

Supplementary Table 1. Identification of QTLs used in the meta-QTL analysis of genes controlling barley malt quality.

QTL names	Traits	Chr.	MQTL	LOD score	Phenotypic variance	Peak position	From	To	Reference	Parents
QME-1H	Malt extract	1H	MQTL1.1	10.8	9.3	63.21	53.21	73.21	Walker <i>et al.</i> , 2013	Vlamingh × Buloke
QDP-1H	Diastatic Power	1H	MQTL1.1	1.6	20	93	86	100.07	Emebiri <i>et al.</i> , 2004	VB9524 × ND11231*12
QGP-1H	Grain protein content	1H	MQTL1.1	3.03	3.1	19.01	0	46.51	Walker <i>et al.</i> , 2013	Vlamingh × Buloke
QMe.nab-1H.1	Malt extract	1H	MQTL1.2	3	20	12.4	2.4	22.4	Marquez-Cedillo <i>et al.</i> , 2000	Harrington × Morex
QMe.StMo-1H.1	Malt extract	1H	MQTL1.2	3	20	13	0	28	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QAa.HaTR-1H.1	alpha-amylase activity	1H	MQTL1.2	3	20	13	0	28	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QDp.StMo-1H	Diastatic Power	1H	MQTL1.2	3	20	13	0	28	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QMe.StMo-1H.2	Malt extract	1H	MQTL1.2 MQTL1.3	3	20	22	0	87	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QGpc.DiMo-1H	Protein content	1H	MQTL1.2 MQTL1.3	3	20	13	0	28	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QMe.HaMo-1H.1	Malt extract	1H	MQTL1.2 MQTL1.3	3	20	36	21	51	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QPv.NaTx-1H	viscosity	1H	MQTL1.2 MQTL1.3	3.29	7.4	65.7	40.7	90.7	Wang <i>et al.</i> , 2018	TX9425 × Naso Nijo
QWort-BG-1H	wort β-glucan	1H	MQTL1.3	15.33	13.92	50.56	43.96	57.16	Cu <i>et al.</i> , 2016	Navigator × Admiral
QVIS-1H	viscosity	1H	MQTL1.3	15.93	15.18	50.56	44.66	56.46	Cu <i>et al.</i> , 2016	Navigator × Admiral
QAlpha-1Ha	alpha-amylase	1H	MQTL1.3	11.64	14.31	50.56	44.06	57.06	Cu <i>et al.</i> , 2016	Navigator × Admiral
QAlpha-1Hb	alpha-amylase	1H	MQTL1.3	9.49	15.52	50.56	45.56	55.56	Cu <i>et al.</i> , 2016	Navigator × Admiral
QSP-1Hb	soluble protein	1H	MQTL1.3 MQTL1.4	9.07	10.05	50.56	41.66	59.46	Cu <i>et al.</i> , 2016	Navigator × Admiral
QSP-1Ha	soluble protein	1H	MQTL1.3 MQTL1.4	8.69	9.03	50.56	40.66	60.46	Cu <i>et al.</i> , 2016	Navigator × Admiral
QMe.StMo-1H.3	Malt extract	1H	MQTL1.3 MQTL1.4	3	20	58	43	73	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
Qgbg1.1	Grain β-glucans	1H	MQTL1.4	6.63	27.9	60.3	55.5	65.1	Laidò <i>et al.</i> , 2009	Nure × Tremois
Qvis1.1	Wort viscosity	1H	MQTL1.4	10.75	39.5	60.3	58.5	62.1	Laidò <i>et al.</i> , 2009	Nure × Tremois
QBgn.StMo-1H	β-glucan	1H	MQTL1.4 MQTL1.5	3	20	79	14	144	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QBgsk.StMo-1H.1	β-glucanase activity (kilned malt)	1H	MQTL1.4 MQTL1.5	3	20	79	14	144	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QS/T.HaMo-1H	Soluble/Total protein	1H	MQTL1.4 MQTL1.5	3	20	79	14	144	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QBgsg.StMo-1H	beta-glucanase activity	1H	MQTL1.4 MQTL1.5	3.5	16.1	10	79	148	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QPC-1H	ProteinContent	1H	MQTL1.5	5.77	23.3	59.9	59.8	60	Elía <i>et al.</i> , 2010	Triumph × Morex
QS/T.nab-1H	Soluble protein to total protein	1H	MQTL1.5 MQTL1.6	3	20	72.1	62.1	82.1	Marquez-Cedillo <i>et al.</i> , 2000	Harrington × Morex
QMe.HaMo-1H.2	Malt extract	1H	MQTL1.6	3	20	112	97	127	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QMe.nab-1H.2	Malt extract	1H	MQTL1.6	3	20	99.2	89.2	102.9	Marquez-Cedillo <i>et al.</i> , 2000	Harrington × Morex
QMe.StMo-1H.4	Malt extract	1H	MQTL1.6	3	20	112	97	127	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
Qpc1.1	Grain protein content	1H	MQTL1.6	5.73	29.1	108.7	104.1	113.3	Szücs <i>et al.</i> , 2009	Nure × Tremois
QBgnm.StMo-1H.1	beta-glucan (malt)	1H	MQTL1.6	3	20	112	97	127	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QFge.HaTR-1H.1	Malt extract	1H	MQTL1.6	3	20	112	97	127	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive

Supplementary Table 1 continued

QTL names	Traits	Chr.	MQTL	LOD score	Phenotypic variance	Peak position	From	To	Reference	Parents
QBgsk.StMo-1H.2	beta-glucanase activity (kilned malt)	1H	MQTL1.6	3	20	112	97	127	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
Qgbg1.2	Grain b-glucans	1H	MQTL1.6	4.48	16.9	101.1	94.1	108.1	Laidò <i>et al.</i> , 2009	Nure × Tremois
QBgsg.StMo-1H.3	beta-glucanase activity (green malt)	1H	MQTL1.6	3	20	112	97	127	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QMe.StMo-1H.5	Malt extract	1H	MQTL1.7	3	20	155	140	170	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QFge.HaTR-1H.2	Malt extract	1H	MQTL1.7	3	20	142	127	157	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QBgnm.StMo-1H.2	beta-glucan (malt)	1H	MQTL1.7	3	20	140	125	155	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QAa.StMo-1H	alpha-amylase activity	1H	MQTL1.7	3	20	155	140	170	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QPv.NaTx-2H	viscosity	2H	MQTL2.1	6.39	15.2	43.9	36.4	51.4	Wang <i>et al.</i> , 2018	TX9425 × Naso Nijo
QDp.nab-2H	Diastatic Power	2H	MQTL2.1	3	20	36.5	26.5	46.5	Marquez-Cedillo <i>et al.</i> , 2000	Harrington × Morex
QPc.nab-2H.1	Grain protein	2H	MQTL2.1	3	20	36.5	26.5	46.5	Marquez-Cedillo <i>et al.</i> , 2000	Harrington × Morex
QFv.NaTx-2H	viscosity	2H	MQTL2.1 MQTL2.2	7.49	18.4	55.6	45.6	65.6	Wang <i>et al.</i> , 2018	TX9425 × Naso Nijo
QGpc.HaMo-2H.1	Grain protein content	2H	MQTL2.1 MQTL2.2	3	20	44	29	59	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QMe.GaHN-2H	Malt extract	2H	MQTL2.1 MQTL2.2	3	20	44	29	59	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QMe.DiMo-2H	Malt extract	2H	MQTL2.1 MQTL2.2	3	20	44	29	59	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QGpc.StMo-2H.1	Protein content	2H	MQTL2.1 MQTL2.2	3	20	57	42	72	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QDp.StMo-2H	Diastatic Power	2H	MQTL2.1 MQTL2.2	3	20	57	42	72	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QBgn.StMo-2H.2	beta-glucan	2H	MQTL2.1 MQTL2.2 MQTL2.3	3	20	63	48	78	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QGpc.StMo-2H.2	Grain protein content	2H	MQTL2.1 MQTL2.2 MQTL2.3	5.9	9.2	62	29	95	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QDP-2Hb	Diastatic Power	2H	MQTL2.2 MQTL2.3	3.76	15.9	65.6	65.43	65.77	Elía <i>et al.</i> , 2010	Triumph × Morex
QDP.StMo-2H.3	Diastatic Power	2H	MQTL2.2 MQTL2.3	3	20	73	58	88	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QME-2H	Malt extract	2H	MQTL2.3	9.3	34.8	81.25	81.18	81.32	Elía <i>et al.</i> , 2010	Triumph × Morex
QP-2Ha	ProteinContent	2H	MQTL2.3	17	53.4	81.25	81.2	81.3	Elía <i>et al.</i> , 2010	Triumph × Morex
QDP-2Hc	Diastatic Power	2H	MQTL2.3	4.52	18.8	81.25	81.11	81.39	Elía <i>et al.</i> , 2010	Triumph × Morex
QAa.StMo-2H.1	alpha-amylase activity	2H	MQTL2.3 MQTL2.4	4	18.9	16	0	32	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QGpc.HaMo-2H.2	protein content	2H	MQTL2.4	3	20	114	99	129	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QS/T.HaMo-2H	Soluble/Total protein	2H	MQTL2.4	3	20	114	99	129	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QPc.nab-2H.2	Grain protein	2H	MQTL2.4	3	20	93.5	88.5	98.5	Marquez-Cedillo <i>et al.</i> , 2000	Harrington × Morex

Supplementary Table 1 continued

QTL names	Traits	Chr.	MQTL	LOD score	Phenotypic variance	Peak position	From	To	Reference	Parents
QS/T.nab-2H	Soluble protein to total protein	2H	MQTL2.4	3	20	93.5	83.5	103.5	Marquez-Cedillo <i>et al.</i> , 2000	Harrington × Morex
qDP.3H	Diastatic Power	3H	MQTL3.1	3	11.4	50.4	50.33	50.47	Goddard <i>et al.</i> , 2019	Chevallier × NFC Tipple
QME-3Ha	Malt extract	3H	MQTL3.1	2.76	2.2	18.61	0	63.61	Walker <i>et al.</i> , 2013	Vlamingh × Buloke
QDP-3H	Diastatic Power	3H	MQTL3.2	2.3	20	212	205	219.07	Emebiri <i>et al.</i> , 2004	VB9524 × ND11231*12
QME-3Hb	Malt extract	3H	MQTL3.2 MQTL3.3	3.94	3.1	130.21	98.21	162.21	Walker <i>et al.</i> , 2013	Vlamingh × Buloke
qBG.3H	Wort β-glucan	3H	MQTL3.3	3	23.3	185.1	185.07	185.13	Goddard <i>et al.</i> , 2019	Chevallier × NFC Tipple
QME-3H	Malt extract	3H	MQTL3.4	1.2	20	293	286	300.7	Emebiri <i>et al.</i> , 2004	VB9524 × ND11231*12
QBgnm.Ha TR-3H.1	beta-glucan (malt)	3H	MQTL3.4	3	20	35	20	50	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QBgnm.St Mo-3H	beta-glucan (malt)	3H	MQTL3.4	3	20	35	20	50	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QGpc.StM o-3H.1	protein content	3H	MQTL3.4 MQTL3.5	3	20	85	70	100	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QSP-3H	soluble protein	3H	MQTL3.4 MQTL3.5	3.1	2.59	69.85	35.85	103.85	Cu <i>et al.</i> , 2016	Navigator × Admiral
QDp.StMo-3H	Diastatic Power	3H	MQTL3.5	3	20	155	140	170	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QAa.StMo-3H	alpha-amylase activity	3H	MQTL3.5	3	20	112	97	127	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QGpc.StM o-3H.2	protein content	3H	MQTL3.5	3	20	155	140	170	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QBgnm.Ha TR-3H.2	beta-glucan (malt)	3H	MQTL3.5	3	20	112	97	127	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QGpc.StM o-3H	Grain protein content	3H	MQTL3.5	3	20	112	97	127	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QS/T.DiMo-3H	Soluble/Total protein	3H	MQTL3.5	3	20	166	151	181	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QVIS-3H	Viscosity	3H	MQTL3.5 MQTL3.6	3	13.7	124	102	146	Zhou <i>et al.</i> , 2012	Harrington × Mikamo Golden
QP-3H	protein content	3H	MQTL3.6	3.9	16.5	109.6	109.44	109.76	Elia <i>et al.</i> , 2010	Triumph × Morex
QDp.StMo-4H	Diastatic Power	4H	MQTL4.1	3	20	22	7	37	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QMe.StMo-4H	Malt extract	4H	MQTL4.1	3	20	26	11	41	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QAa.HaMo-4H	alpha-amylase activity	4H	MQTL4.1	3	20	26	11	41	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QBgnm.St Mo-4H	beta-glucan (malt)	4H	MQTL4.1	3	20	7	0	22	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QAa.StMo-4H.1	alpha-amylase activity	4H	MQTL4.1	3	20	26	11	41	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QS/T.nab-4H	Soluble protein to total protein	4H	MQTL4.1	3	20	30.4	20.4	40.4	Marquez-Cedillo <i>et al.</i> , 2000	Harrington × Morex
QAa.nab-4H	α-amylase	4H	MQTL4.1	3	20	30.4	20.4	40.4	Marquez-Cedillo <i>et al.</i> , 2000	Harrington × Morex
QPc.nab-4H.1	Grain protein	4H	MQTL4.1	3	20	30.4	20.4	40.4	Marquez-Cedillo <i>et al.</i> , 2000	Harrington × Morex
QGpc.HaM o-4H	Grain protein content	4H	MQTL4.1	3	20	26	11	41	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QS/T.HaM o-4H	Soluble/Total protein	4H	MQTL4.1	3	20	26	11	41	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QGpc.DiM o-4H	protein content	4H	MQTL4.1 MQTL4.2	3	20	42	27	57	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive

Supplementary Table 1 continued

QTL names	Traits	Chr.	MQTL	LOD score	Phenotypic variance	Peak position	From	To	Reference	Parents
QGpc.HaT R-4H.1	Grain protein content	4H	MQTL4.1 MQTL4.2	3	20	42	27	57	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QBgs.StM o-4H	beta-glucanase activity	4H	MQTL4.2	6	22.6	56	43	69	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QBeta-4Ha	β-amylase	4H	MQTL4.2 MQTL4.3 MQTL4.4	4.56	3.08	74.21	45.21	103.21	Cu <i>et al.</i> , 2016	Navigator × Admiral
QDP-4Ha	Diastatic Power	4H	MQTL4.2 MQTL4.3 MQTL4.4	4.83	3.34	74.21	48.21	100.21	Cu <i>et al.</i> , 2016	Navigator × Admiral
QPc.nab-4H.2	Grain protein	4H	MQTL4.3 MQTL4.4	3	20	99.85	89.85	109.85	Marquez-Cedillo <i>et al.</i> , 2000	Harrington × Morex
QDP-4Hc	Diastatic Power	4H	MQTL4.4	22.28	30.74	134.64	132.64	136.64	Cu <i>et al.</i> , 2016	Navigator × Admiral
QDP-4Hb	Diastatic Power	4H	MQTL4.4	43.5	49.66	134.64	133.64	135.64	Cu <i>et al.</i> , 2016	Navigator × Admiral
QDP-4H	Diastatic Power	4H	MQTL4.4	3.6	15.30	91.2	91.03	91.37	Elía <i>et al.</i> , 2010	Triumph × Morex
QGpc.HaT R-4H.2	Grain protein content	4H	MQTL4.4	3	20	81	66	96	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QBeta-4Hc	β-amylase	4H	MQTL4.4	22.5	31	134.64	131.84	137.44	Cu <i>et al.</i> , 2016	Navigator × Admiral
QBeta-4Hb	β-amylase	4H	MQTL4.4	44.53	50.64	134.64	133.14	136.14	Cu <i>et al.</i> , 2016	Navigator × Admiral
QAa.StMo-4H.2	alpha-amylase activity	4H	MQTL4.4	2.7	15.3	81	61	101	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QFge.HaT R-5H.1	Malt extract	5H	MQTL5.1	3	20	13	0	28	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QGpc.HaT R-5H	Grain protein content	5H	MQTL5.1	3	20	0	0	7.5	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QGpc.StM o-5H	Grain protein content	5H	MQTL5.2	3	20	58	43	73	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QS/T.DiMo-5H.1	Soluble/Total protein	5H	MQTL5.2	3	20	45	30	60	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QDp.DiMo-5H	Diastatic Power	5H	MQTL5.2	3	20	45	30	60	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QAa.DiMo-5H	alpha-amylase activity	5H	MQTL5.2	3	20	45	30	60	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QGpc.DiM o-5H.1	Grain protein content	5H	MQTL5.2	3	20	45	30	60	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QBgnw.DiMo-5H	beta-glucan (wort)	5H	MQTL5.2	3	20	45	30	60	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QMe.DiMo-5H.1	Malt extract	5H	MQTL5.2	3	20	45	30	60	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QDp.StMo-5H	Diastatic Power	5H	MQTL5.2	3	20	58	43	73	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QMe.DiMo-5H.2	Malt extract	5H	MQTL5.3	3	20	92	77	107	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QAa.StMo-5H.1	alpha-amylase activity	5H	MQTL5.3	3	20	111	96	126	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QAa.HaMo-5H	alpha-amylase activity	5H	MQTL5.3	3	20	111	96	126	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QWort-BG-5H	wort β-glucan	5H	MQTL5.3	6.64	6.08	128.92	114.92	142.92	Cu <i>et al.</i> , 2016	Navigator × Admiral
QBgs.StM o-5H	beta-glucanase activity	5H	MQTL5.3	6.4	23	92	79	105	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QAa.ChHa-5H	alpha-amylase activity	5H	MQTL5.3	3	20	111	96	126	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QBgsk.StM o-5H	beta-glucanase activity	5H	MQTL5.3	5.3	20.3	92	77	107	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive

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QAa.StMo-5H	alpha-amylase	5H	MQTL5.3	5.2	22.7	111	98	124	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QAa.HaTR-5H	alpha-amylase activity	5H	MQTL5.3	3	20	111	96	126	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QGpc.HaMo-5H	protein content	5H	MQTL5.3	3	20	92	77	107	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QVIS-5H	viscosity	5H	MQTL5.3 MQTL5.4	5.8	5.33	130.04	114.04	146.04	Cu <i>et al.</i> , 2016	Navigator × Admiral
QBgnm.HaTR-5H.1	beta-glucan (malt)	5H	MQTL5.4	3	20	159	144	179	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QEv.HaTR-5H	Extract viscosity	5H	MQTL5.4	3	20	159	144	179	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QGpc.DiMo-5H.2	protein content	5H	MQTL5.4 MQTL5.5	3	20	177	162	192	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QME-5Hb	Malt extract	5H	MQTL5.5	15.8	53.6	137	132	142	Zhou <i>et al.</i> , 2012	Harrington × Mikamo Golden
QME-5Hc	Malt extract	5H	MQTL5.5	15.2	52.1	145	140	150	Zhou <i>et al.</i> , 2012	Harrington × Mikamo Golden
QMe.DiMo-5H.3	Malt extract	5H	MQTL5.5	3	20	218	203	233	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
Qvis5.1	Wort viscosity	5H	MQTL5.5	4.55	24.3	137.5	132	143	Laidò <i>et al.</i> , 2009	Nure × Tremois
QME-5Ha	Malt extract	5H	MQTL5.5	9.1	35.7	145	137	153	Zhou <i>et al.</i> , 2012	Harrington × Mikamo Golden
QDP-5H	Diastatic Power	5H	MQTL5.5 MQTL5.6	3.4	15	157	137	177	Zhou <i>et al.</i> , 2012	Harrington × Mikamo Golden
QME-6H	Malt extract	6H	MQTL6.1	1.9	20	172	165	179.07	Emebiri <i>et al.</i> , 2004	VB9524 × ND11231*12
QMe.StMo-6H	Malt extract	6H	MQTL6.2	3	20	3	0	18	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QDP-6H	Diastatic Power	6H	MQTL6.3	3.7	20	242	235	249.07	Emebiri <i>et al.</i> , 2004	VB9524 × ND11231*12
QAa.StMo-6H	alpha-amylase activity	6H	MQTL6.3 MQTL6.4	3	20	68	53	83	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QDp.StMo-6H	Diastatic Power	6H	MQTL6.3 MQTL6.4	3	20	86	71	101	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QVIS-6H	viscosity	6H	MQTL6.3 MQTL6.4	3.5	15.8	49	30	68	Zhou <i>et al.</i> , 2012	Harrington × Mikamo Golden
QAa.HaTR-6H	alpha-amylase activity	6H	MQTL6.3 MQTL6.4	3	20	105	90	120	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QDp.HaTR-6H	Diastatic Power	6H	MQTL6.3 MQTL6.4	3	20	105	90	120	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QEv.HaTR-6H	Extract viscosity	6H	MQTL6.3 MQTL6.4	3	20	105	90	120	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QAa.ChHa-6H	alpha-amylase activity	6H	MQTL6.3 MQTL6.4	3	20	105	90	120	Szücs <i>et al.</i> , 2009	Wolfe Dominant × Wolfe Recessive
QBG-6Ha	Beta-glucan	6H	MQTL6.3 MQTL6.4	3	13.8	45	24	66	Zhou <i>et al.</i> , 2012	Harrington × Mikamo Golden
QBG-6Hb	Beta-glucan	6H	MQTL6.3 MQTL6.4	3.9	17.2	45	28	62	Zhou <i>et al.</i> , 2012	Harrington × Mikamo Golden
QWort-BG-6H	wort β-glucan	6H	MQTL6.3 MQTL6.4	5.68	6.63	92.3	79.3	105.3	Cu <i>et al.</i> , 2016	Navigator × Admiral
Qpc6.1	Grain protein content	6H	MQTL6.4	3.94	18.7	117.9	110.9	124.9	Laidò <i>et al.</i> , 2009	Nure × Tremois
QAlpha-6H	alpha-amylase	6H	MQTL6.4	5.21	5.64	113.64	98.64	128.65	Cu <i>et al.</i> , 2016	Navigator × Admiral
QVIS-7Hc	viscosity	7H	MQTL7.1	8.02	9.49	18.48	9.08	27.88	Cu <i>et al.</i> , 2016	Navigator × Admiral
QSP-7Hb	soluble protein	7H	MQTL7.1	5.43	6.07	3.41	0	17.41	Cu <i>et al.</i> , 2016	Navigator × Admiral
QDP-7Ha	Diastatic Power	7H	MQTL7.1 MQTL7.2	3	20	1.1	0.33	1.67	Han <i>et al.</i> , 2004	Steptoe × Morex
QWort-BG-7Hb	wort β-glucan	7H	MQTL7.2	5.13	5.87	72.14	57.14	87.14	Cu <i>et al.</i> , 2016	Navigator × Admiral

Supplementary Table 1 continued

QTL names	Traits	Chr.	MQTL	LOD score	Phenotypic variance	Peak position	From	To	Reference	Parents
QWort-BG-7Hb	wort β -glucan	7H	MQTL7.2	5.13	5.87	72.14	57.14	87.14	Cu <i>et al.</i> , 2016	Navigator $\times$ Admiral
QWort-BG-7Hc	wort β -glucan	7H	MQTL7.2	4.64	7.49	52.35	41.35	63.35	Cu <i>et al.</i> , 2016	Navigator $\times$ Admiral
QVIS-7Hd	viscosity	7H	MQTL7.2	14.41	15.05	68.03	62.13	73.93	Cu <i>et al.</i> , 2016	Navigator $\times$ Admiral
QDp.StMo-7H.3	Diastatic Power	7H	MQTL7.2	3	20	60	45	75	Szücs <i>et al.</i> , 2009	Wolfe Dominant $\times$ Wolfe Recessive
QPc.nab-7H	Grain protein	7H	MQTL7.2	3	20	69.25	59.25	79.25	Marquez-Cedillo <i>et al.</i> , 2000	Harrington $\times$ Morex
QAa.StMo-7H.3	alpha-amylase activity	7H	MQTL7.2	3	20	60	45	75	Szücs <i>et al.</i> , 2009	Wolfe Dominant $\times$ Wolfe Recessive
QSP-7Ha	soluble protein	7H	MQTL7.2	11.64	14.37	62.8	56.6	69	Cu <i>et al.</i> , 2016	Navigator $\times$ Admiral
QBgnm.StMo-7H.1	beta-glucan (malt)	7H	MQTL7.2	3	20	60	45	75	Szücs <i>et al.</i> , 2009	Wolfe Dominant $\times$ Wolfe Recessive
QDp.nab-7H.1	Diastatic Power	7H	MQTL7.2	3	20	69.25	59.25	79.25	Marquez-Cedillo <i>et al.</i> , 2000	Harrington $\times$ Morex
QVIS-7Hb	viscosity	7H	MQTL7.2	5.26	6.05	72.14	58.14	86.14	Cu <i>et al.</i> , 2016	Navigator $\times$ Admiral
QBgnm.StMo-7H.2	beta-glucan (malt)	7H	MQTL7.2	3	20	60	45	75	Szücs <i>et al.</i> , 2009	Wolfe Dominant $\times$ Wolfe Recessive
QWort-BG-7Ha	wort β -glucan	7H	MQTL7.2	7.8	9.09	40.76	31.76	49.76	Cu <i>et al.</i> , 2016	Navigator $\times$ Admiral
QBgsk.StMo-7H.2	beta-glucanase activity (kilned malt)	7H	MQTL7.2	3	20	60	45	75	Szücs <i>et al.</i> , 2009	Wolfe Dominant $\times$ Wolfe Recessive
QVIS-7Ha	viscosity	7H	MQTL7.2	5.43	6.31	40.76	26.76	54.76	Cu <i>et al.</i> , 2016	Navigator $\times$ Admiral
QBgsk.StMo-7H.1	beta-glucanase activity (kilned malt)	7H	MQTL7.2	3	20	60	45	75	Szücs <i>et al.</i> , 2009	Wolfe Dominant $\times$ Wolfe Recessive
QSP-7Hc	soluble protein	7H	MQTL7.2	10.87	12.41	66.16	59.16	73.16	Cu <i>et al.</i> , 2016	Navigator $\times$ Admiral
QGpc.HaMo-7H	protein content	7H	MQTL7.2	3	20	91	76	106	Szücs <i>et al.</i> , 2009	Wolfe Dominant $\times$ Wolfe Recessive
QS/T.HaTR-7H	Soluble/Total protein	7H	MQTL7.2	3	20	60	45	75	Szücs <i>et al.</i> , 2009	Wolfe Dominant $\times$ Wolfe Recessive
QEv.HaTR-7H	Extract viscosity	7H	MQTL7.2	3	20	73	58	88	Szücs <i>et al.</i> , 2009	Wolfe Dominant $\times$ Wolfe Recessive
QDP-7Hb	Diastatic Power	7H	MQTL7.2 MQTL7.3	3	20	15.8	15.13	16.47	Han <i>et al.</i> , 2004	Steptoe $\times$ Morex
QBG-7Hb	Wort β -glucan	7H	MQTL7.2 MQTL7.3	3	20	16.8	16.03	17.37	Han <i>et al.</i> , 2004	Steptoe $\times$ Morex
QAA-7Hb	alpha-amylase	7H	MQTL7.2 MQTL7.3	3	20	18.1	17.43	18.77	Han <i>et al.</i> , 2004	Steptoe $\times$ Morex
QME-7H	Malt extract	7H	MQTL7.2 MQTL7.3	3	20	19.81	19.13	20.47	Han <i>et al.</i> , 2004	Steptoe $\times$ Morex
QAlpha-7H	alpha-amylase	7H	MQTL7.2 MQTL7.3	3.92	4.02	91.59	69.59	113.59	Cu <i>et al.</i> , 2016	Navigator $\times$ Admiral
QGpc.DiMo-7H	Grain protein content	7H	MQTL7.3	3	20	120	105	135	Szücs <i>et al.</i> , 2009	Wolfe Dominant $\times$ Wolfe Recessive
QP-7Ha	protein content	7H	MQTL7.3	3.45	14.95	49.35	49.17	49.53	Elía <i>et al.</i> , 2010	Triumph $\times$ Morex
QME-7Hc	Malt extract	7H	MQTL7.3 MQTL7.4	2.57	4	137.31	113.31	161.31	Walker <i>et al.</i> , 2013	Vlamingh $\times$ Buloke
QDp.HaTR-7H	Diastatic Power	7H	MQTL7.3 MQTL7.4	3	20	150	135	165	Szücs <i>et al.</i> , 2009	Wolfe Dominant $\times$ Wolfe Recessive
QME-7Hd	Malt extract	7H	MQTL7.3 MQTL7.4	2.74	5.3	148.21	130.21	166.21	Walker <i>et al.</i> , 2013	Vlamingh $\times$ Buloke
QME-7Hb	Malt extract	7H	MQTL7.3 MQTL7.4	5.02	4	172.31	148.31	196.31	Walker <i>et al.</i> , 2013	Vlamingh $\times$ Buloke
QGP-7He	Grain Protein Content	7H	MQTL7.4	8.04	9.8	182.61	172.11	193.11	Walker <i>et al.</i> , 2013	Vlamingh $\times$ Buloke
QGP-7Hc	Grain Protein Content	7H	MQTL7.4	9.48	11.8	163.21	155.21	171.21	Walker <i>et al.</i> , 2013	Vlamingh $\times$ Buloke
QGP-7Hd	Grain Protein Content	7H	MQTL7.4	10.96	11.7	168.21	160.21	176.21	Walker <i>et al.</i> , 2013	Vlamingh $\times$ Buloke

Supplementary Table 2. Number of major QTLs and QTLs for MQTLs of genes controlling barley malt quality.

Meta-QTL	No. of original QTLs	QTLs
MQTL1.1	3	QME-1H; QDP-1H; QGP-1H;
MQTL1.2	8	QMe.nab-1H.1; QMe.StMo-1H.1; QAa.HaTR-1H.1; QDp.StMo-1H; QMe.StMo-1H.2; QGpc.DiMo-1H; QMe.HaMo-1H.1; QPv.NaTx-1H
MQTL1.3	11	QMe.StMo-1H.2; QGpc.DiMo-1H; QMe.HaMo-1H.1; QPv.NaTx-1H; QWort-BG-1H; QVIS-1H; QAlpha-1Ha; QAlpha-1Hb; QSP-1Hb; QSP-1Ha; QMe.StMo-1H.3
MQTL1.4	9	QSP-1Hb; QSP-1Ha; QMe.StMo-1H.3; Qgbg1.1; Qvis1.1; QBgn.StMo-1H; QBgsk.StMo-1H.1; QS/T.HaMo-1H; QBgsg.StMo-1H
MQTL1.5	6	QBgn.StMo-1H; QBgsk.StMo-1H.1; QS/T.HaMo-1H; QBgsg.StMo-1H; QPC-1H; QS/T.nab-1H
MQTL1.6	10	QS/T.nab-1H; QMe.HaMo-1H.2; QMe.nab-1H.2; QMe.StMo-1H.4; Qpc1.1; QBgnm.StMo-1H.1; QFge.HaTR-1H.1; QBgsk.StMo-1H.2; Qgbg1.2; QBgsg.StMo-1H.3
MQTL1.7	4	QMe.StMo-1H.5; QFge.HaTR-1H.2; QBgnm.StMo-1H.2; QAa.StMo-1H
MQTL2.1	11	QPv.NaTx-2H; QDp.nab-2H; QPc.nab-2H.1; QFv.NaTx-2H; QGpc.HaMo-2H.1; QMe.GaHN-2H; QMe.DiMo-2H; QGpc.StMo-2H.1; QDp.StMo-2H; QBgn.StMo-2H.2; QGpc.StMo-2H.2
MQTL2.2	10	QFv.NaTx-2H; QGpc.HaMo-2H.1; QMe.GaHN-2H; QMe.DiMo-2H; QGpc.StMo-2H.1; QDp.StMo-2H; QBgn.StMo-2H.2; QGpc.StMo-2H.2; QDP-2Hb; QDP.StMo-2H.3
MQTL2.3	8	QBgn.StMo-2H.2; QGpc.StMo-2H.2; QDP-2Hb; QDP.StMo-2H.3; QME-2H; QP-2Ha; QDP-2Hc; QAa.StMo-2H.1
MQTL2.4	6	QAa.StMo-2H.1; QGpc.HaMo-2H.2; QS/T.HaMo-2H; QPc.nab-2H.2; QGpc.StMo-2H.3; QS/T.nab-2H
MQTL3.1	2	qDP.3H; QME-3Ha
MQTL3.2	2	QDP-3H; QME-3Hb
MQTL3.3	2	QME-3Hb; qBG.3H
MQTL3.4	5	QME-3H; QBgnm.HaTR-3H.1; QBgnm.StMo-3H; QGpc.StMo-3H.1; QSP-3H
MQTL3.5	9	QGpc.StMo-3H.1; QSP-3H; QDp.StMo-3H; QAa.StMo-3H; QGpc.StMo-3H.2; QBgnm.HaTR-3H.2; QGpc.StMo-3H; QS/T.DiMo-3H; QVIS-3H

Supplementary Table 2 continued

Meta-QTL	No. of original QTLs	QTLs
MQTL3.6	2	QVIS-3H; QP-3H
MQTL4.1	12	QDp.StMo-4H; QMe.StMo-4H; QAa.HaMo-4H; QBgnm.StMo-4H; QAa.StMo-4H.1; QS/T.nab-4H; QAa.nab-4H; QPc.nab-4H.1; QGpc.HaMo-4H; QS/T.HaMo-4H; QGpc.DiMo-4H; QGpc.HaTR-4H.1
MQTL4.2	5	QGpc.DiMo-4H; QGpc.HaTR-4H.1; QBgsg.StMo-4H; QBeta-4Ha; QDP-4Ha
MQTL4.3	3	QBeta-4Ha; QDP-4Ha; QPc.nab-4H.2
MQTL4.4	10	QBeta-4Ha; QDP-4Ha; QPc.nab-4H.2; QDP-4Hc; QDP-4Hb; QDP-4H; QGpc.HaTR-4H.2; QBeta-4Hc; QBeta-4Hb; QAa.StMo-4H.2
MQTL5.1	2	QFge.HaTR-5H.1; QGpc.HaTR-5H
MQTL5.2	8	QGpc.StMo-5H; QS/T.DiMo-5H.1; QDp.DiMo-5H; QAa.DiMo-5H; QGpc.DiMo-5H.1; QBgnw.DiMo-5H; QMe.DiMo-5H.1; QDp.StMo-5H
MQTL5.3	12	QMe.DiMo-5H.2; QAa.StMo-5H.1; QAa.HaMo-5H; QWort-BG-5H; QBgsg.StMo-5H; QAa.ChHa-5H; QBgsk.StMo-5H; QS/T.DiMo-5H.2; QAa.StMo-5H; QAa.HaTR-5H; QGpc.HaMo-5H; QVIS-5H
MQTL5.4	4	QVIS-5H; QBgnm.HaTR-5H.1; QEv.HaTR-5H; QGpc.DiMo-5H.2
MQTL5.5	7	QGpc.DiMo-5H.2; QME-5Hb; QME-5Hc; QMe.DiMo-5H.3; Qvis5.1; QME-5Ha; QDP-5H
MQTL5.6	1	QDP-5H
MQTL6.1	1	QME-6H
MQTL6.2	1	QMe.StMo-6H
MQTL6.3	11	QDP-6H; QAa.StMo-6H; QDp.StMo-6H; QVIS-6H; QAa.HaTR-6H; QDp.HaTR-6H; QEv.HaTR-6H; QAa.ChHa-6H; QBG-6Ha; QBG-6Hb; QWort-BG-6H
MQTL6.4	12	QAa.StMo-6H; QDp.StMo-6H; QVIS-6H; QAa.HaTR-6H; QDp.HaTR-6H; QEv.HaTR-6H; QAa.ChHa-6H; QBG-6Ha; QBG-6Hb; QWort-BG-6H; Qpc6.1; QAlpha-6H

Supplementary Table 2 continued

Meta-QTL	No. of original QTLs	QTLs
MQTL7.1	3	QVIS-7Hc; QSP-7Hb; QDP-7Ha
MQTL7.2	25	QDP-7Ha; QWort-BG-7Hb; QWort-BG-7Hc; QVIS-7Hd; QDp.StMo-7H.3; QPc.nab-7H; QAa.StMo-7H.3; QSP-7Ha; QBgnm.StMo-7H.1; QDp.nab-7H.1; QVIS-7Hb; QBgnm.StMo-7H.2; QWort-BG-7Ha; QBgsk.StMo-7H.2; QVIS-7Ha; QBgsk.StMo-7H.1; QSP-7Hc; QGpc.HaMo-7H; QS/T.HaTR-7H; QEv.HaTR-7H; QDP-7Hb; QBG-7Hb; QAA-7Hb; QME-7H; QAlpha-7H
MQTL7.3	11	QDP-7Hb; QBG-7Hb; QAA-7Hb; QME-7H; QAlpha-7H; QGpc.DiMo-7H; QP-7Ha; QME-7Hc; QDp.HaTR-7H; QME-7Hd; QME-7Hb
MQTL7.4	7	QME-7Hc; QDp.HaTR-7H; QME-7Hd; QME-7Hb; QGP-7He; QGP-7Hc; QGP-7Hd

Supplementary Table 3. MQTL, chromosome number, flanking and nearby markers, and number of QTLs, studies, and populations in MQTLs of genes controlling barley malt quality.

MQTL	Chr.	Flanking marker	MQTL position	MQTL confidence interval (cM)	Closest marker	Number of initial QTLs	Number of studies	Number of populations
MQTL1.1	1H	1_0764(82.64)-2_1000(93.8)	88.47	82.84 - 94.1	XP13M50-115(85)-1_1484(91.3)	3	2	2
MQTL1.1	1H	1_0764(82.64)-2_1000(93.8)	88.47	82.84 - 94.1	XP13M50-115(85)-1_1484(91.3)			
MQTL1.1	1H	1_0764(82.64)-2_1000(93.8)	88.47	82.84 - 94.1	XP13M50-115(85)-1_1484(91.3)			
MQTL1.2	1H	P15M47-314(164.49)-1_0854(176.7)	170.55	164.45 - 176.65	Xp14m49B251(170.5)-iGpi(170.73)	8	3	3
MQTL1.2	1H	P15M47-314(164.49)-1_0854(176.7)	170.55	164.45 - 176.65	Xp14m49B251(170.5)-iGpi(170.73)			
MQTL1.2	1H	P15M47-314(164.49)-1_0854(176.7)	170.55	164.45 - 176.65	Xp14m49B251(170.5)-iGpi(170.73)			
MQTL1.2	1H	P15M47-314(164.49)-1_0854(176.7)	170.55	164.45 - 176.65	Xp14m49B251(170.5)-iGpi(170.73)			
MQTL1.2	1H	P15M47-314(164.49)-1_0854(176.7)	170.55	164.45 - 176.65	Xp14m49B251(170.5)-iGpi(170.73)			
MQTL1.2	1H	P15M47-314(164.49)-1_0854(176.7)	170.55	164.45 - 176.65	Xp14m49B251(170.5)-iGpi(170.73)			
MQTL1.2	1H	P15M47-314(164.49)-1_0854(176.7)	170.55	164.45 - 176.65	Xp14m49B251(170.5)-iGpi(170.73)			
MQTL1.2	1H	P15M47-314(164.49)-1_0854(176.7)	170.55	164.45 - 176.65	Xp14m49B251(170.5)-iGpi(170.73)			
MQTL1.3	1H	417979D1(193.96)-E39M62-225(201.6)	199.23	196.605 - 201.855	3263-2865(199.2)- E42M51-243(199.31)	11	3	3
MQTL1.3	1H	417979D1(193.96)-E39M62-225(201.6)	199.23	196.605 - 201.855	3263-2865(199.2)- E42M51-243(199.31)			
MQTL1.3	1H	417979D1(193.96)-E39M62-225(201.6)	199.23	196.605 - 201.855	3263-2865(199.2)- E42M51-243(199.31)			
MQTL1.3	1H	417979D1(193.96)-E39M62-225(201.6)	199.23	196.605 - 201.855	3263-2865(199.2)- E42M51-243(199.31)			
MQTL1.3	1H	417979D1(193.96)-E39M62-225(201.6)	199.23	196.605 - 201.855	3263-2865(199.2)- E42M51-243(199.31)	11	3	3
MQTL1.3	1H	417979D1(193.96)-E39M62-225(201.6)	199.23	196.605 - 201.855	3263-2865(199.2)- E42M51-243(199.31)			
MQTL1.3	1H	417979D1(193.96)-E39M62-225(201.6)	199.23	196.605 - 201.855	3263-2865(199.2)- E42M51-243(199.31)			
MQTL1.3	1H	417979D1(193.96)-E39M62-225(201.6)	199.23	196.605 - 201.855	3263-2865(199.2)- E42M51-243(199.31)			
MQTL1.3	1H	417979D1(193.96)-E39M62-225(201.6)	199.23	196.605 - 201.855	3263-2865(199.2)- E42M51-243(199.31)			
MQTL1.3	1H	417979D1(193.96)-E39M62-225(201.6)	199.23	196.605 - 201.855	3263-2865(199.2)- E42M51-243(199.31)			
MQTL1.3	1H	417979D1(193.96)-E39M62-225(201.6)	199.23	196.605 - 201.855	3263-2865(199.2)- E42M51-243(199.31)			
MQTL1.3	1H	417979D1(193.96)-E39M62-225(201.6)	199.23	196.605 - 201.855	3263-2865(199.2)- E42M51-243(199.31)			
MQTL1.4	1H	P15M53-165(208.98)- bPb-7609(212.22)	210.54	208.86 - 212.22	ISSR16-9 (210.52)-Xp11m61A238(210.68)	9	3	3
MQTL1.4	1H	P15M53-165(208.98)- bPb-7609(212.22)	210.54	208.86 - 212.22	ISSR16-9 (210.52)-Xp11m61A238(210.68)			
MQTL1.4	1H	P15M53-165(208.98)- bPb-7609(212.22)	210.54	208.86 - 212.22	ISSR16-9 (210.52)-Xp11m61A238(210.68)			
MQTL1.4	1H	P15M53-165(208.98)- bPb-7609(212.22)	210.54	208.86 - 212.22	ISSR16-9 (210.52)-Xp11m61A238(210.68)			
MQTL1.4	1H	P15M53-165(208.98)- bPb-7609(212.22)	210.54	208.86 - 212.22	ISSR16-9 (210.52)-Xp11m61A238(210.68)			
MQTL1.4	1H	P15M53-165(208.98)- bPb-7609(212.22)	210.54	208.86 - 212.22	ISSR16-9 (210.52)-Xp11m61A238(210.68)			
MQTL1.4	1H	P15M53-165(208.98)- bPb-7609(212.22)	210.54	208.86 - 212.22	ISSR16-9 (210.52)-Xp11m61A238(210.68)			
MQTL1.4	1H	P15M53-165(208.98)- bPb-7609(212.22)	210.54	208.86 - 212.22	ISSR16-9 (210.52)-Xp11m61A238(210.68)			

Supplementary Table 3 continued

[illegible]

Supplementary Table 3 continued

MQTL	Chr.	Flanking marker	MQTL position	MQTL confidence interval (cM)	Closest marker	Number of initial QTLs	Number of studies	Number of populations
MQTL2.1	2H	ABC156A(30.778)- 1447-464(39.231)	34.74	30.85 - 39.295	GBM1214 (34.665)-MWG858(35.007)	11	3	3
MQTL2.1	2H	ABC156A(30.778)- 1447-464(39.231)	34.74	30.85 - 39.295	GBM1214 (34.665)-MWG858(35.007)			
MQTL2.2	2H	1341-841(47.543)- bPb-3575(59.693)	53.33	47.145 - 59.515	bPt-6333(52.672)- bPt-9839(53.923)	10	3	3
MQTL2.2	2H	1341-841(47.543)- bPb-3575(59.693)	53.33	47.145 - 59.515	bPt-6333(52.672)- bPt-9839(53.923)			
MQTL2.2	2H	1341-841(47.543)- bPb-3575(59.693)	53.33	47.145 - 59.515	bPt-6333(52.672)- bPt-9839(53.923)			
MQTL2.2	2H	1341-841(47.543)- bPb-3575(59.693)	53.33	47.145 - 59.515	bPt-6333(52.672)- bPt-9839(53.923)			
MQTL2.2	2H	1341-841(47.543)- bPb-3575(59.693)	53.33	47.145 - 59.515	bPt-6333(52.672)- bPt-9839(53.923)			
MQTL2.2	2H	1341-841(47.543)- bPb-3575(59.693)	53.33	47.145 - 59.515	bPt-6333(52.672)- bPt-9839(53.923)			
MQTL2.2	2H	1341-841(47.543)- bPb-3575(59.693)	53.33	47.145 - 59.515	bPt-6333(52.672)- bPt-9839(53.923)			
MQTL2.2	2H	1341-841(47.543)- bPb-3575(59.693)	53.33	47.145 - 59.515	bPt-6333(52.672)- bPt-9839(53.923)			
MQTL2.2	2H	1341-841(47.543)- bPb-3575(59.693)	53.33	47.145 - 59.515	bPt-6333(52.672)- bPt-9839(53.923)			
MQTL2.2	2H	1341-841(47.543)- bPb-3575(59.693)	53.33	47.145 - 59.515	bPt-6333(52.672)- bPt-9839(53.923)			
MQTL2.2	2H	1341-841(47.543)- bPb-3575(59.693)	53.33	47.145 - 59.515	bPt-6333(52.672)- bPt-9839(53.923)			
MQTL2.3	2H	GMS3(72.348)- Ipbs2240-3(83.988)	77.88	72.454- 83.215	Bmac0273C(77.876)-Bmag0711(79.143)	8	2	2
MQTL2.3	2H	GMS3(72.348)- Ipbs2240-3(83.988)	77.88	72.454- 83.215	Bmac0273C(77.876)-Bmag0711(79.143)			
MQTL2.3	2H	GMS3(72.348)- Ipbs2240-3(83.988)	77.88	72.454- 83.215	Bmac0273C(77.876)-Bmag0711(79.143)	8	2	2
MQTL2.3	2H	GMS3(72.348)- Ipbs2240-3(83.988)	77.88	72.454- 83.215	Bmac0273C(77.876)-Bmag0711(79.143)			
MQTL2.3	2H	GMS3(72.348)- Ipbs2240-3(83.988)	77.88	72.454- 83.215	Bmac0273C(77.876)-Bmag0711(79.143)			
MQTL2.3	2H	GMS3(72.348)- Ipbs2240-3(83.988)	77.88	72.454- 83.215	Bmac0273C(77.876)-Bmag0711(79.143)			
MQTL2.3	2H	GMS3(72.348)- Ipbs2240-3(83.988)	77.88	72.454- 83.215	Bmac0273C(77.876)-Bmag0711(79.143)			
MQTL2.3	2H	GMS3(72.348)- Ipbs2240-3(83.988)	77.88	72.454- 83.215	Bmac0273C(77.876)-Bmag0711(79.143)			
MQTL2.4	2H	bPt-8737(103.669)- bPb-8274(107.285)	105.15	103.125 - 107.175	bPb-6822(105.080)-bPb-3769(105.437)	6	2	2
MQTL2.4	2H	bPt-8737(103.669)- bPb-8274(107.285)	105.15	103.125 - 107.175	bPb-6822(105.080)-bPb-3769(105.437)			
MQTL2.4	2H	bPt-8737(103.669)- bPb-8274(107.285)	105.15	103.125 - 107.175	bPb-6822(105.080)-bPb-3769(105.437)			
MQTL2.4	2H	bPt-8737(103.669)- bPb-8274(107.285)	105.15	103.125 - 107.175	bPb-6822(105.080)-bPb-3769(105.437)			
MQTL2.4	2H	bPt-8737(103.669)- bPb-8274(107.285)	105.15	103.125 - 107.175	bPb-6822(105.080)-bPb-3769(105.437)			
MQTL2.4	2H	bPt-8737(103.669)- bPb-8274(107.285)	105.15	103.125 - 107.175	bPb-6822(105.080)-bPb-3769(105.437)			

Supplementary Table 3 continued

[illegible]

Supplementary Table 3 continued

MQTL	Chr.	Flanking marker	MQTL position	MQTL confidence interval(cM)	Closest marker	Number of initial QTLs	Number of studies	Number of populations
MQTL3.5	3H	bPt-4750(311.59)- bPb-6228(323.42)	317.48	311.665 - 323.295	6871-945(317.05)- bPb-1183(317.49)	9	3	3
MQTL3.6	3H	AW983293C(363.62)- bPb1481(407.88)	385.55	363.64 - 407.46	dym4(385.42)- bPb7695(386.18)	2	2	2
MQTL3.6	3H	AW983293C(363.62)- bPb1481(407.88)	385.55	363.64 - 407.46	dym4(385.42)- bPb7695(386.18)			
MQTL4.1	4H	GBM1221(104.82)- bp8724(112.775)	108.8	104.9 - 112.7	bPb-2476(108.609)- *E42M40-94(109.241)	12	2	2
MQTL4.1	4H	GBM1221(104.82)- bp8724(112.775)	108.8	104.9 - 112.7	bPb-2476(108.609)- *E42M40-94(109.241)			
MQTL4.1	4H	GBM1221(104.82)- bp8724(112.775)	108.8	104.9 - 112.7	bPb-2476(108.609)- *E42M40-94(109.241)			
MQTL4.1	4H	GBM1221(104.82)- bp8724(112.775)	108.8	104.9 - 112.7	bPb-2476(108.609)- *E42M40-94(109.241)			
MQTL4.1	4H	GBM1221(104.82)- bp8724(112.775)	108.8	104.9 - 112.7	bPb-2476(108.609)- *E42M40-94(109.241)			
MQTL4.1	4H	GBM1221(104.82)- bp8724(112.775)	108.8	104.9 - 112.7	bPb-2476(108.609)- *E42M40-94(109.241)			
MQTL4.1	4H	GBM1221(104.82)- bp8724(112.775)	108.8	104.9 - 112.7	bPb-2476(108.609)- *E42M40-94(109.241)			
MQTL4.1	4H	GBM1221(104.82)- bp8724(112.775)	108.8	104.9 - 112.7	bPb-2476(108.609)- *E42M40-94(109.241)			
MQTL4.1	4H	GBM1221(104.82)- bp8724(112.775)	108.8	104.9 - 112.7	bPb-2476(108.609)- *E42M40-94(109.241)			
MQTL4.1	4H	GBM1221(104.82)- bp8724(112.775)	108.8	104.9 - 112.7	bPb-2476(108.609)- *E42M40-94(109.241)			
MQTL4.1	4H	GBM1221(104.82)- bp8724(112.775)	108.8	104.9 - 112.7	bPb-2476(108.609)- *E42M40-94(109.241)			
MQTL4.1	4H	GBM1221(104.82)- bp8724(112.775)	108.8	104.9 - 112.7	bPb-2476(108.609)- *E42M40-94(109.241)			
MQTL4.1	4H	GBM1221(104.82)- bp8724(112.775)	108.8	104.9 - 112.7	bPb-2476(108.609)- *E42M40-94(109.241)			
MQTL4.1	4H	GBM1221(104.82)- bp8724(112.775)	108.8	104.9 - 112.7	bPb-2476(108.609)- *E42M40-94(109.241)			
MQTL4.1	4H	GBM1221(104.82)- bp8724(112.775)	108.8	104.9 - 112.7	bPb-2476(108.609)- *E42M40-94(109.241)			
MQTL4.2	4H	AWBMA30(127.686)- ABA003(145.195)	136.74	128.295 - 145.185	SOLPRO(136.618)- bPb-6427(137.323)	5	2	2
MQTL4.2	4H	AWBMA30(127.686)- ABA003(145.195)	136.74	128.295 - 145.185	SOLPRO(136.618)- bPb-6427(137.323)			
MQTL4.2	4H	AWBMA30(127.686)- ABA003(145.195)	136.74	128.295 - 145.185	SOLPRO(136.618)- bPb-6427(137.323)			
MQTL4.2	4H	AWBMA30(127.686)- ABA003(145.195)	136.74	128.295 - 145.185	SOLPRO(136.618)- bPb-6427(137.323)			
MQTL4.2	4H	AWBMA30(127.686)- ABA003(145.195)	136.74	128.295 - 145.185	SOLPRO(136.618)- bPb-6427(137.323)			
MQTL4.3	4H	bPb-4966(170.272)- E39M59-424(188.192)	179.25	170.29 - 188.21	bags8a14(178.739)- *E39M61-367(179.292)	3	2	2
MQTL4.3	4H	bPb-4966(170.272)- E39M59-424(188.192)	179.25	170.29 - 188.21	bags8a14(178.739)- *E39M61-367(179.292)			
MQTL4.3	4H	bPb-4966(170.272)- E39M59-424(188.192)	179.25	170.29 - 188.21	bags8a14(178.739)- *E39M61-367(179.292)			
MQTL4.4	4H	bPb-9808(213.704)- bPb-9086(213.882)	213.72	213.625 - 213.815	bPb-9808(213.704)- bPb-9820(213.745)	10	3	3
MQTL4.4	4H	bPb-9808(213.704)- bPb-9086(213.882)	213.72	213.625 - 213.815	bPb-9808(213.704)- bPb-9820(213.745)			
MQTL4.4	4H	bPb-9808(213.704)- bPb-9086(213.882)	213.72	213.625 - 213.815	bPb-9808(213.704)- bPb-9820(213.745)			
MQTL4.4	4H	bPb-9808(213.704)- bPb-9086(213.882)	213.72	213.625 - 213.815	bPb-9808(213.704)- bPb-9820(213.745)			
MQTL4.4	4H	bPb-9808(213.704)- bPb-9086(213.882)	213.72	213.625 - 213.815	bPb-9808(213.704)- bPb-9820(213.745)			
MQTL4.4	4H	bPb-9808(213.704)- bPb-9086(213.882)	213.72	213.625 - 213.815	bPb-9808(213.704)- bPb-9820(213.745)			
MQTL4.4	4H	bPb-9808(213.704)- bPb-9086(213.882)	213.72	213.625 - 213.815	bPb-9808(213.704)- bPb-9820(213.745)			

Supplementary Table 3 continued

MQTL	Chr.	Flanking marker	MQTL position	MQTL confidence interval(cM)	Closest marker	Number of initial QTLs	Number of studies	Number of populations
MQTL4.4	4H	bPb-9808(213.704)-bPb-9086(213.882)	213.72	213.625 - 213.815	bPb-9808(213.704)- bPb-9820(213.745)	10	3	3
MQTL4.4	4H	bPb-9808(213.704)-bPb-9086(213.882)	213.72	213.625 - 213.815	bPb-9808(213.704)- bPb-9820(213.745)			
MQTL4.4	4H	bPb-9808(213.704)-bPb-9086(213.882)	213.72	213.625 - 213.815	bPb-9808(213.704)- bPb-9820(213.745)			
MQTL5.1	5H	3997-796(52.078)-bPt-1586(59.278)	55.61	51.99 - 59.23	bPb-0170(54.968)- bPb-0085(55.675)	2	1	1
MQTL5.1	5H	3997-796(52.078)-bPt-1586(59.278)	55.61	51.99 - 59.23	bPb-0170(54.968)- bPb-0085(55.675)			
MQTL5.2	5H	bPb-0050(100.357)-bPt-5575(111.4358)	105.99	100.685 - 111.295	SCRI_RS_198009(105.611)-baak29b22(106.145)	8	1	1
MQTL5.2	5H	bPb-0050(100.357)-bPt-5575(111.4358)	105.99	100.685 - 111.295	SCRI_RS_198009(105.611)-baak29b22(106.145)			
MQTL5.2	5H	bPb-0050(100.357)-bPt-5575(111.4358)	105.99	100.685 - 111.295	SCRI_RS_198009(105.611)-baak29b22(106.145)			
MQTL5.2	5H	bPb-0050(100.357)-bPt-5575(111.4358)	105.99	100.685 - 111.295	SCRI_RS_198009(105.611)-baak29b22(106.145)			
MQTL5.2	5H	bPb-0050(100.357)-bPt-5575(111.4358)	105.99	100.685 - 111.295	SCRI_RS_198009(105.611)-baak29b22(106.145)			
MQTL5.2	5H	bPb-0050(100.357)-bPt-5575(111.4358)	105.99	100.685 - 111.295	SCRI_RS_198009(105.611)-baak29b22(106.145)			
MQTL5.2	5H	bPb-0050(100.357)-bPt-5575(111.4358)	105.99	100.685 - 111.295	SCRI_RS_198009(105.611)-baak29b22(106.145)			
MQTL5.2	5H	bPb-0050(100.357)-bPt-5575(111.4358)	105.99	100.685 - 111.295	SCRI_RS_198009(105.611)-baak29b22(106.145)			
MQTL5.3	5H	Bmag113a(162.751)-GBR0242(171.226)	167	162.79 - 171.21	scssr16991(166.958)-E35M48-48(167.167)	12	2	2
MQTL5.3	5H	Bmag113a(162.751)-GBR0242(171.226)	167	162.79 - 171.21	scssr16991(166.958)-E35M48-48(167.167)			
MQTL5.3	5H	Bmag113a(162.751)-GBR0242(171.226)	167	162.79 - 171.21	scssr16991(166.958)-E35M48-48(167.167)	12	2	2
MQTL5.3	5H	Bmag113a(162.751)-GBR0242(171.226)	167	162.79 - 171.21	scssr16991(166.958)-E35M48-48(167.167)			
MQTL5.3	5H	Bmag113a(162.751)-GBR0242(171.226)	167	162.79 - 171.21	scssr16991(166.958)-E35M48-48(167.167)			
MQTL5.3	5H	Bmag113a(162.751)-GBR0242(171.226)	167	162.79 - 171.21	scssr16991(166.958)-E35M48-48(167.167)			
MQTL5.3	5H	Bmag113a(162.751)-GBR0242(171.226)	167	162.79 - 171.21	scssr16991(166.958)-E35M48-48(167.167)			
MQTL5.3	5H	Bmag113a(162.751)-GBR0242(171.226)	167	162.79 - 171.21	scssr16991(166.958)-E35M48-48(167.167)			
MQTL5.3	5H	Bmag113a(162.751)-GBR0242(171.226)	167	162.79 - 171.21	scssr16991(166.958)-E35M48-48(167.167)			
MQTL5.3	5H	Bmag113a(162.751)-GBR0242(171.226)	167	162.79 - 171.21	scssr16991(166.958)-E35M48-48(167.167)			
MQTL5.3	5H	Bmag113a(162.751)-GBR0242(171.226)	167	162.79 - 171.21	scssr16991(166.958)-E35M48-48(167.167)			
MQTL5.3	5H	Bmag113a(162.751)-GBR0242(171.226)	167	162.79 - 171.21	scssr16991(166.958)-E35M48-48(167.167)			
MQTL5.4	5H	bPb-0710(197.205)-GBR0951(214.553)	205.84	197.165 - 214.515	GBS0531-1(205.67)-bp13291(205.854)	4	2	2
MQTL5.4	5H	bPb-0710(197.205)-GBR0951(214.553)	205.84	197.165 - 214.515	GBS0531-1(205.67)-bp13291(205.854)			
MQTL5.4	5H	bPb-0710(197.205)-GBR0951(214.553)	205.84	197.165 - 214.515	GBS0531-1(205.67)-bp13291(205.854)			
MQTL5.4	5H	bPb-0710(197.205)-GBR0951(214.553)	205.84	197.165 - 214.515	GBS0531-1(205.67)-bp13291(205.854)			
MQTL5.5	5H	5126-1311(234.779)-k04490(240.103)	237.37	234.64 - 240.1	SCRI_RS_230566(237.196)-5925-565(237.745)	7	3	3

Supplementary Table 3 continued

[illegible]

Supplementary Table 3 continued

[illegible]

Supplementary Table 3 continued

MQTL	Chr.	Flanking marker	MQTL position	MQTL confidence interval (cM)	Closest marker	Number of initial QTLs	Number of studies	Number of populations
MQTL7.3	7H	PSR117(160.792)- BOPA2_12_30166(176.729)	168.89	161.055 - 176.725	bp4054(168.478)- ABC154A(169.165)	11	5	5
MQTL7.3	7H	PSR117(160.792)- BOPA2_12_30166(176.729)	168.89	161.055 - 176.725	bp4054(168.478)- ABC154A(169.165)			
MQTL7.3	7H	PSR117(160.792)- BOPA2_12_30166(176.729)	168.89	161.055 - 176.725	bp4054(168.478)- ABC154A(169.165)			
MQTL7.3	7H	PSR117(160.792)- BOPA2_12_30166(176.729)	168.89	161.055 - 176.725	bp4054(168.478)- ABC154A(169.165)			
MQTL7.3	7H	PSR117(160.792)- BOPA2_12_30166(176.729)	168.89	161.055 - 176.725	bp4054(168.478)- ABC154A(169.165)			
MQTL7.3	7H	PSR117(160.792)- BOPA2_12_30166(176.729)	168.89	161.055 - 176.725	bp4054(168.478)- ABC154A(169.165)			
MQTL7.3	7H	PSR117(160.792)- BOPA2_12_30166(176.729)	168.89	161.055 - 176.725	bp4054(168.478)- ABC154A(169.165)			
MQTL7.3	7H	PSR117(160.792)- BOPA2_12_30166(176.729)	168.89	161.055 - 176.725	bp4054(168.478)- ABC154A(169.165)			
MQTL7.3	7H	PSR117(160.792)- BOPA2_12_30166(176.729)	168.89	161.055 - 176.725	bp4054(168.478)- ABC154A(169.165)			
MQTL7.3	7H	PSR117(160.792)- BOPA2_12_30166(176.729)	168.89	161.055 - 176.725	bp4054(168.478)- ABC154A(169.165)			
MQTL7.3	7H	PSR117(160.792)- BOPA2_12_30166(176.729)	168.89	161.055 - 176.725	bp4054(168.478)- ABC154A(169.165)			
MQTL7.4	7H	bPb-5403(197.743)- bPb- 6821(203.899)	200.67	197.705 - 203.635	bPb-3566(200.371)- bah50i23(200.901)	7	2	2
MQTL7.4	7H	bPb-5403(197.743)- bPb- 6821(203.899)	200.67	197.705 - 203.635	bPb-3566(200.371)- bah50i23(200.901)			
MQTL7.4	7H	bPb-5403(197.743)- bPb- 6821(203.899)	200.67	197.705 - 203.635	bPb-3566(200.371)- bah50i23(200.901)			
MQTL7.4	7H	bPb-5403(197.743)- bPb- 6821(203.899)	200.67	197.705 - 203.635	bPb-3566(200.371)- bah50i23(200.901)			
MQTL7.4	7H	bPb-5403(197.743)- bPb- 6821(203.899)	200.67	197.705 - 203.635	bPb-3566(200.371)- bah50i23(200.901)	7	2	2
MQTL7.4	7H	bPb-5403(197.743)- bPb- 6821(203.899)	200.67	197.705 - 203.635	bPb-3566(200.371)- bah50i23(200.901)			
MQTL7.4	7H	bPb-5403(197.743)- bPb- 6821(203.899)	200.67	197.705 - 203.635	bPb-3566(200.371)- bah50i23(200.901)			