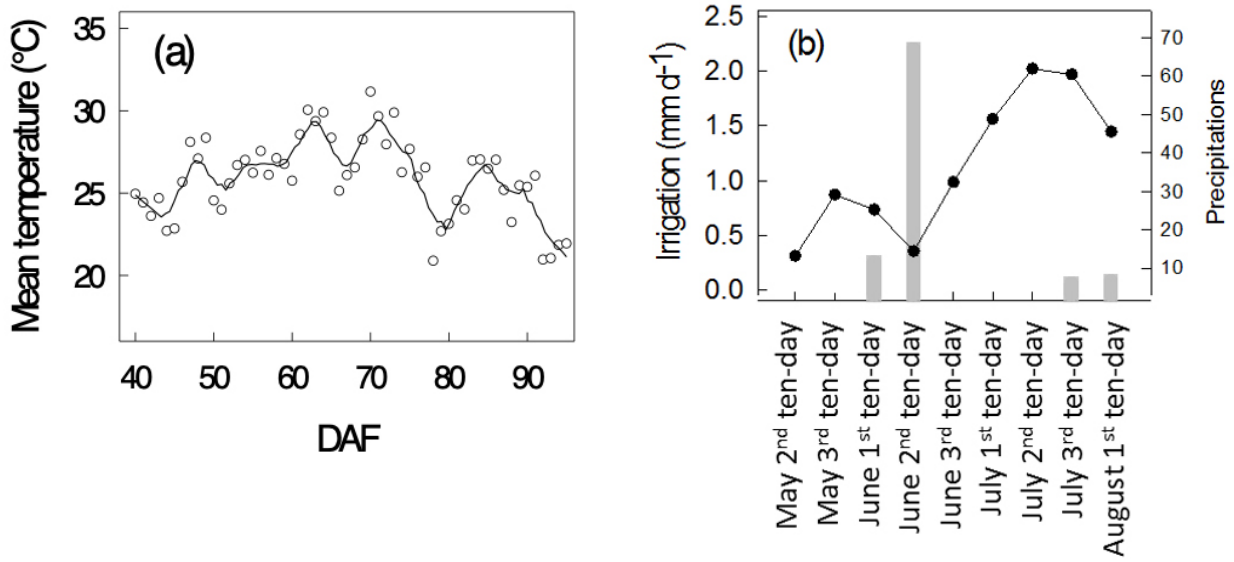


Figure S1. (a) Mean ambient air temperature in Montpellier Institut Agro germplasm from 40 to 95 days after flowering. Flowering date was 05/12/2015. (b) Irrigation (dots) and precipitations (bars) during the growing season in 2015.

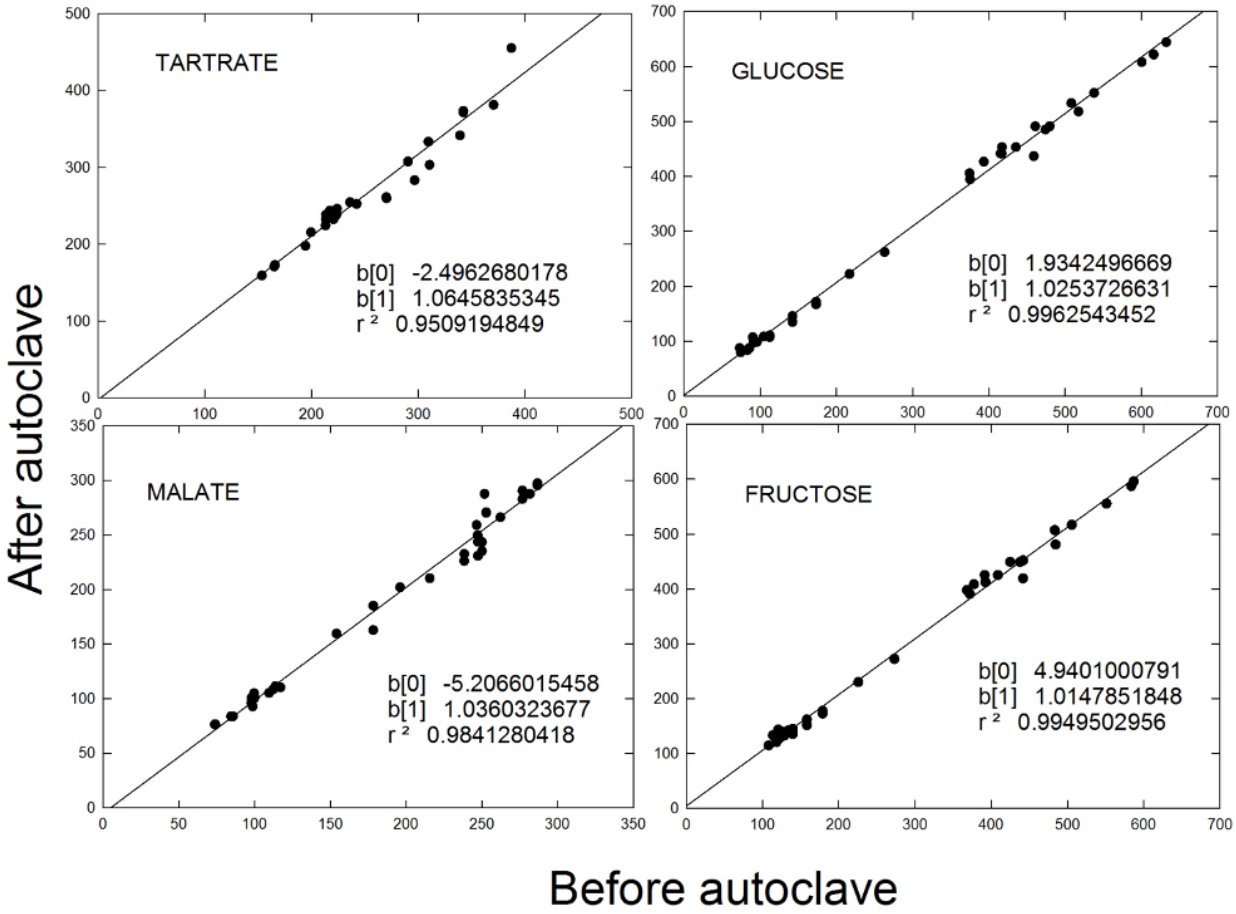


Figure S2. Autoclaving does not affect Malate, Tartrate, Glucose and Fructose HPLC peak surfaces.

More or less ripe berries were crushed in five water volume before autoclaving 5 min at 120 °C, and virgorous shaking. Aliquots of the juice were taken before and after autoclaving, before a second dilution, 10000g 10 min centrifugation and HPLC (total dilution = 75-100), according to Rienth *et al.*,2014.

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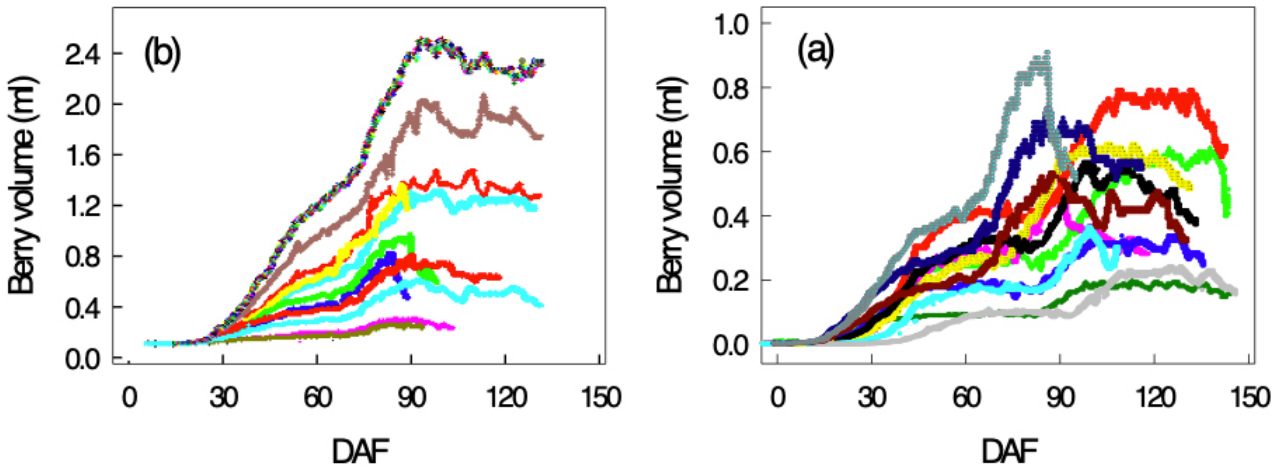


Figure S3. Development of individual berries from Cabernet-Sauvignon (a) and Pinot noir (b), recalculated from diameter data of Friend *et al.* (2009). Each berry is represented by a given color.

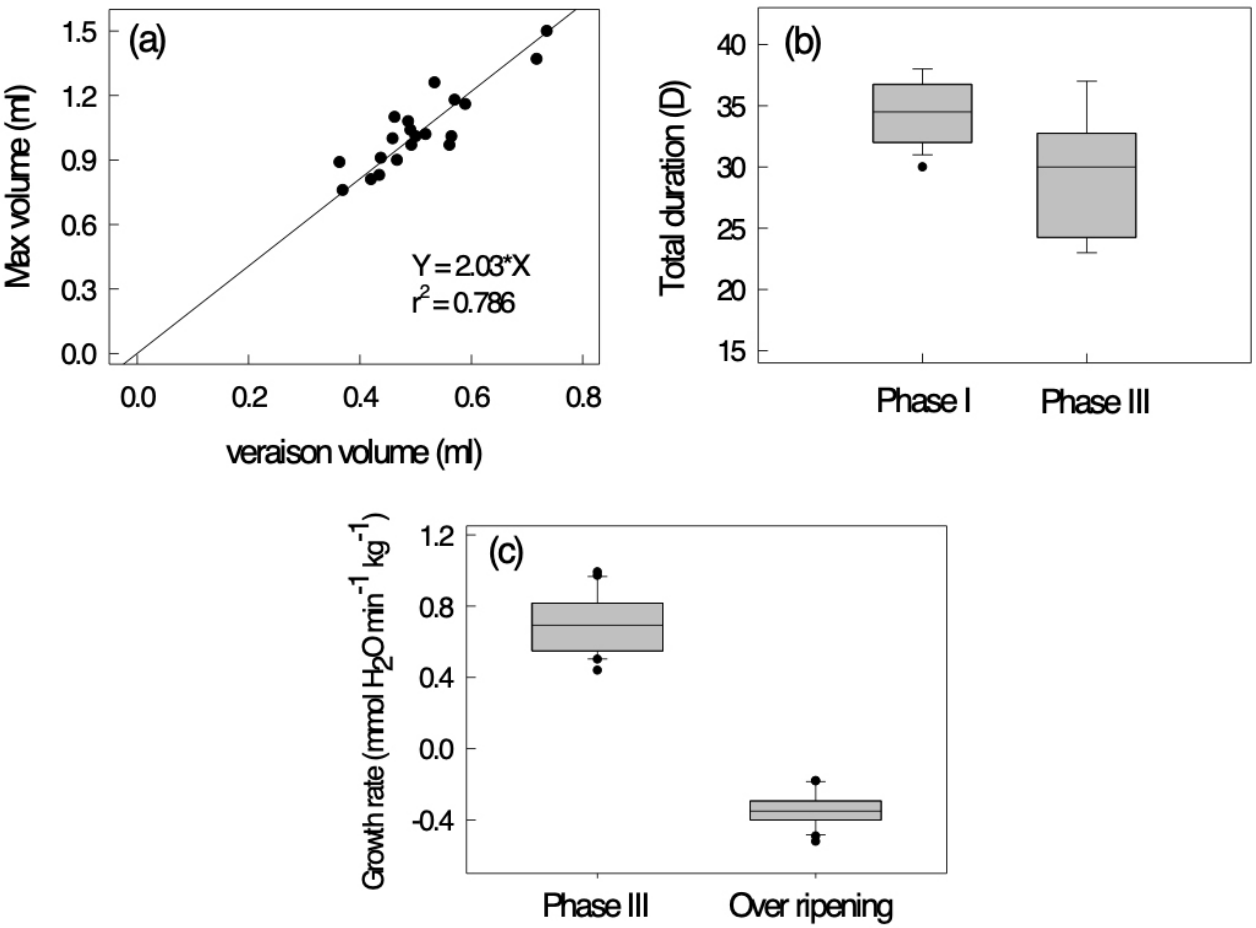


Figure S4. Development of Pinot Meunier clusters.
(a) Relationship between maximum berry volume and veraison volume.
(b) total duration of phase I growth (green) and phase III growth (ripening) periods.
(c) growth rates of phase III and over ripening.

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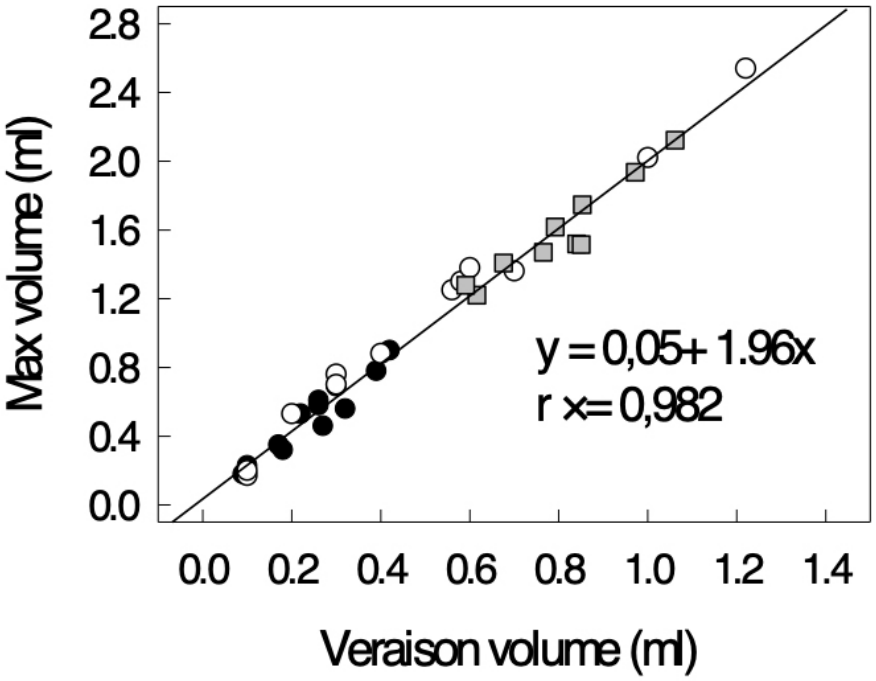


Figure S5. Relation between maximum and veraison berry volumes in Cabernet-Sauvignon (black circles), Pinot noir (open circles) and ML1 microvine (gray squares) fruits as determined in Figure 2.

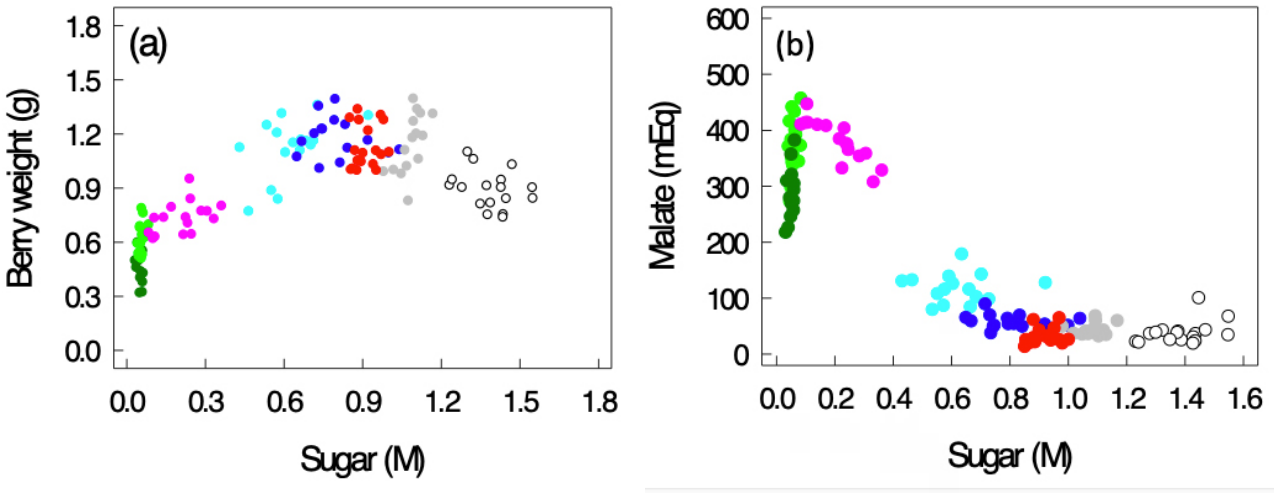


Figure S6. The heterogeneity of berry weight and malate along the sugar concentration in cv. Meunier, cluster-based sampling.

(a) Average fruit weight and sugar concentration per cluster, sampling date, and (b) average malate and sugar concentrations per cluster, sampling date. Colors represent: -20 DAV (dark green), -10 DAV (green), 0 DAV (pink), 10 DAV (cyan), 20 DAV (blue), 30 DAV (red), 40 DAV (grey) and 50 DAV (open circles).

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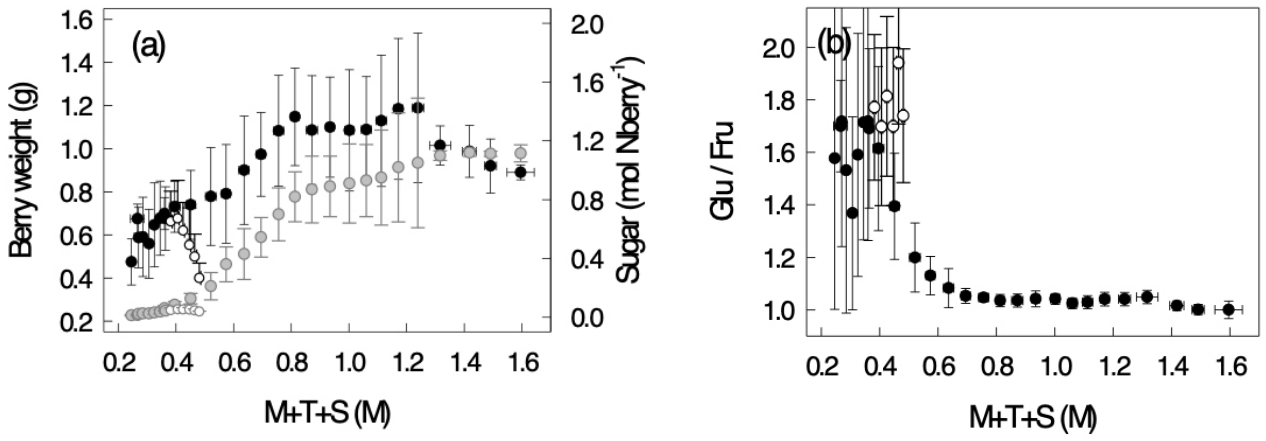


Figure S7. (a) Growth (closed circles) and normalized sugar accumulation (gray circles) in Pinot Meunier (Cluster based sampling), and (b) evolution of the Glu/Fru ratio, with respect to total solute concentration (Malate+ Tartrate+ Sugar).

1035 individual berries were ranked according to totale solutes (M+T+S), before calculating average values and standard deviation on every successive 0.05M (M+T+S) intervals. Open circles correspond to atypically small berries loosing water rather than ripening, as indicated by the Glu/Fru ratio. Normalized sugar accumulation (gray circles) was calculated as $1000x[G+F]xBw/Bw_{max}$ where [G+F] : glucose plus fructose concentration, Bw : Berry Weight, Bw_{max} : maximal average berry weight (1.2 g). The number of berry per 0.05 M class varies from(7-69) with an average value of (31).

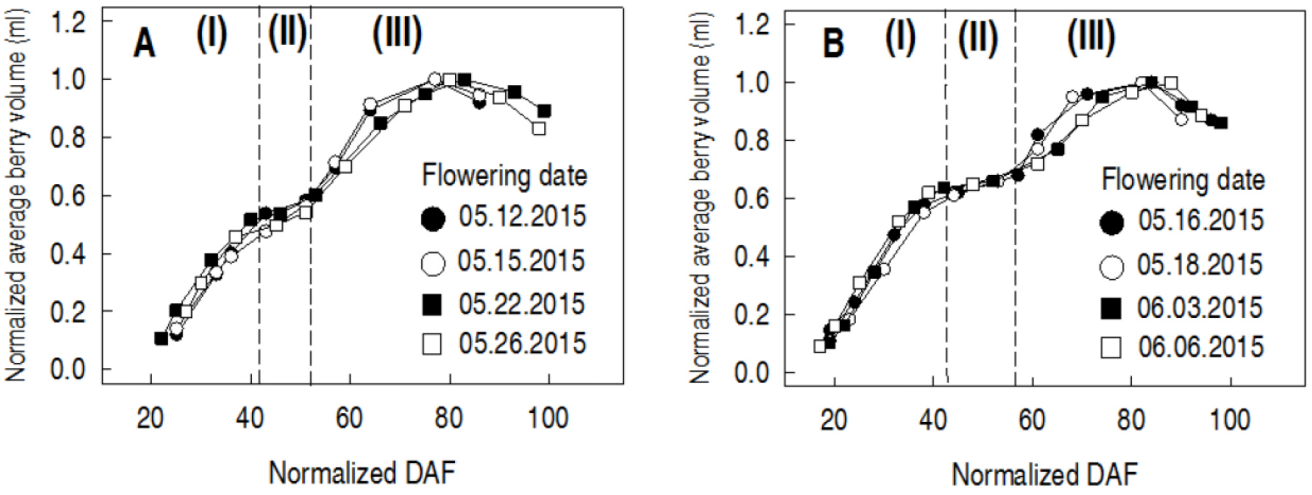


Figure S8. Second growth phase delays among clusters mostly result from their different flowering dates.

Cluster growth was measured by pevriodic immersion. (a) Pinot Meurnier, (b) Zinfandel. Normalized average berry volume is calculated as $V/(V_{max}* Nb)$ where V is cluster volume , V_{max} is maximum cluster volume at the end of phase III (ca 80 DAF), and Nb is the number of berries per cluster. Normalized DAF was obtained upon synchronizing all veraison dates (growth resumption, phaseII/phase III transition) at 55 DAF.

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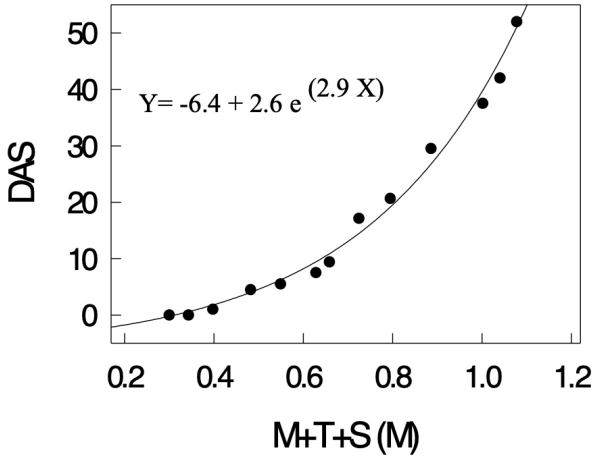


Figure S9. Relationship between DAS and total solutes concentration (Malate + Tartrate + Sugars) of Syrah berries harvested in 2015. $y = x\text{-}6.4 + 2.6e^{(2.9x)}$, $R^{2x} = 0.993$, $P \leq 0.0001$.

Each point corresponds to average values obtained on samples of 30 berries harvested at each date (see Figure 6b). 500 individual berries were ranked according to totale solutes (M+T+S), before calculating average values and standard deviation on every successive 0.05M (M+T+S) intervals. The number of berry per 0.05 M class varies from(9-26 berries) with an average value of (16).

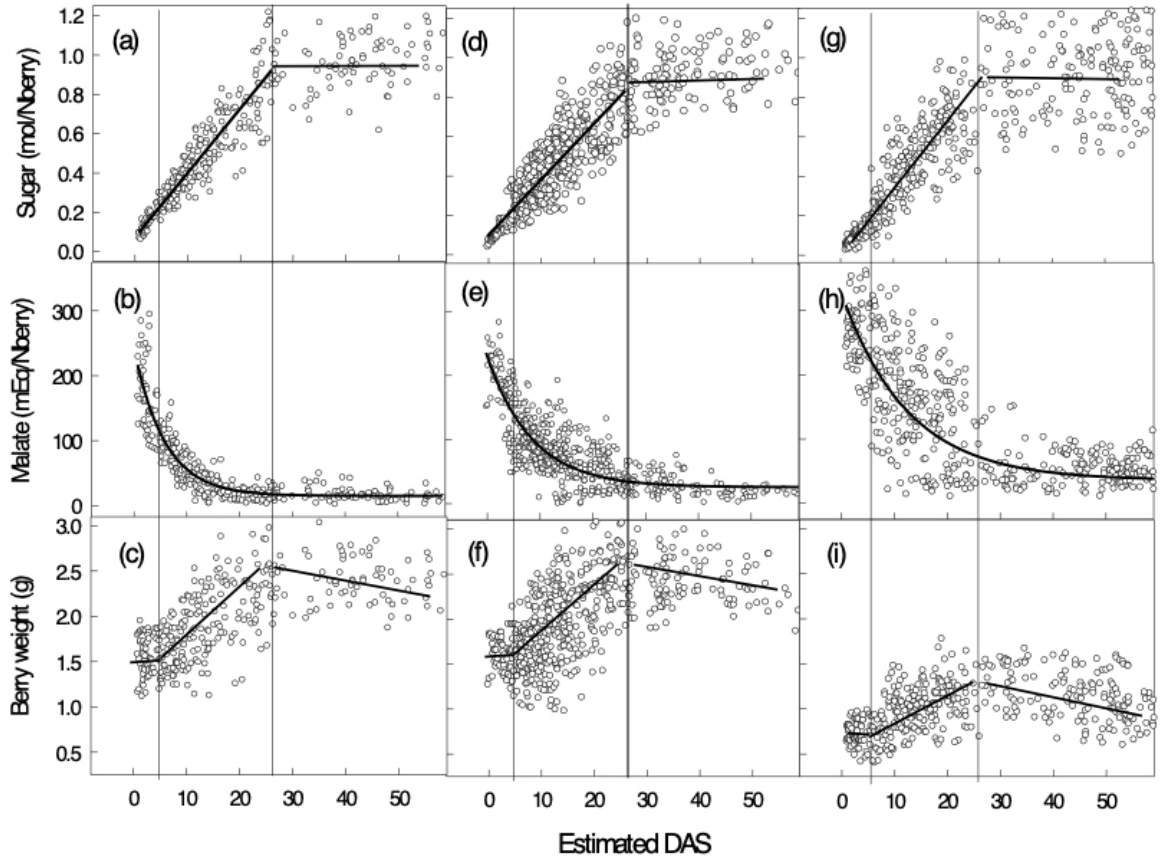


Figure S10. Kinetics of sugar accumulation (a, d, g), malate breakdown (b, e, h) and growth (c, f, i) in individual berries.

(a, b, c) : crude results on synchronized Syrah berries, (d, e, f) : recalculated durations on randomly sampled Syrah berries and (g, h, i) : Meunier berries, cluster based sampling. Results were expressed for, respectively, 385 and 833 berries in Syrah and Meunier, in order to consider 1 kg fresh weight at the completion of phloem unloading in both cultivars. DAS was estimated from total solutes according to the exponential fitting in synchronized syrah (see Figure 8). Berry weight and sugar accumulation linear regression (a): (y = 0.07+0.034x, r = 0.91), (d): (y = 0.1+0.028x, r = 0.85), (g): (y = 0.03+0.03x, r = 0.88), (c): (y = 1.4+0.04x, r = 0.56), (f): (y = 1.4+0.05x, r = 0.49), (i): (y = 0.66+0.02x, r = 0.47). Malate exponential decay, (b): ($y = 15+226\ e^{-0.14x}$, r = 0.91), (h): ($y = 26+204\ e^{-0.1x}$, r = 0.85), (h): ($y = 35+291\ e^{-0.08x}$, r = 0.78).

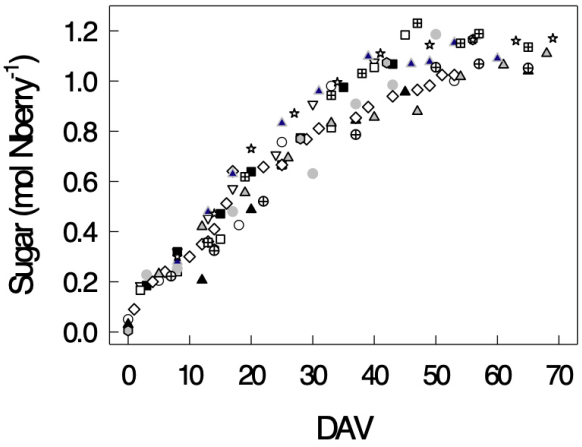


Figure S11. Normalized sugar accumulation in various cultivars, recalculated from literature data on concentration and volume. Data are from Davies *et al.* (1996), Rogiers *et al.* (1997), McCarthy and Coombe (1999), Coombe and McCarthy (2000), Famiani *et al.* (2016) as determined in Table S2.

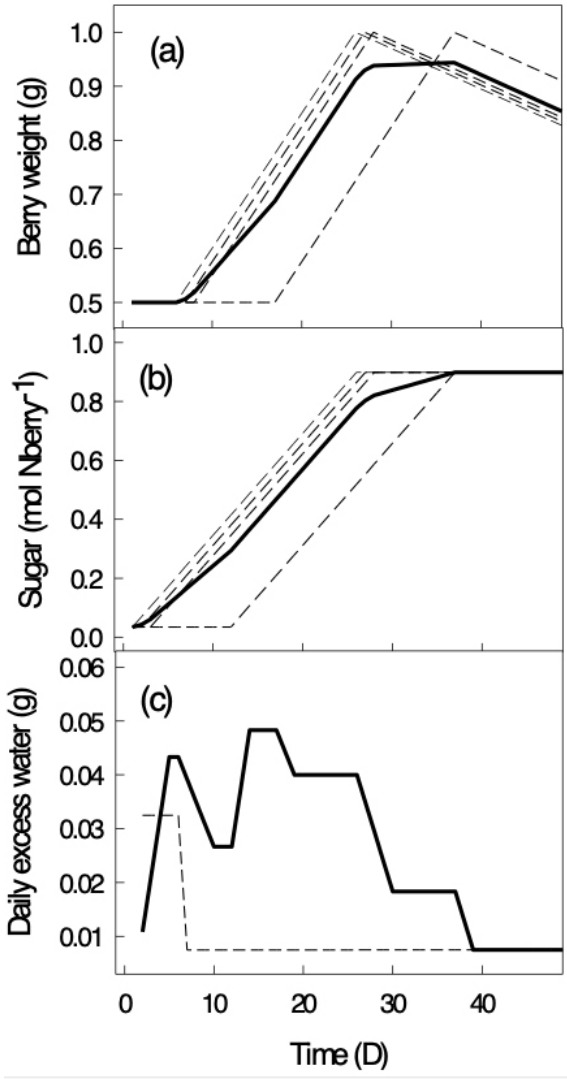


Figure S12. Proof of concept that sugar accumulation at constant volume may represent an averaging artefact.
Four identical but delayed berries presenting the development pattern documented here are considered (dotted lines): growth resumes 6 days later than the onset of sugar accumulation, then water and sugar accumulate simultaneously for 20 days. Phloem unloading totally stops at 0.9 M sugars, before immediate berry shriveling. Averaging these four non-synchronized berries (black line) generates an artefactual excess of water during mid and late ripening. Daily excess water is calculated as: (half imported hexose/0.532)-daily imported volume, according to Figure 2 in Jensen *et al.* (2013).

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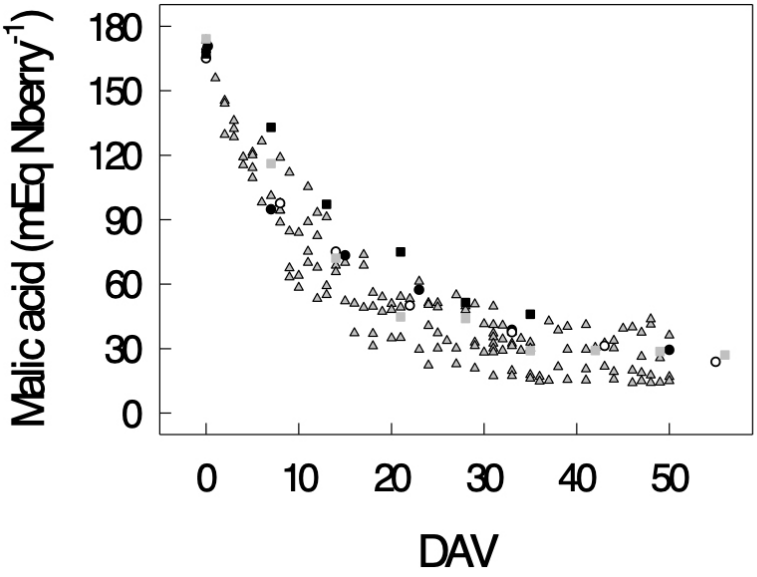


Figure S13. Malic acid breakdown in various cultivars, recalculated from concentration and volume data in the literature. Data from Duchêne *et al.* (2014) triangle up, Bobeica *et al.* (2015), Famiani *et al.* (2016) see Table S3.

Table S1. Berry development in Zinfandel and Pinot Meunier clusters flowering at different dates.

Cultivars	Clusters			Flowering date	Growth rate [a]		
	N° berries	Cluster weight (g)	Mean berry weight (g)		Phase (I)	Phase (III)	Over ripening [a]
Pinot Meunier	165	199	1.31	05.12.2015	0.77	0.71	-0.3
	119	185	1.55	05.15.2015	0.76	0.7	-0.23
	74	131	1.77	05.22.2015	0.71	0.67	-0.2
	51	93	1.82	05.26.2015	0.73	062	-0.2
Mean	102.25	152	1.59		0.74 (NS)	0.67(NS)	-0.2
SD	50.47	49	0.28		0.03	0.04	-0.03
Zinfandel	141	290	1.94	05.16.2015	0.77	0.67	-0.19
	133	228	1.71	05.18.2015	0.75	0.69	-0.24
	112	217	2.05	06.03.2015	0.7	0.67	-0.2
	73	164	2.25	06.06.2015	0.68	0.6	-0.2
Mean	114.75	224.75	1.99		0.72 (NS)	0.66 (NS)	-0.2
SD	30.4	51.7	0.23		0.05	0.04	-0.03

Values with (NS) are non significantly different (Wilcox: $P > 0.05$). [a] mmol H_2O min^{-1} $Nberry^{-1}$.

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Table S2. The intensity of sugar accumulation in different cultivars (recalculated from literature data).

References	Cultivars	Duration	Max berry weight (g)	Final sugars (mol Nberry^{-1})	Sugars accumulation rate (µmol min^{-1} Nberry^{-1})
Famiani *et al.* (2016)	Pinot Noir	40	1.5	1.08	18.80
	Sagrantino	60	1.6	1.13	13.04
Coombe and McCarthy (2000)	Muscat G.B	40	3.3	1.17	20.24
		43	3.3	1.16	18.68
		45	3	1.28	19.79
		57	2.2	1.28	15.65
Rogiers *et al.* (2006)	Shiraz	56	1.3	1.11	13.76
Davies *et al.* (1997)	Shiraz	56	1.5	1.26	15.65
Davies *et al.* (1996)	Shiraz	56	1.3	1.20	14.91
McCarthy and Coombe (1999)	Shiraz	45	1.6	1.18	18.23
		50	1.65	1.27	17.60
		45	1.8	1.14	17.57
		47	1.4	1.23	18.17
Mean		49.23	1.96	1.19	17.08
SD		6.97	0.75	0.07	2.27
CI		3.79	0.41	0.03	1.24

Table S3. The intensity of malate breakdown in some cultivars (calculated from literature data).

References	Cultivars	Malate Breakdown duration	Max Berry weight (g)	Véraison malate (mEq Nberry^{-1})	Malate breakdown (µmol min^{-1}Nberry^{-1})
Famiani *et al.* (2016)	Sagrantino	36	1.6	146	1.4
	Pinot noir	28	1.5	171	2.1
Duchêne *et al.* (2014)	Riesling	30	1.4	181	2.1
	Gewurztraminer	30	1.6	162	1.9
Bobeica *et al.* (2015)	Sangiovese	35	1.8	186	1.9
Mean		32	1.6	166	1.9
SD		3	0.13	14	0.24
CI		2.5	0.11	11	0.2

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