Supplementary Table 1. Descriptive statistics of quality-related traits in the population of 94 RILs derived from a cross between ‘Boramchan’ and ‘Pecos’ across two years.

Year	Trait[z]	Mean	SD[y]	CV (%)	Median	Min	Max	Range	Skew	Kurtosis	SE	Unimodality[x]	Bimodality
2022	HR	65.95	18.57	28.16	66.23	17.33	96.03	78.70	−0.28	−0.45	1.91	TRUE	FALSE
	OR	13.99	13.13	93.85	10.52	0.23	54.40	54.17	1.16	0.79	1.35	TRUE	FALSE
	BR	18.97	7.94	41.86	20.83	2.77	31.13	28.37	−0.54	−0.86	0.82	TRUE	FALSE
	DR	0.61	0.66	108.20	0.33	0	3.63	3.63	1.90	4.25	0.07	TRUE	FALSE
	WT	48.91	3.62	7.40	48.4	39.4	57.47	18.07	0.21	−0.18	0.37	TRUE	FALSE
	PaT	73.83	1.41	1.91	73.68	70.72	76.87	6.15	0.03	−0.82	0.14	FALSE	TRUE
	PV	271.46	30.42	11.21	270.58	203.19	340.5	137.31	0.08	−0.41	3.14	TRUE	FALSE
	TV	144.97	21.01	14.49	143.33	91.47	213.00	121.53	0.26	0.72	2.17	TRUE	FALSE
	FV	247.60	25.61	10.34	246.35	173.53	318.42	144.89	−0.07	0.68	2.64	TRUE	FALSE
	BD	126.49	25.67	20.29	127.40	61.17	181.81	120.64	0.06	−0.39	2.65	TRUE	FALSE
	SB	−23.86	27.35	−114.63	−25.22	−95.08	44.53	139.61	−0.29	−0.06	2.82	TRUE	FALSE
	Toyo	75.46	4.38	5.80	75.35	64.35	86.87	22.52	0.21	−0.07	0.45	TRUE	FALSE
	HN	58.83	6.96	11.83	58.26	42.49	84.77	42.28	0.54	0.94	0.72	TRUE	FALSE
	TN	39.39	3.56	9.04	39.19	33.19	48.03	14.84	0.40	−0.47	0.37	TRUE	FALSE
	AN	54.07	4.07	7.53	54.51	37.86	62.75	24.89	−0.77	1.59	0.42	FALSE	TRUE
	SN	66.72	8.46	12.68	65.26	51.75	86.68	34.93	0.39	−0.79	0.87	FALSE	TRUE
2023	HR	64.28	19.99	31.10	68.30	7.63	95.85	88.22	−0.67	−0.05	2.06	TRUE	FALSE
	OR	21.81	16.77	76.89	17.51	0.73	73.42	72.68	0.84	0.00	1.73	TRUE	FALSE
	BR	12.08	6.47	53.56	11.14	2.12	25.10	22.98	0.30	−1.10	0.67	FALSE	TRUE
	DR	1.27	1.52	119.69	0.82	0.10	11.68	11.58	3.89	21.65	0.16	TRUE	FALSE
	WT	45.28	6.43	14.20	46.48	24.50	55.98	31.48	−1.07	1.12	0.66	TRUE	FALSE
	PaT	74.84	1.47	1.96	74.80	70.46	77.36	6.90	−0.24	−0.66	0.15	FALSE	TRUE
	PV	263.43	27.34	10.38	266.82	185.58	329.44	143.85	−0.75	0.90	2.82	TRUE	FALSE
	TV	149.04	26.95	18.08	147.85	85.83	213.69	127.85	−0.01	−0.34	2.78	TRUE	FALSE
	FV	244.62	31.98	13.07	247.36	157.67	307.23	149.56	−0.56	0.21	3.30	TRUE	FALSE
	BD	114.36	22.86	19.99	112.83	54.88	163.75	108.88	−0.16	−0.21	2.36	TRUE	FALSE
	SB	−18.81	23.81	−126.58	−20.34	−72.81	41.83	114.65	0.21	−0.25	2.46	TRUE	FALSE
	Toyo	74.70	3.92	5.25	74.44	60.67	84.63	23.96	0.00	1.18	0.40	TRUE	FALSE
	HN	55.80	6.42	11.51	55.83	44.33	74.74	30.41	0.12	−0.39	0.66	TRUE	FALSE
	TN	39.10	3.30	8.44	39.14	30.95	47.19	16.24	0.14	−0.25	0.34	TRUE	FALSE
	AN	55.41	4.33	7.81	56.04	44.03	63.11	19.08	−0.62	−0.19	0.45	TRUE	FALSE
	SN	69.22	8.03	11.60	69.40	50.56	93.30	42.74	0.38	0.36	0.83	TRUE	FALSE

[z]HR: head rice, OR: opaque rice, BR: broken rice, DR: damaged rice, WT: whiteness, PaT: pasting temperature, PV: peak viscosity, TV: trough viscosity, FV: final viscosity, BD: breakdown, SB: setback, Toyo: glossiness, HN: hardness, TN: toughness, AN: adhesiveness, SN: stickiness.
[y]SD: standard deviation, CV: coefficient of variation, SE: standard error.
[x]Unimodality and bimodality were determined using the LaplacesDemon package in R.

Supplementary Table 2. Sequence analysis of nucleotide variations involved in the function of candidate genes.

Var ID	Variants type	Chromosome	Position (bp)	Reference allele	Alternative allele	Boramchan genotype	Pecos genotype	HGVS[z] (protein)	Candidate gene
vg0300220116	SNP	3	220,116	A	T	ref. allele	T	p.Leu17His	*qLTG3-1*

[z]HGVS: Human Genome Variation Society.

Supplementary Table 3. ANOVA analysis with *F*-values for the effects of *Hd1* and *Hd6* and their interactions on the phenotype variation of quality-related tratis.

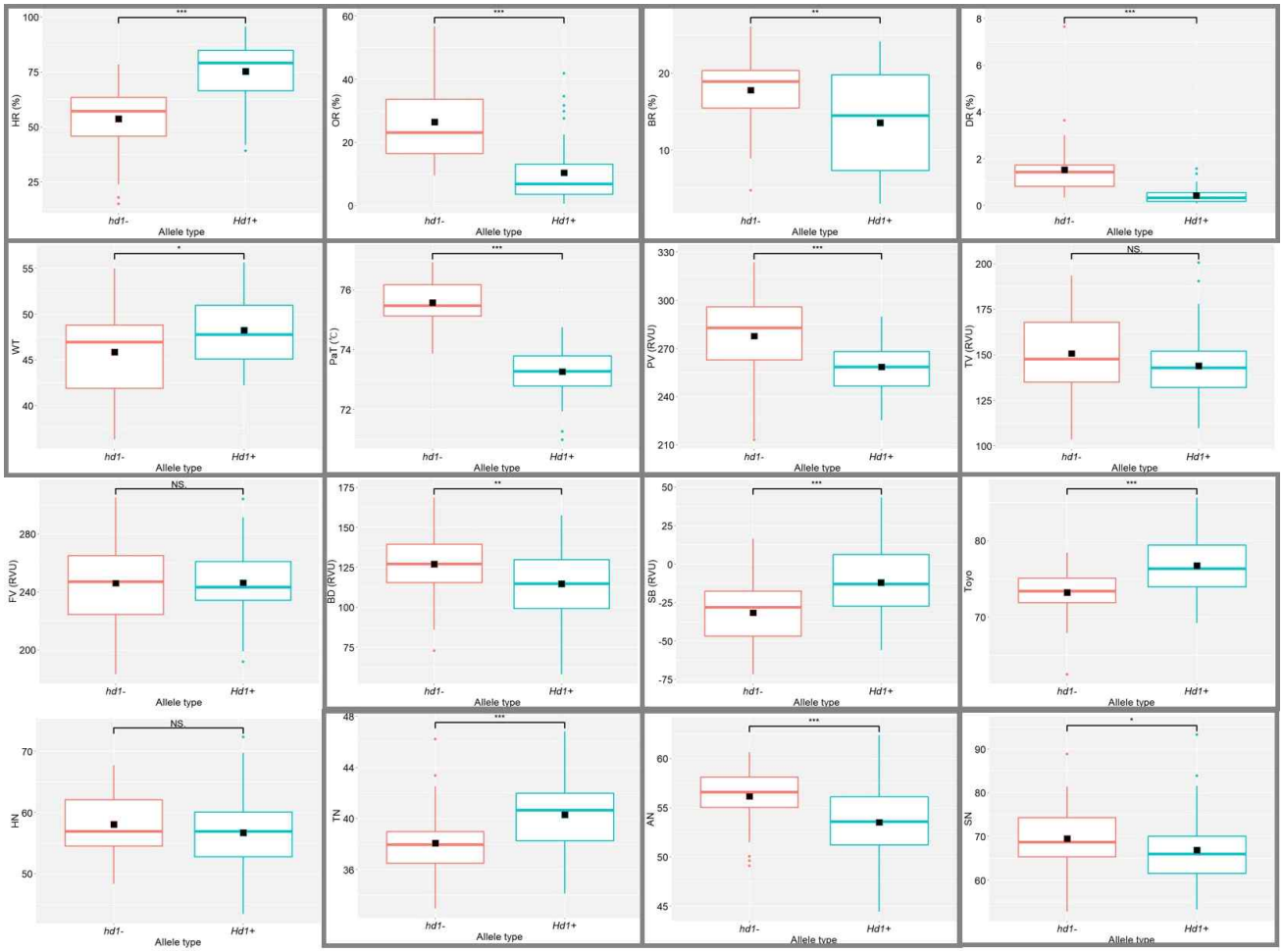
Source of variance	df[z]	HR[y] (%)	OR (%)	BR (%)	DR (%)	WT	PaT (℃)	PV (RVU)	TV (RVU)	FV (RVU)	BD (RVU)	SB (RVU)	Toyo	HN	TN	AN	SN
Hd1	1	47.6**	44.9**	12.8**	39.6**	7.5**	234.2**	19.8**	2.5^{ns}	0.0^{ns}	9.2**	22.8**	24.1**	1.5^{ns}	15.8**	14.2**	2.9^{ns}
Hd6	1	0.4^{ns}	0.0^{ns}	4.2*	0.0^{ns}	0.2^{ns}	3.2^{ns}	1.7^{ns}	2.8^{ns}	4.6*	9.9**	16.7**	0.0^{ns}	2.4^{ns}	2.6^{ns}	0.1^{ns}	0.1^{ns}
*Hd1***Hd6*	1	0.0^{ns}	0.1^{ns}	0.5^{ns}	0.3^{ns}	1.2^{ns}	0.0^{ns}	3.0^{ns}	0.3^{ns}	0.3^{ns}	1.6^{ns}	1.4^{ns}	1.1^{ns}	1.6^{ns}	1.2^{ns}	0.0^{ns}	0.0^{ns}

[z]Degree of freedom.
[y]HR: head rice, OR: opaque rice, BR: broken rice, DR: damaged rice, WT: whiteness, Pat: pasting temperature, PV: peak viscosity, TV: trough viscosity, FV: final viscosity, BD: breakdown, SB: setback, Toyo: glossiness, HN: hardness, TN: toughness, AN: adhesiveness, SN: stickiness. NS, *, and ** mean no significant, significant $p<0.05$, and $p<0.01$ by two-way ANOVA, respectively.

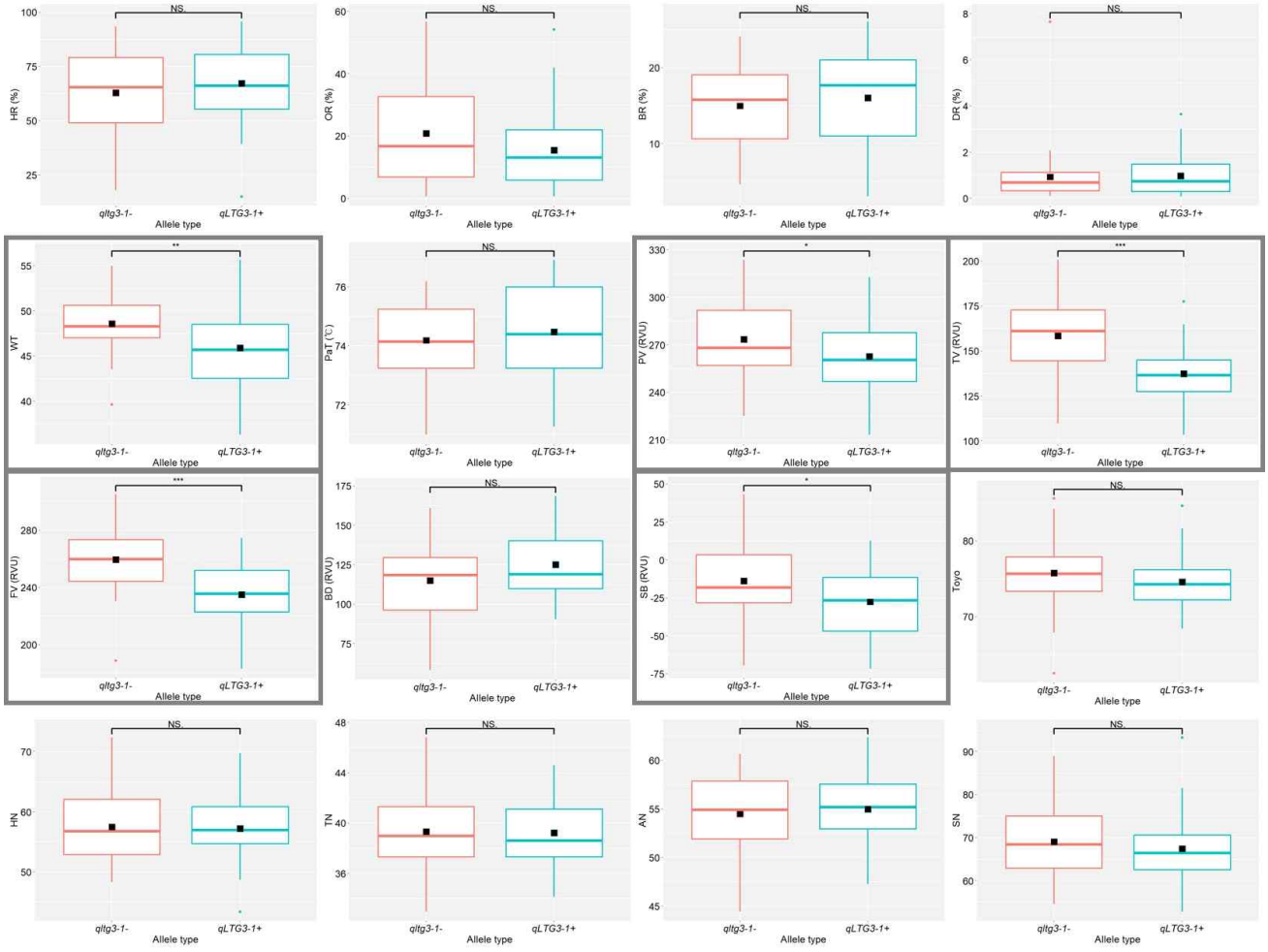
Supplementary Table 4. ANOVA analysis with *F*-values for the effects of *GW5* and *qGS10* and their interactions on the phenotype variation of quality-related tratis.

Source of variance	df[z]	HR[y] (%)	OR (%)	BR (%)	DR (%)	WT	PaT (℃)	PV (RVU)	TV (RVU)	FV (RVU)	BD (RVU)	SB (RVU)	Toyo	HN	TN	AN	SN
GW5	1	6.1*	5.1*	4.9*	0.0^{ns}	59.1**	21.7**	0.0^{ns}	8.5**	13.8**	10.7**	20.5**	2.1^{ns}	0.6^{ns}	0.8^{ns}	5.1*	4.9*
qGS10	1	0.2^{ns}	0.1^{ns}	0.0^{ns}	1.2^{ns}	2.7^{ns}	6.8*	14.3**	0.2^{ns}	0.0^{ns}	25.3**	20.4**	2.1^{ns}	0.0^{ns}	1.0^{ns}	0.8^{ns}	0.3^{ns}
*GW5***qGS10*	1	0.2^{ns}	0.5^{ns}	0.2^{ns}	1.1^{ns}	0.5^{ns}	0.9^{ns}	0.0^{ns}	4.5*	3.7^{ns}	5.6*	5.4*	0.1^{ns}	0.0^{ns}	0.8^{ns}	1.8^{ns}	3.7^{ns}

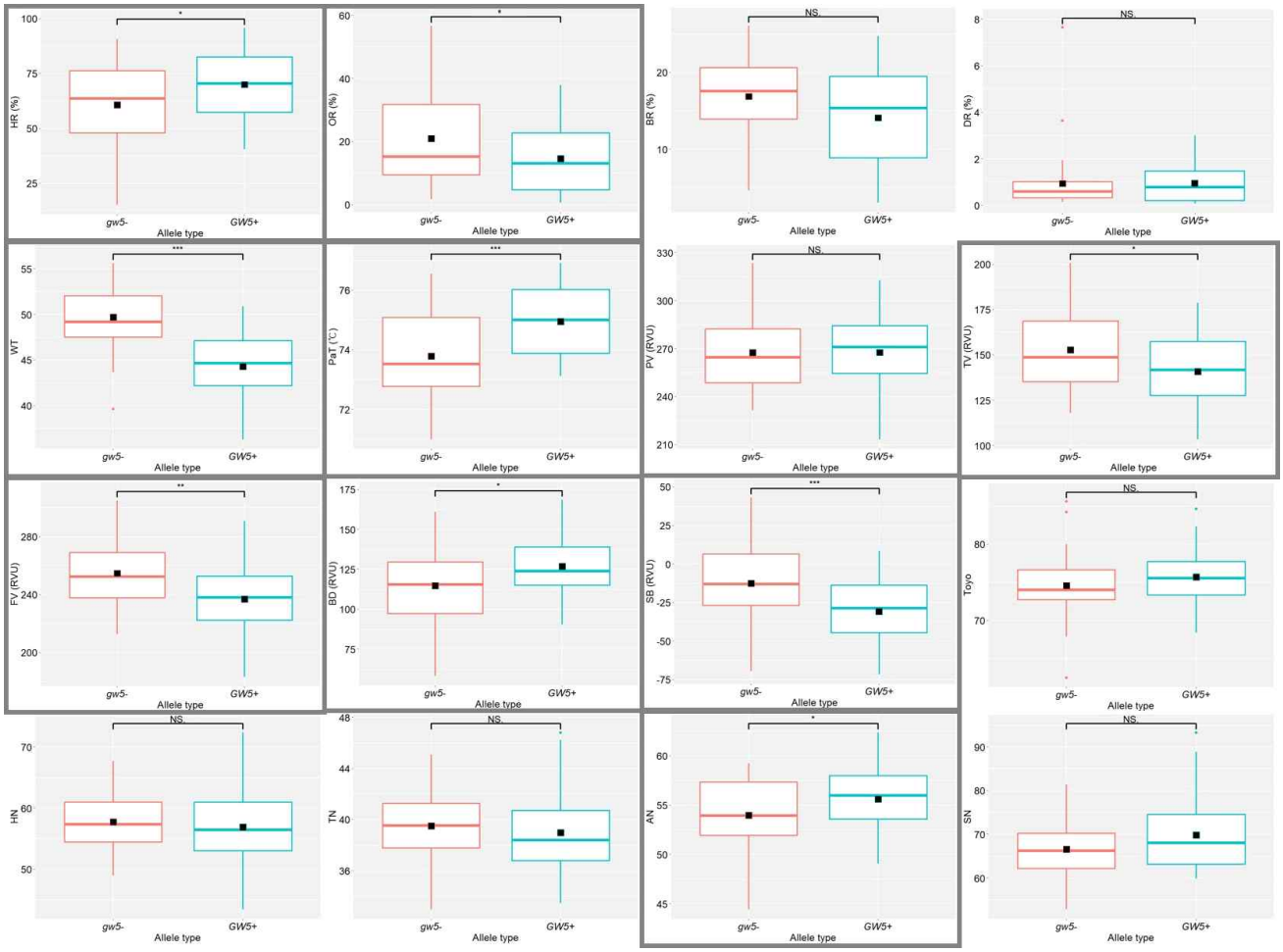
[z]Degree of freedom.
[y]HR: head rice, OR: opaque rice, BR: broken rice, DR: damaged rice, WT: whiteness, Pat: pasting temperature, PV: peak viscosity, TV: trough viscosity, FV: final viscosity, BD: breakdown, SB: setback, Toyo: glossiness, HN: hardness, TN: toughness, AN: adhesiveness, SN: stickiness. NS, *, and ** mean no significant, significant $p<0.05$, and $p<0.01$ by two-way ANOVA, respectively.



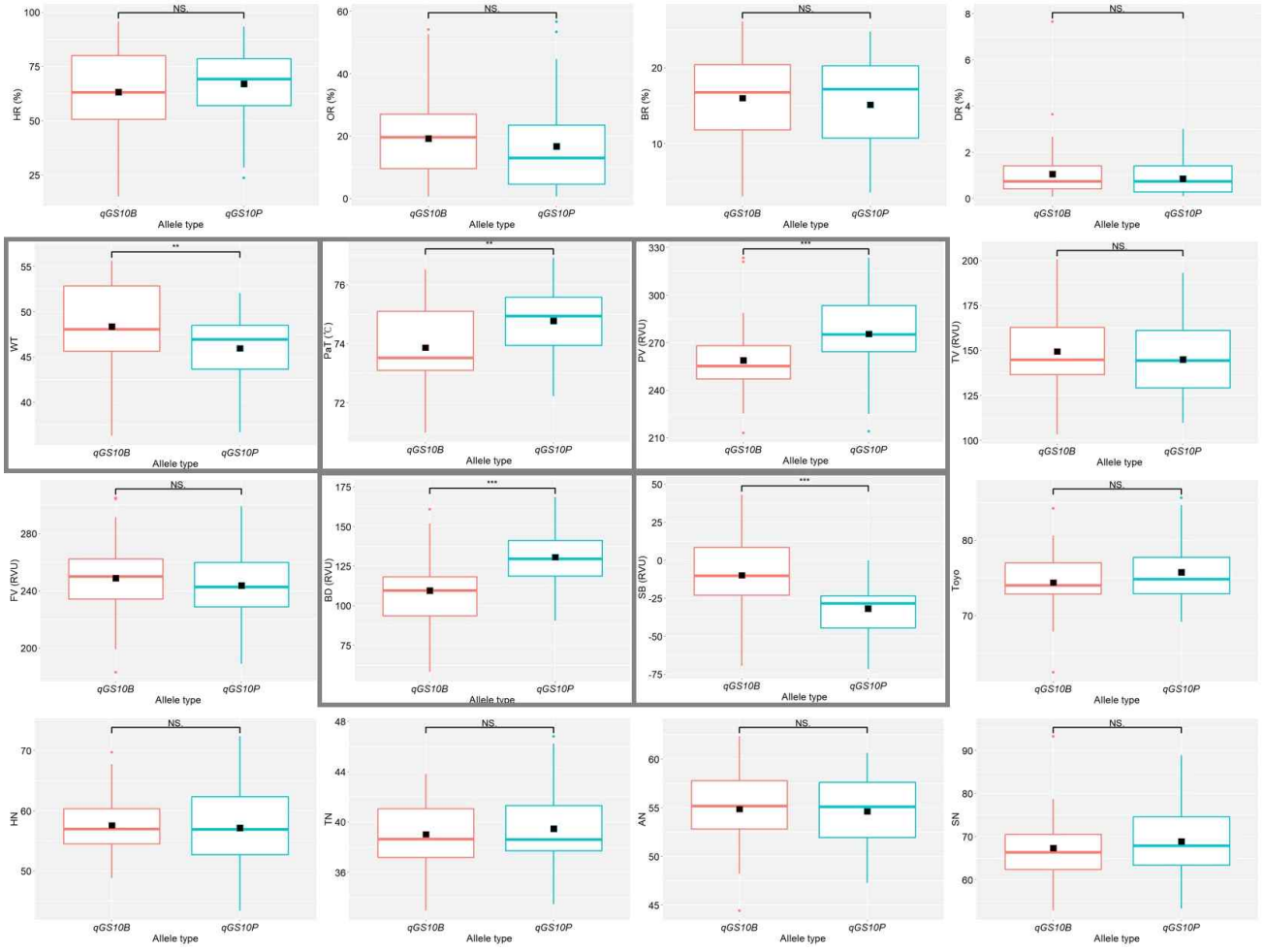
Supplementary Fig. 1. Effects of *Hd1* alleles on the phenotypes of quality-related traits in the BP_RIL population. Box plots showing the variation in head rice (HR), opaque rice (OR), broken rice (BR), damaged rice (DR), whiteness (WT), pasting temperature (Pat), peak viscosity (PV), trough viscosity (TV), final viscosity (FV), breakdown (BD), setback (SB)glossiness (Toyo), hardness (HN), toughness (TN), adhesiveness (AN), and stickiness (SN) by allele types, $Hd1^{+}$ (Boramchan type) and $hd1^{-}$ (Pecos type). The black rectangles indicate the means of each phenotype by allele types. NS, *, **, and *** indicate no significant, significance at the 0.05, 0.01, and 0.001 probability levels by *t*-test, respectively. The outer gray borders of the figures indicate the traits that are statistically different.



Supplementary Fig. 2. Effects of *qLTG3-1* alleles on the phenotypes of quality-related traits in the BP_RIL population. Box plots showing the variation in head rice (HR), opaque rice (OR), broken rice (BR), damaged rice (DR), whiteness (WT), pasting temperature (Pat), peak viscosity (PV), trough viscosity (TV), final viscosity (FV), breakdown (BD), setback (SB)glossiness (Toyo), hardness (HN), toughness (TN), adhesiveness (AN), and stickiness (SN) by allele types, $qltg3\text{-}1^{-}$ (Boramchan type) and $qLTG3\text{-}1^{+}$ (Pecos type). The black rectangles indicate the means of each phenotype by allele types. NS, *, **, and *** indicate no significant, significance at the 0.05, 0.01, and 0.001 probability levels by *t*-test, respectively. The outer gray borders of the figures indicate the traits that are statistically different.



Supplementary Fig. 3. Effects of *GW5* alleles on the phenotypes of quality-related traits in the BP_RIL population. Box plots showing the variation in head rice (HR), opaque rice (OR), broken rice (BR), damaged rice (DR), whiteness (WT), pasting temperature (Pat), peak viscosity (PV), trough viscosity (TV), final viscosity (FV), breakdown (BD), setback (SB)glossiness (Toyo), hardness (HN), toughness (TN), adhesiveness (AN), and stickiness (SN) by allele types, $gw5^{-}$ (Boramchan type) and $GW5^{+}$ (Pecos type). The black rectangles indicate the means of each phenotype by allele types. NS, *, **, and *** indicate no significant, significance at the 0.05, 0.01, and 0.001 probability levels by *t*-test, respectively. The outer gray borders of the figures indicate the traits that are statistically different.



Supplementary Fig. 4. Effects of *qGS10* alleles on the phenotypes of quality-related traits in the BP_RIL population. Box plots showing the variation in head rice (HR), opaque rice (OR), broken rice (BR), damaged rice (DR), whiteness (WT), pasting temperature (Pat), peak viscosity (PV), trough viscosity (TV), final viscosity (FV), breakdown (BD), setback (SB)glossiness (Toyo), hardness (HN), toughness (TN), adhesiveness (AN), and stickiness (SN) by allele types, $qGS10^{B}$ (Boramchan type) and $qGS10^{P}$ (Pecos type). The black rectangles indicate the means of each phenotype by allele types. NS, **, and *** indicate no significant, significance at the 0.01 and 0.001 probability levels by *t*-test, respectively. The outer gray borders of the figures indicate the traits that are statistically different.