Table S1. Collected hyperspectral vegetation indices in this study.

	Vegetation index	Abbreviation	Equation	References
Chlorophyll related	Normalized difference vegetation index	NDVI	(N - R)/(N + R)	[48]
	Soil adjusted vegetable index	SAVI	1.5*(N-R)/(N+R+0.5)	[49]
	Optimized Soil adjusted vegetation index	OSAVI	(N - R) / (N + R + 0.16)	[50]
	Modified Chlorophyll Absorption in Reflectance Index	MCARI	((RE1 - R) - 0.2 * (RE1 - G)) * (RE1 / R)	[51]
	Transformed Chlorophyll Absorption in Reflectance Index	TCARI	3 * ((RE1 - R) - 0.2 * (RE1 - G) * (RE1 / R))	[52]
	Modified soil adjustment vegetation index	MSAVI	0.5 * (2.0 * N + 1 - (((2 * N + 1) ** 2) - 8 * (N - R)) ** 0.5)	[53]
	Simple Ratio	SR	N/R	[54]
Water related	Normalized Difference Water Index	NDWI	(G - N) / (G + N)	[55]
	Normalized Difference Greenness Index	NDGI	(((lambdaN - lambdaR)/(lambdaN - lambdaG)) * G + (1.0 - ((lambdaN - lambdaR)/(lambdaN - lambdaG))) * N - R)/(((lambdaN - lambdaR)/(lambdaN - lambdaG)) * G + (1.0 - ((lambdaN - lambdaR)/(lambdaN - lambdaG))) * N + R)	[56]
	Ratio vegetation index	RVI	RE2 / R	[57]
	Difference vegetation index	DVI	N-R	[58]
	Renormalized Difference Vegetation Index	RDVI	(N-R)/$\sqrt{N+R}$	[58]
	Modified simple ratio index	MSR	$(N/R-1)/\sqrt{N/R+1}$	[59]
	Non-Linear Vegetation Index	NLI	((N^2)-R)/((N^2)+R)	[60]
	Green Chlorophyll Index	GCI	N/G–1	[61]
N ang K related	Leaf Chlorophyll Index	LCI	(N-RE2)/(N+R)	[62]
	Normalized Difference Red Edged Index	NDRE	(N-RE1)/(N+RE1)	[63]
	Green normalized difference vegetation index	GNDVI	(N-G)/(N+G)	[64]

Red-edge Chlorophyll Index	Clre	RE1/RE2-1	[65]
Chlorophyll green index	Clgreen	N/G-1	[65]
Plant biochemical index	PBI	N/G	[66]
Plant pigment ratio	PPR	(G-B)/(G+B)	[66]
Two-Band Enhanced Vegetation Index	EVI2	2.5*(N-R)/(N+2.4*R+0.5)	[67]
Greenness index	GI	G/R	[68]
Normalized Difference Vegetation Index	NDVI705	(RE2-RE1)/(RE2+RE1)	[63]
Nitrogen reflectance index	NRI	(G-R)/(G+R)	[69]
Anthocyanin Reflectance Index	ARI	(1/G)/(1/RE1)	[70]
Modified Normalized Difference	mND705	(RE2-RE1)/(RE2+RE1-1)	[71]
Modified Simple Ratio	mSR705	$(\mathrm{RE2}-1)/\sqrt{\mathrm{RE2}+1}$	[71]
MERIS Terrestrial Chlorophyll Index	MTCI	(RE2-RE1)/(RE1-R)	[72]
Transformed Vegetation Index	TVI	(((N - R)/(N + R)) + 0.5) ** 0.5	[73]
Spectral polygon vegetation index	SPVI	0.4*[3.7*(N-R)-1.2*(G-R)]	[73]
Enhanced vegetation index	EVI	2.5(N-R)/(N+6R-7.5B+1)	[49]

Note: B, G, R, RE1, RE2, and N represent the spectral bands of blue, green, red, red-edge 1, red-edge 2, and near-infrared, respectively, with reflectance at 460 nm, 550 nm, 680 nm, 705 nm, 750 nm, and 916 nm.

Table S2. Color features extracted from RGB and hyperspectral images in this study

Color index	Abbreviation	Equation	References
Normalized Red Index	r	R/(R+G+B)	[74]
Normalized Green Index	g	G/(R+G+B)	[74]
Normalized Blue Index	b	B/(R+G+B)	[74]
Green Blue Difference Index	GBDI	G-B	[75]
Excess Green	EGVI	2×G-R-B	[76]
Vegetation Index Excess Red Vegetation Index	ERVI	1.4×R-B	[76]
Gray	Gray	(0.2898×R)+(0.5870×G)+(0.1140×B)	[77]
Red Green Ratio Index	RGRI	R/G	[78]
Excess Red Index	ExR	(1.4×R-G)/(G+R+B)	[76]
Excess GreenVegetation Index	ExG	(2×G-R-B)/(G+R+B)	[79]
Excess Blue Index	ExB	(1.4×B-G)/(G+R+B)	[79]

Excess Green Minus Excess Red	ExGR	ExG-ExR	[80]
Normalized Green Blue Difference Index	NGBDI	(G-B)/(G+B)	[81]
Woebbecke Index	WI	(G-B)/(R-G)	[79]
Normalized Pigment Chlorophyll Ratio Index	NPCI	(R-B)/(R+B)	[68]
Normalized Green Red Difference Index	NGRDI	(G-R)/(G+R)	[48]
Visible Atmospherically Resistance Index	VARVI	(G-R)/(G+R-B)	[82]
Green Leaf Index	GLI	(2×G-R-B)/(2×G+R+B)	[79]
Hue Index	HI	(2×R-G-B)/(G-B)	[83]
True Color Vegetation Index	TCVI	1.4×(2×R-2×B)/(2×R-G-2×B+0.4)	[84]
Color Index Of Vegetation	CIVE	0.441×R-0.881×G+0.385×B+18.78745	[85]
Red Green Blue Vegetation Index	RGBVI	((G×G)-(B×R))/(G×G)+(B×R))	[86]
Modified Green Blue Vegetation Index	MGBVI	(G×G)-(B×B))((G×G)+(B×B))	[87]
Modified Green Blue Vegetation Index	MGRVI	(G2-R2)(G2+R2)	[86]
Redness Index	RI	R2/(B×G3)	[88]
Brightness Index	BI	$\sqrt{((R^2 + G^2)/2}$	[83]
Excess Green index	EGI	2×g-r-b	[79]
Visible Atmospherically Resistant Index	VARI	(g-r)/(g+r-b)	[82]

Note: R, G, and B represent the average values extracted from the region of interest of the image. Hyperspectral images are color images synthesized at 460, 550, and 680nm.

Table S3. Hyperparameters in the selected regression algorithms.

Method [a]	Model parameters	Definition	Value
PLSR	"n_components"	Number of components to keep.	Ranged from 1 to 50 and in intervals of 1
GPR	"kernel"	The specified kernel function type.	"RBF", "Matern", "RationalQuadratic", "ExpSineSquared"
	"alpha"	Represents the noise variance in the observed data	1e-10, 1e-2, 0.1, 1.0
BRR	"alpha_1"	The α_1 prior parameters of noise variance	Ranged from 10^{-6} to 1 and in intervals of 5
	"alpha_2"	The α_2 prior parameters of noise variance	Ranged from 10^{-6} to 1 and in intervals of 5
	"lambda_1"	The λ_1 prior parameters of the weight prior	Ranged from 10^{-6} to 1 and in intervals of 5
	"lambda_2"	The λ_2 prior parameters of the weight prior	Ranged from 10^{-6} to 1 and in intervals of 5

[a] Regression methods: PLSR = Partial Least Squares Regression, GPR = Gaussian process regression, BRR = Bayesian ridge regression.

Table S4 Introduction to model performance indicators

Index	Formula	Explanation
R2	$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2}$	The closer to 1, the better, it indicates the model's explanatory power
RMSE	$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}$	The absolute magnitude of the error, the smaller the better
NRMSE	$NRMSE = \frac{RMSE}{y_{max} - y_{min}}$	Standardized errors for facilitate comparison across datasets
RPD	$RPD = \frac{\sqrt{\frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n-1}}}{RMSE}$	The larger the better, >2 means the model predicts good

In the formula: y_i:measured value, $\bar{y}$: Average measured value, $\hat{y}_i$: Predicted value, n: sample size.

Table S5. The prediction results of the PLSR model for the functional traits of grape leaves under different pretreatments

Leaf traits	Pretreatment	Calibration set			Validation set		
		R^2	*NRMSE*	*RPD*	R^2	*NRMSE*	*RPD*
SPAD	OR	0.8956	0.0731	3.0944	0.8392	0.0977	2.4934
	SNV	0.9609	0.0423	5.0569	0.8427	0.0903	2.521
	MA	0.8897	0.0751	3.0114	0.8437	0.0963	2.5294
	SG	**0.8896**	**0.0752**	**3.0095**	**0.8572**	**0.092**	**2.6461**
	MSC	0.9525	0.0467	4.5904	0.857	0.0944	2.644
LNC	OR	0.5759	0.1189	1.5356	0.5508	0.1308	1.492
	SNV	0.6873	0.1006	1.7883	0.6439	0.1243	1.6758
	MA	0.5822	0.118	1.5471	0.5635	0.129	1.5135
	SG	0.5988	0.1207	1.5787	0.5592	0.1331	1.5063
	MSC	**0.7071**	**0.1**	**1.8478**	**0.67**	**0.1185**	**1.7408**
LKC	OR	0.6859	0.1283	1.7842	0.6483	0.1271	1.6862
	SNV	**0.7828**	**0.1081**	**2.1459**	**0.7127**	**0.1125**	**1.8656**
	MA	0.6657	0.1324	1.7296	0.6346	0.1296	1.6543
	SG	0.6644	0.1326	1.7261	0.637	0.1292	1.6598
	MSC	0.7088	0.1068	1.8531	0.6617	0.1464	1.7192
FWC	OR	0.7908	0.1006	2.1864	0.7777	0.1256	2.121
	SNV	0.8754	0.0797	2.8333	0.8254	0.0979	2.393
	MA	0.7661	0.1063	2.0675	0.7384	0.1362	1.9552
	SG	0.8143	0.0947	2.3208	0.7907	0.1219	2.1858
	MSC	**0.8643**	**0.082**	**2.7142**	**0.8611**	**0.0981**	**2.6833**
DWC	OR	0.819	0.0872	2.3504	0.7967	0.1157	2.2178
	SNV	0.959	0.0454	4.9357	0.8506	0.0893	2.5869
	MA	**0.8888**	**0.0684**	**2.9991**	**0.8819**	**0.0882**	**2.9099**
	SG	0.8799	0.071	2.885	0.8686	0.0922	2.7588
	MSC	0.9662	0.0374	5.4415	0.8728	0.0894	2.8042

Table S6. The prediction results of the GPR model for the functional traits of grape leaves under different pretreatments

Leaf traits	Pretreatment	Training set			Test set		
		R^2	*NRMSE*	*RPD*	R^2	*NRMSE*	*RPD*
SPAD	OR	0.8306	0.0875	2.4299	0.781	0.1183	2.1368
	SNV	**0.8641**	**0.0794**	**2.7129**	**0.8259**	**0.0895**	**2.3968**
	MA	0.8203	0.0901	2.3592	0.7819	0.1181	2.1411
	SG	0.8298	0.0877	2.4242	0.7809	0.1183	2.1362
	MSC	0.8783	0.0742	2.8664	0.7866	0.1168	2.1647
LNC	OR	0.7779	0.0891	2.1218	0.506	0.132	1.4228
	SNV	0.7887	0.082	2.1753	0.5244	0.1579	1.45
	MA	0.4111	0.1452	1.3031	0.3732	0.1487	1.2631
	SG	0.7773	0.0893	2.1192	0.5059	0.132	1.4226

	MSC	**0.7111**	**0.0973**	**1.8604**	**0.6173**	**0.1264**	**1.6165**
	OR	0.9762	0.0305	6.4802	0.5118	0.1759	1.4312
	SNV	0.833	0.0814	2.4471	0.572	0.157	1.5285
LKC	MA	0.7764	0.0936	2.1145	0.4918	0.1794	1.4028
	SG	0.5737	0.1301	1.5316	0.5354	0.1636	1.4671
	MSC	**0.8322**	**0.0816**	**2.441**	**0.5757**	**0.1563**	**1.5352**
	OR	0.8506	0.0866	2.5869	0.7551	0.1234	2.0207
	SNV	0.8828	0.0843	2.9215	0.725	0.123	1.9069
FWC	MA	0.8471	0.0875	2.5578	0.7454	0.1258	1.9818
	SG	0.8502	0.0867	2.584	0.755	0.1234	2.0202
	MSC	**0.8742**	**0.0794**	**2.8197**	**0.8065**	**0.1097**	**2.2732**
	OR	0.8612	0.0811	2.6837	0.7378	0.115	1.9527
	SNV	0.8821	0.0804	2.9122	0.7551	0.1178	2.0206
DWC	MA	0.8577	0.0821	2.6512	0.7282	0.1171	1.9182
	SG	0.8609	0.0812	2.6813	0.7375	0.1151	1.9516
	MSC	**0.8859**	**0.0736**	**2.96**	**0.7671**	**0.1084**	**2.072**

Table S7. The prediction results of the BRR model for the functional traits of grape leaves under different pretreatments

Leaf traits	Pretreatment	Training set			Test set		
		R^2	*NRMSE*	*RPD*	R^2	*NRMSE*	*RPD*
	OR	0.8759	0.0749	2.8385	0.8139	0.1091	2.3179
	SNV	**0.8464**	**0.0841**	**2.5515**	**0.8446**	**0.0984**	**2.5369**
SPAD	MA	0.7969	0.0967	2.2191	0.7929	0.1136	2.1973
	SG	0.868	0.078	2.752	0.8243	0.1046	2.3855
	MSC	0.8413	0.0855	2.5101	0.8408	0.0996	2.506
	OR	**0.6783**	**0.1048**	**1.7632**	**0.6461**	**0.1227**	**1.6809**
	SNV	0.7017	0.1009	1.8311	0.6406	0.1237	1.668
LNC	MA	0.6231	0.1161	1.6289	0.5524	0.1256	1.4947
	SG	0.6498	0.1119	1.6898	0.561	0.1244	1.5093
	MSC	0.6896	0.103	1.7949	0.6367	0.1244	1.659
	OR	0.6801	0.1295	1.768	0.6452	0.1277	1.6789
	SNV	**0.8307**	**0.0814**	**2.4302**	**0.6698**	**0.1446**	**1.7402**
LKC	MA	0.646	0.1362	1.6807	0.6137	0.1333	1.609
	SG	0.6591	0.1337	1.7128	0.6377	0.1291	1.6613
	MSC	0.7332	0.1022	1.9359	0.6548	0.1479	1.702
	OR	0.8179	0.0938	2.3431	0.8024	0.1184	2.2499
	SNV	**0.901**	**0.07**	**3.1777**	**0.8438**	**0.104**	**2.5301**
FWC	MA	0.7757	0.1041	2.1113	0.7422	0.1352	1.9695
	SG	0.8	0.0983	2.2363	0.7893	0.1223	2.1783
	MSC	0.8816	0.0766	2.9059	0.8405	0.1051	2.5042
	OR	0.8861	0.0711	2.9626	0.8265	0.1045	2.4007
DWC	**SNV**	**0.9373**	**0.0528**	**3.9921**	**0.8582**	**0.0945**	**2.6551**
	MA	0.8891	0.0701	3.0035	0.837	0.1012	2.4772

	SG	0.8938	0.0686	3.0681	0.8474	0.098	2.56
	MSC	0.9399	0.0516	4.0787	0.8481	0.0978	2.5654

Table S8. The prediction results of the PLSR model for functional traits of grape leaves under different feature selections

Leaf traits	Pretreatment	Feature selection	Training set			Test set		
			R^2	*NRMSE*	*RPD*	R^2	*NRMSE*	*RPD*
		CARS	**0.8723**	**0.0767**	**2.7982**	**0.8676**	**0.0908**	**2.7484**
SPAD	SG	LASSO	0.8758	0.0756	2.8376	0.857	0.0944	2.6441
		RFE	0.7545	0.106	2.0181	0.7264	0.1191	1.9117
		CARS	**0.7199**	**0.0978**	**1.8895**	**0.7132**	**0.1105**	**1.8674**
LNC	MSC	LASSO	0.7244	0.0993	1.905	0.6947	0.1038	1.8097
		RFE	0.4602	0.139	1.3611	0.4298	0.1418	1.3243
		CARS	**0.753**	**0.1138**	**2.0121**	**0.7209**	**0.1133**	**1.8929**
LKC	SNV	LASSO	0.7322	0.102	1.9323	0.6471	0.1464	1.6833
		RFE	0.4162	0.1583	1.3088	0.3922	0.1699	1.2826
		CARS	**0.9025**	**0.0687**	**3.2018**	**0.8733**	**0.0948**	**2.8093**
FWC	MSC	LASSO	0.8712	0.0789	2.7864	0.8607	0.0994	2.6796
		RFE	0.8763	0.0754	2.8438	0.8684	0.0925	2.7564
		CARS	0.8399	0.082	2.4993	0.8351	0.1042	2.4626
DWC	MA	**LASSO**	**0.8764**	**0.072**	**2.8441**	**0.8724**	**0.0909**	**2.799**
		RFE	0.8143	0.0908	2.3207	0.81	0.1093	2.2942

Table S9. The prediction results of the GPR model for functional traits of grape leaves under different feature selections

Leaf traits	Pretreatment	Feature selection	Training set			Test set		
			R^2	*NRMSE*	*RPD*	R^2	*NRMSE*	*RPD*
		CARS	**0.8256**	**0.0888**	**2.3944**	**0.7924**	**0.1152**	**2.195**
SPAD	SG	LASSO	0.8334	0.0868	2.4499	0.7911	0.1155	2.1877
		RFE	0.7603	0.1041	2.0423	0.6776	0.1435	1.7611
		CARS	0.7325	0.0978	1.9335	0.6382	0.113	1.6626
LNC	MSC	**LASSO**	**0.7325**	**0.0978**	**1.9334**	**0.6674**	**0.1083**	**1.734**
		RFE	0.6179	0.1169	1.6177	0.4248	0.1424	1.3185
		CARS	0.7936	0.104	2.2013	0.6221	0.1318	1.6268
LKC	SNV	**LASSO**	**0.7537**	**0.1028**	**2.0149**	**0.6422**	**0.1303**	**1.6717**
		RFE	0.4902	0.1479	1.4006	0.4032	0.1683	1.2945
		CARS	0.8663	0.0813	2.7348	0.8276	0.1093	2.4085
FWC	MSC	LASSO	0.8682	0.0808	2.7545	0.7803	0.1234	2.1333
		RFE	**0.8688**	**0.0806**	**2.761**	**0.8657**	**0.0965**	**2.7287**
		CARS	0.801	0.0915	2.2415	0.7036	0.1397	1.8368
DWC	MA	**LASSO**	**0.8117**	**0.089**	**2.3047**	**0.7343**	**0.1323**	**1.9399**
		RFE	0.7511	0.1023	2.0045	0.5696	0.1683	1.5243

Table S10. The prediction results of the BRR model for functional traits of grape leaves under different feature selections

Leaf traits	Pretreatment	Feature selection	Training set			Test set		
			R^2	*NRMSE*	*RPD*	R^2	*NRMSE*	*RPD*
		CARS	**0.8727**	**0.0766**	**2.8028**	**0.8632**	**0.0923**	**2.7034**
SPAD	SG	LASSO	0.8218	0.0897	2.3691	0.7842	0.1174	2.1527
		RFE	0.7616	0.1044	2.0481	0.7452	0.1149	1.981
		CARS	**0.7158**	**0.0985**	**1.8758**	**0.7014**	**0.1127**	**1.8299**
LNC	MSC	LASSO	0.713	0.1013	1.8665	0.6873	0.105	1.7882
		RFE	0.5698	0.1199	1.5246	0.3566	0.1534	1.2467
		CARS	**0.7553**	**0.1132**	**2.0213**	**0.7358**	**0.1102**	**1.9456**
LKC	SNV	LASSO	0.7062	0.1118	1.8448	0.6505	0.1296	1.6916
		RFE	0.4647	0.1565	1.3667	0.3975	0.2102	1.2883
		CARS	**0.9034**	**0.0681**	**3.217**	**0.8803**	**0.0854**	**2.8906**
FWC	MSC	LASSO	0.8777	0.0767	2.8595	0.8629	0.0915	2.7007
		RFE	0.8554	0.0851	2.6301	0.8088	0.109	2.2869
		CARS	0.7893	0.0941	2.1784	0.7265	0.133	1.912
DWC	MA	**LASSO**	**0.8275**	**0.0875**	**2.4075**	**0.8041**	**0.111**	**2.2595**
		RFE	0.7649	0.0994	2.0623	0.6994	0.1407	1.8239

Table S11. The prediction results of the PLSR model for the functional traits of grape leaves under different feature combinations

Leaf traits	Feature combination	Number of features	Calibration set			Validation set		
			R^2	*NRMSE*	*RPD*	R^2	*NRMSE*	*RPD*
	Ref+VIS	**89**	**0.9472**	**0.0494**	**4.3501**	**0.8713**	**0.0805**	**2.7876**
	Ref+HSI_CT	112	0.7993	0.0939	2.2320	0.7547	0.1082	2.0190
SPAD	Ref+RGB_CT	86	0.9110	0.0637	3.3515	0.8428	0.094	2.5224
	REF+VIS+HSI_CT	145	0.7836	0.1000	2.1495	0.7664	0.1084	2.0689
	Ref+VIS+RGB_CT	119	0.8770	0.0754	2.8515	0.8128	0.097	2.3113
	Ref+VIS	36	0.7215	0.0975	1.8948	0.7108	0.1109	1.8596
	Ref+HSI_CT	51	0.7460	0.0953	1.9842	0.6591	0.1096	1.7128
LNC	**Ref+RGB_CT**	**32**	**0.7438**	**0.0935**	**1.9757**	**0.7136**	**0.1104**	**1.8687**
	REF+VIS+HSI_CT	66	0.6882	0.1061	1.7908	0.6043	0.1324	1.5898
	Ref+VIS+RGB_CT	47	0.6672	0.1096	1.7335	0.6418	0.1259	1.6709
	Ref+VIS	54	0.7475	0.1176	1.9902	0.6935	0.1145	1.8063
	Ref+HSI_CT	**36**	**0.7833**	**0.1090**	**2.1484**	**0.7426**	**0.1049**	**1.9709**
LKC	Ref+RGB_CT	51	0.771	0.1095	2.0898	0.7069	0.1161	1.8471
	REF+VIS+HSI_CT	64	0.7709	0.112	2.0892	0.7014	0.113	1.83
	Ref+VIS+RGB_CT	79	0.755	0.1072	2.0202	0.6496	0.1387	1.6895
	Ref+VIS	62	0.9162	0.0637	3.4549	0.8727	0.088	2.8025
	Ref+HSI_CT	76	0.9259	0.0644	3.6733	0.8749	0.0828	2.8269
FWC	**Ref+RGB_CT**	**66**	**0.9033**	**0.0735**	**3.2155**	**0.8970**	**0.0751**	**3.116**
	REF+VIS+HSI_CT	102	0.9326	0.0586	3.8532	0.7376	0.1201	1.9521
	Ref+VIS+RGB_CT	92	0.9316	0.059	3.8244	0.8544	0.0894	2.6206

	Ref+VIS	496	0.8976	0.071	3.1254	0.8630	0.0839	2.702
	Ref+HSI_CT	535	0.8859	0.0755	2.9609	0.7157	0.1104	1.8753
DWC	**Ref+RGB_CT**	**499**	**0.9385**	**0.055**	**4.0314**	**0.8654**	**0.0832**	**2.7254**
	REF+VIS+HSI_CT	533	0.928	0.0595	3.7268	0.8475	0.0885	2.5606
	Ref+VIS+RGB_CT	572	0.9493	0.0508	4.4407	0.6998	0.1124	1.8252

Note: Ref: Spectral information after preprocessing and feature selection. VIS: Vegetation Index. HSI_CT: Hyperspectral image features (including color features and texture features). RGB_CT: RGB image features (including color and texture features), the same below.

Table S12. The prediction results of the GPR model for the functional traits of grape leaves under different feature combinations

Leaf traits	Feature combination	Number of features	Calibration set			Validation set		
			R^2	*NRMSE*	*RPD*	R^2	*NRMSE*	*RPD*
	Ref+VIS	89	0.9508	0.0476	4.5105	0.7809	0.1168	2.1364
	Ref+HSI_CT	112	0.8931	0.0695	3.0592	0.7883	0.1163	2.1733
SPAD	Ref+RGB_CT	86	0.8639	0.0785	2.7103	0.8119	0.1115	2.3059
	REF+VIS+HSI_CT	145	0.8658	0.0779	2.7297	0.7894	0.116	2.1791
	Ref+VIS+RGB_CT	**119**	**0.9323**	**0.0558**	**3.8433**	**0.8246**	**0.1045**	**2.388**
	Ref+VIS	36	0.9627	0.0365	5.1806	0.5573	0.1249	1.503
	Ref+HSI_CT	51	0.7634	0.0881	2.0561	0.6077	0.1279	1.5965
LNC	Ref+RGB_CT	32	0.6808	0.1023	1.7699	0.6246	0.1252	1.6321
	REF+VIS+HSI_CT	66	0.9715	0.0319	5.9219	0.459	0.1381	1.3596
	Ref+VIS+RGB_CT	**47**	**0.7219**	**0.0955**	**1.8962**	**0.6283**	**0.1245**	**1.6403**
	Ref+VIS	54	0.8036	0.1037	2.2564	0.6144	0.1284	1.6103
	Ref+HSI_CT	**36**	**0.8033**	**0.1015**	**2.255**	**0.6338**	**0.1297**	**1.6526**
LKC	Ref+RGB_CT	51	0.7462	0.1179	1.985	0.6037	0.1302	1.5885
	REF+VIS+HSI_CT	64	0.8243	0.096	2.3855	0.5929	0.1368	1.5672
	Ref+VIS+RGB_CT	79	0.7175	0.1244	1.8815	0.5751	0.1348	1.5341
	Ref+VIS	62	0.8913	0.0735	3.0334	0.7236	0.1248	1.9022
	Ref+HSI_CT	76	0.8522	0.0855	2.6007	0.7015	0.1438	1.8302
FWC	Ref+RGB_CT	66	0.894	0.0724	3.071	0.7777	0.1241	2.1211
	REF+VIS+HSI_CT	102	0.8369	0.0888	2.476	0.7225	0.1299	1.8983
	Ref+VIS+RGB_CT	**92**	**0.8885**	**0.0748**	**2.9949**	**0.7925**	**0.1135**	**2.1954**
	Ref+VIS	496	0.8115	0.089	2.3032	0.7337	0.1324	1.938
	Ref+HSI_CT	535	0.8792	0.0757	0.0757	0.7253	0.1177	1.9078
DWC	**Ref+RGB_CT**	**499**	**0.8738**	**0.0774**	**2.8145**	**0.7982**	**0.1009**	**2.2258**
	REF+VIS+HSI_CT	533	0.8781	0.076	2.8639	0.7884	0.1033	2.174
	Ref+VIS+RGB_CT	572	0.896	0.0702	3.101	0.7699	0.1078	2.0846

Table S13. The prediction results of the BRR model for the functional traits of grape leaves under different feature combinations

Feature combination	Calibration set	Validation set

Leaf traits		Number of features	R^2	*NRMSE*	*RPD*	R^2	*NRMSE*	*RPD*
	Ref+VIS	**89**	**0.8917**	**0.0734**	**3.0384**	**0.879**	**0.0818**	**2.8744**
	Ref+HSI_CT	112	0.806	0.0945	2.2703	0.7843	0.1159	2.1533
SPAD	Ref+RGB_CT	86	0.8053	0.0904	2.2662	0.7875	0.1069	2.1692
	REF+VIS+HSI_CT	145	0.8296	0.092	2.4225	0.7833	0.1094	2.148
	Ref+VIS+RGB_CT	119	0.8639	0.0822	2.7105	0.8396	0.0942	2.4966
	Ref+VIS	36	0.7257	0.0914	1.9093	0.7	0.1207	1.8257
	Ref+HSI_CT	51	0.7245	0.0993	1.9051	0.6591	0.1096	1.7127
LNC	**Ref+RGB_CT**	**32**	**0.7313**	**0.0958**	**1.929**	**0.7137**	**0.1104**	**1.8688**
	REF+VIS+HSI_CT	66	0.7122	0.1015	1.8641	0.6295	0.1143	1.6428
	Ref+VIS+RGB_CT	47	0.7324	0.0956	1.9331	0.6887	0.1151	1.7923
	Ref+VIS	54	0.7511	0.1168	2.0044	0.6954	0.1141	1.812
	Ref+HSI_CT	**36**	**0.757**	**0.1154**	**2.0284**	**0.7041**	**0.1125**	**1.8383**
LKC	Ref+RGB_CT	51	0.727	0.1212	1.9139	0.6993	0.1151	1.8236
	REF+VIS+HSI_CT	64	0.747	0.1178	1.9879	0.6597	0.1206	1.7142
	Ref+VIS+RGB_CT	79	0.7461	0.1092	1.9846	0.647	0.1392	1.6831
	Ref+VIS	**62**	**0.9141**	**0.0682**	**3.411**	**0.8764**	**0.0744**	**2.8443**
	Ref+HSI_CT	76	0.8619	0.0808	2.6912	0.8196	0.1059	2.3545
FWC	Ref+RGB_CT	66	0.903	0.0677	3.2115	0.8727	0.0889	2.8029
	REF+VIS+HSI_CT	102	0.8615	0.081	2.6866	0.7992	0.1117	2.2316
	Ref+VIS+RGB_CT	92	0.8989	0.0707	3.1444	0.8512	0.1015	2.5923
	Ref+VIS	496	0.8906	0.0739	3.0229	0.8663	0.0757	2.735
	Ref+HSI_CT	535	0.8648	0.0822	2.7194	0.7262	0.1083	1.9111
DWC	Ref+RGB_CT	499	0.888	0.0722	2.9878	0.8469	0.089	2.5555
	REF+VIS+HSI_CT	**533**	**0.9206**	**0.063**	**3.5494**	**0.8834**	**0.0707**	**2.9285**
	Ref+VIS+RGB_CT	572	0.8153	0.0928	2.3269	0.6753	0.1296	1.7549