

Supplementary information

Genome-association analysis of Korean Holstein milk traits using genomic estimated breeding value

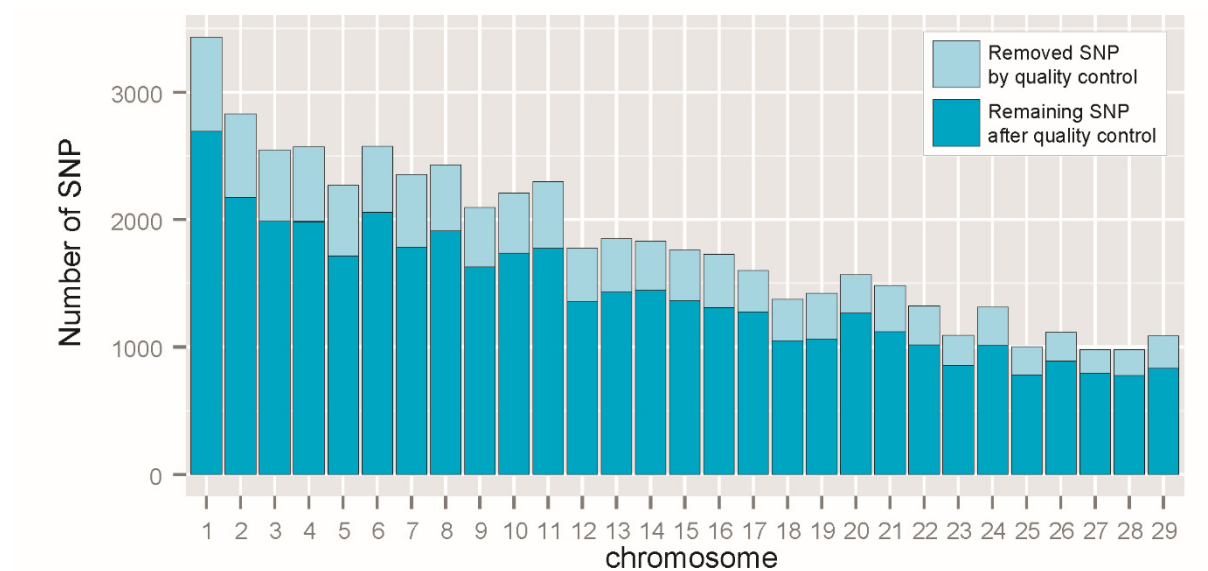
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Supplementary figures 1-11

Supplementary table 1

Supplementary Figures

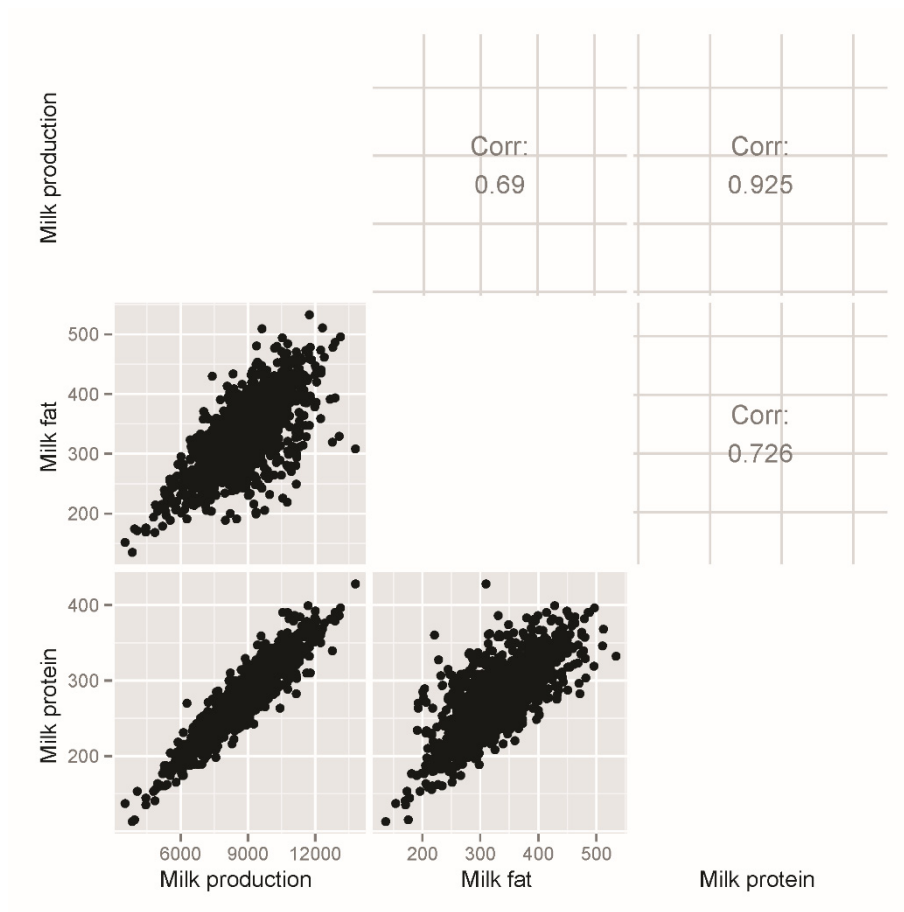
Supplementary Figure 1. Number of SNPs before and after quality control.



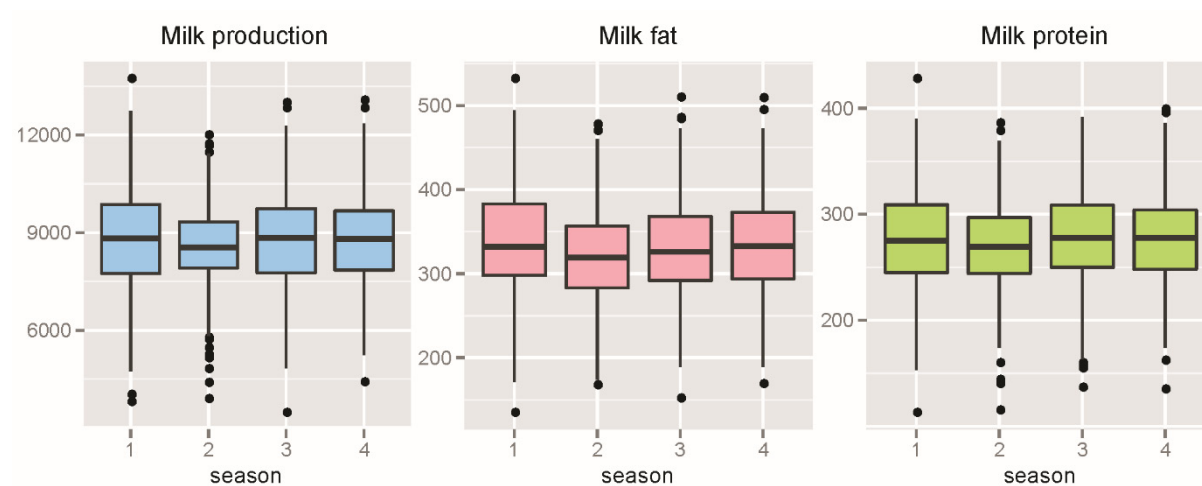
Supplementary Figure 2. Phenotype distributions of milk traits (milk production, fat and protein).



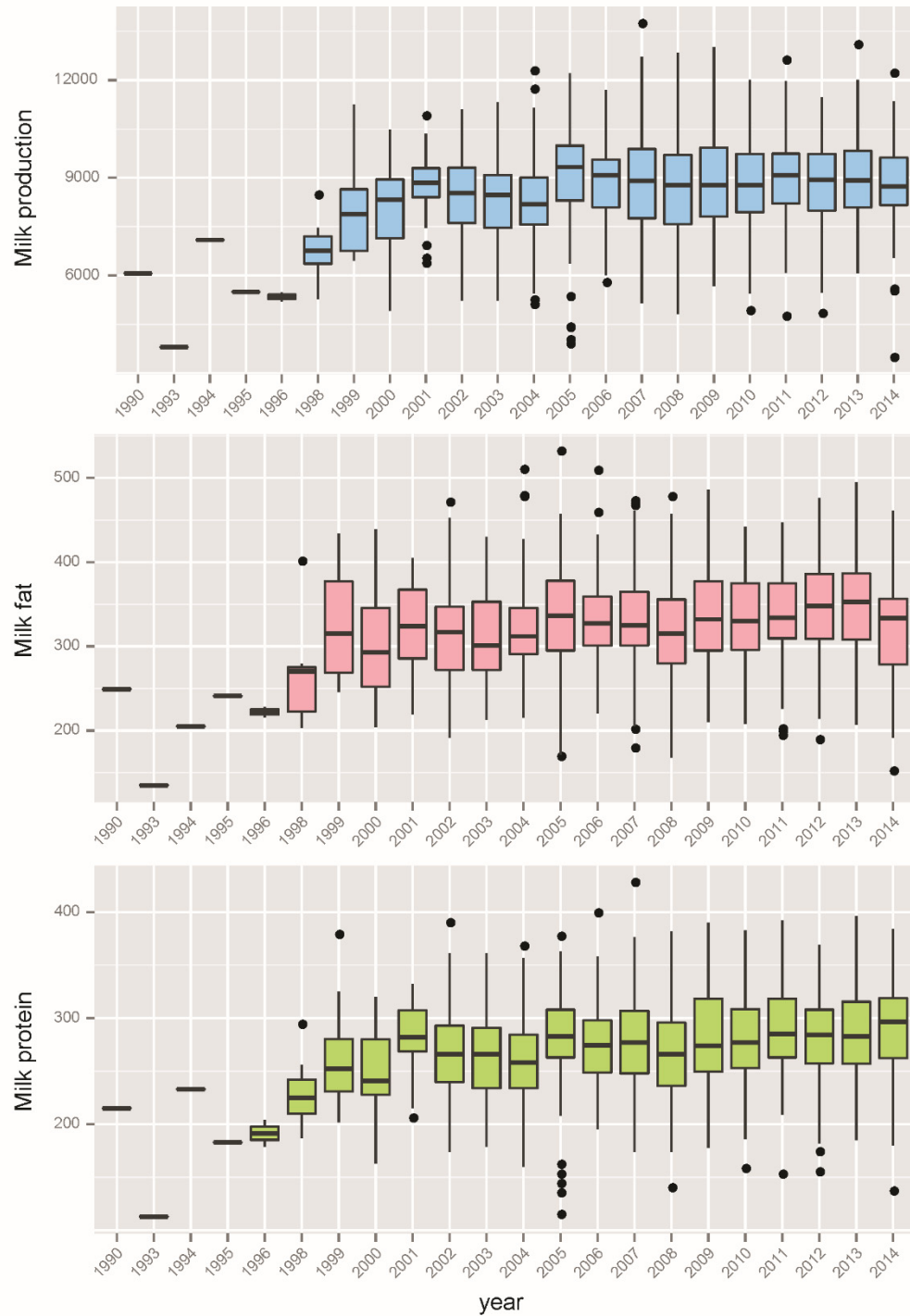
Supplementary Figure 3. All pairwise phenotypic correlation of milk traits (milk production, fat and protein) and correlation coefficients.



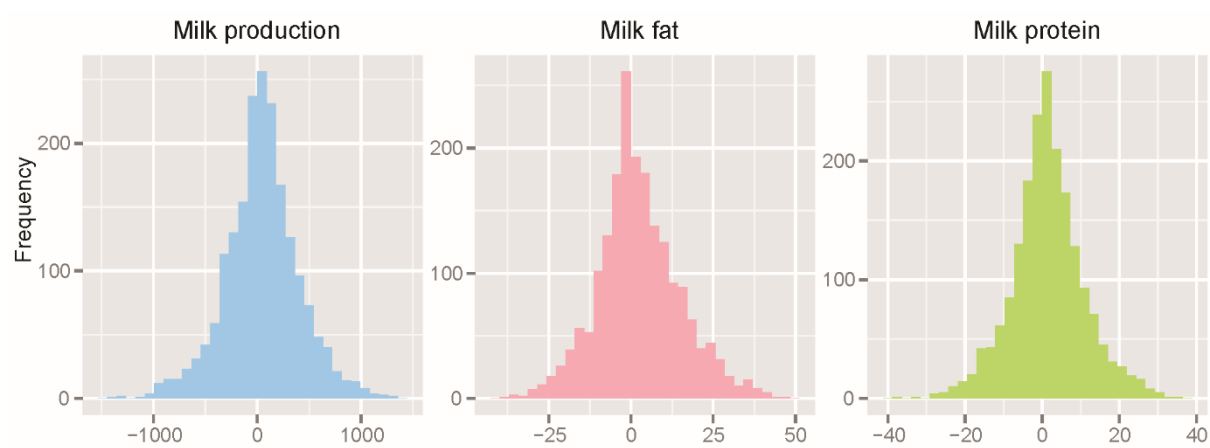
Supplementary Figure 4. Phenotype boxplots per season of each milk traits (12~2: 1.winter, 3~5: 2.spring, 6~8: 3.summer, 9~11: 4.fall)



Supplementary Figure 5. Phenotype boxplots per year (1990~2014) of each milk traits



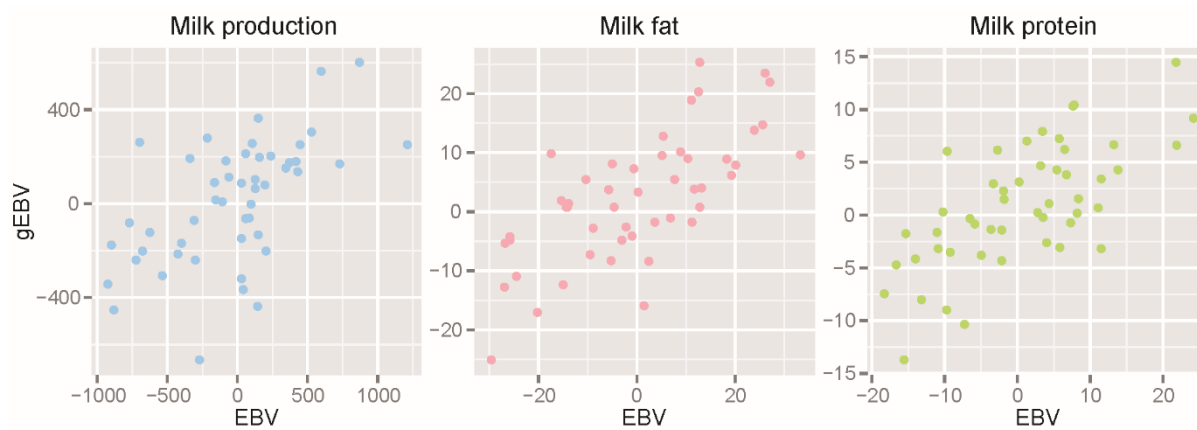
Supplementary Figure 6. Estimated Breeding Value (EBV) distributions of milk traits (milk production, fat and protein).



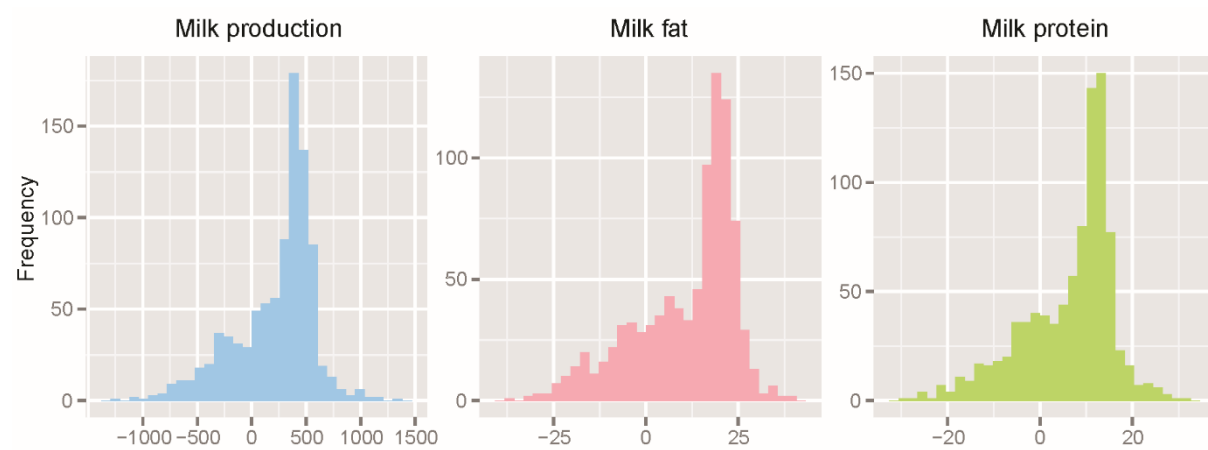
Supplementary Figure 7. SNP effect (from ridge regression) distributions of milk traits (milk production, fat and protein).



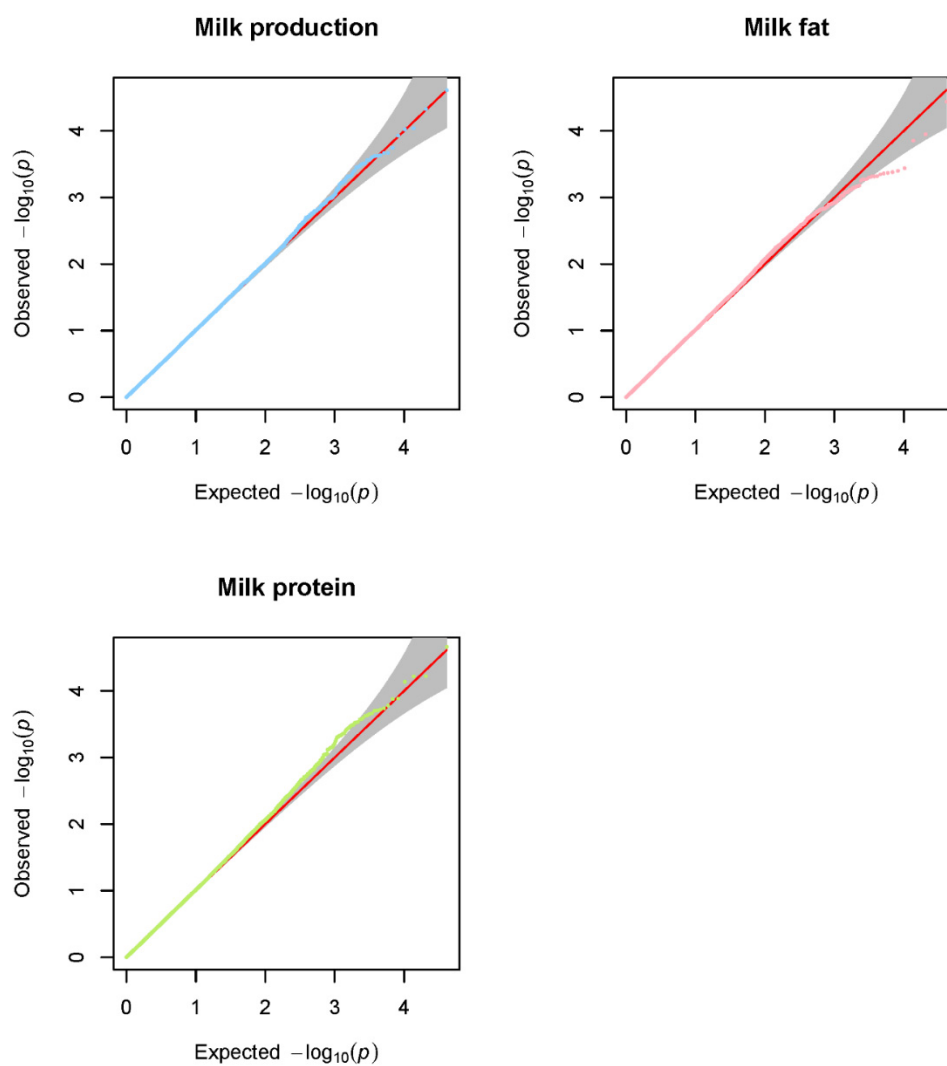
Supplementary Figure 8. Plot of EBV and gEBV in of milk traits (milk production, fat and protein) in test set of ridge regression to infer SNP effect



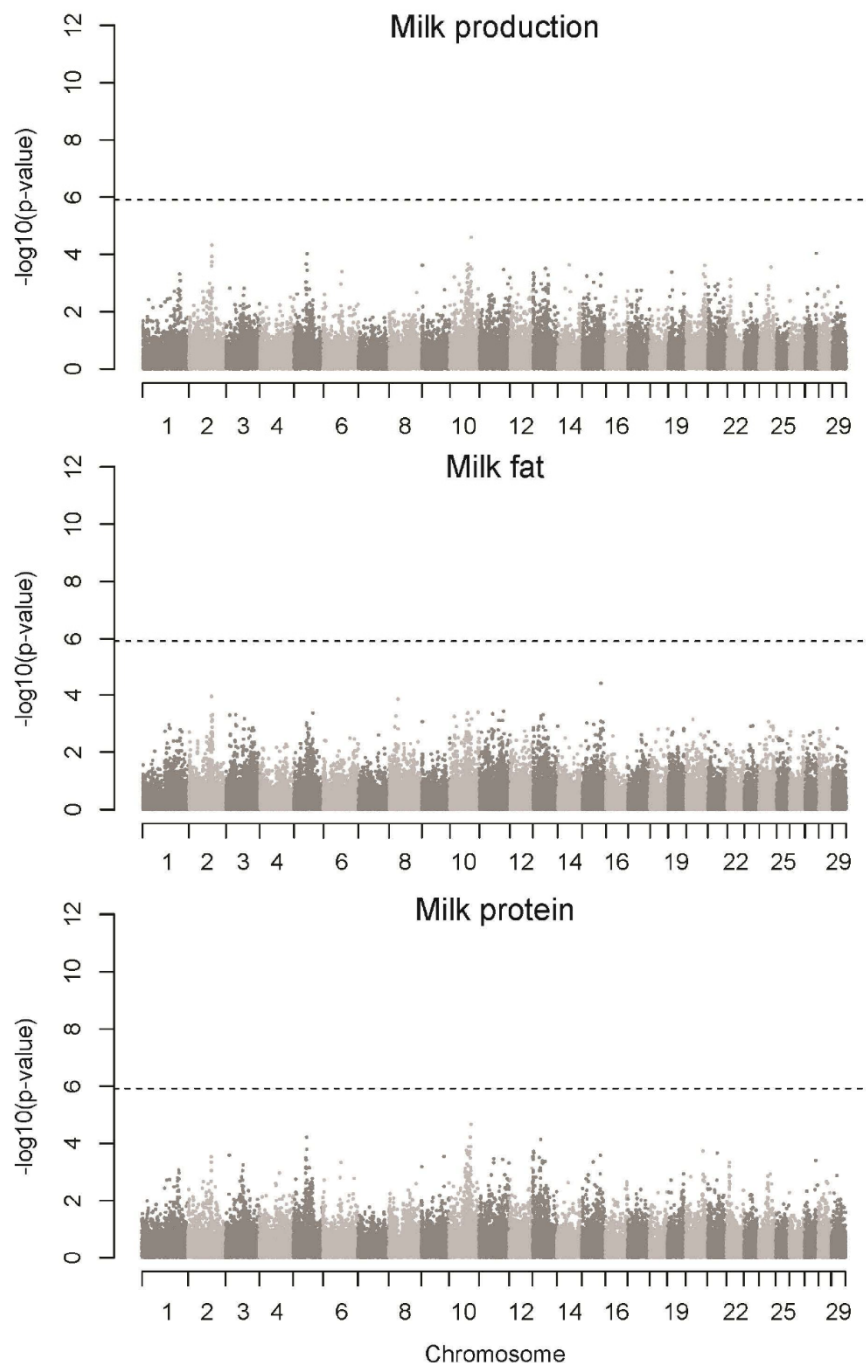
Supplementary Figure 9. Genomic Estimated Breeding Value (gEBV) distributions of milk traits (milk production, fat and protein).



Supplementary Figure 10. Q-Q plot of genomic control p-values in GWAS of each milk traits (milk production, fat and protein).



Supplementary Figure 11. Manhattan plot of genomic control p-value in GWAS result of each milk traits (milk production, fat and protein). Grey dot line meant that the threshold of Bonferroni multiple test based on genomic control p-values in each milk traits association test (genomic p-value < 1.21E-06, equivalent to p-value = 0.05 after Bonferroni multiple correction)



Supplementary Tables

Supplementary Table 1. Significant genetic regions in GWAS results of milk protein

CHR	Region ID	regDIS	p-value	Bonferroni	SNP ID	SNP Pos	SNP p-value	Ensembl Gene ID (Gene Symbol)	QTL Trait
1	CHR1:126549908 -126680933	131025	1.38E-08	1.14.E-04	BTB-00060751 ARS-BFGL-NGS-98257 ARS-BFGL-NGS-113021 ARS-BFGL-NGS-25639 ARS-BFGL-NGS-100109	126549908 126567481 126606801 126651501 126680933	3.06.E-03 8.96.E-03 2.10.E-03 4.68.E-03 1.63.E-03	ENSBTAG000000031178 (SLC9A9)	
2	CHR2:80605588 -81002535	396947	1.42E-06	1.17.E-02	ARS-BFGL-NGS-41490 ARS-BFGL-NGS-5680 Hapmap50262-BTA-122131 ARS-BFGL-NGS-94696 ARS-BFGL-NGS-102243	80605588 80666057 80687709 80970515 81002535	8.09.E-02 1.49.E-01 6.01.E-02 4.62.E-04 3.03.E-04	ENSBTAG000000014832 (TMEFF2) ENSBTAG000000046400 ENSBTAG000000018653 (NABP1) ENSBTAG000000018497 (SDPR)	
3	CHR3:69182813 -69391345	208532	3.75E-07	3.08.E-03	BTB-01635025 BTB-00133734 BTB-00133701 BTB-00133671 BTB-01711286	69182813 69292666 69315385 69342335 69391345	7.89.E-01 3.46.E-03 9.16.E-04 4.24.E-03 1.96.E-03	ENSBTAG000000042950 (SNORD45) ENSBTAG000000024240 (ACADM) ENSBTAG000000005864 (ASB17) ENSBTAG000000043447 (SNORD45) ENSBTAG000000018447 (RABGGTB) ENSBTAG000000018448 (MSH4) ENSBTAG000000042353 (SNORD45)	
5	CHR5:52249541 -53610334	1360793	1.39E-06	1.14.E-02	ARS-BFGL-NGS-52586 Hapmap39507-BTA-73544 Hapmap43667-BTA-73533 ARS-BFGL-NGS-8741 ARS-BFGL-NGS-114150	52249541 52300318 52600701 53263967 53610334	9.13.E-03 7.17.E-03 7.05.E-04 2.47.E-03 8.70.E-01	ENSBTAG000000040344	Production Association (Body weight (birth): QTLID24524) Meat and Carcass Association (Longissimus muscle area: QTLID24694) Meat and Carcass Association (Longissimus muscle area: QTLID24695) Meat and Carcass Association (Marbling score: QTLID24664) Reproduction QTL (Stillbirth (maternal) : QTLID30495) Meat and Carcass QTL (Fat thickness at the 12th rib: QTLID22879)

									Reproduction Association (Calving ease (direct) : QTLID24565) Meat and Carcass QTL (Intramuscular fat: QTLID22864)
5	CHR5:73187595 -73419142	231547	3.93E-07	3.22.E-03	ARS-BFGL-NGS-90377 ARS-BFGL-NGS-119129 ARS-BFGL-NGS-29546 ARS-BFGL-NGS-101650 BTA-119247-no-rs	73187595 73214162 73258507 73334655 73419142	3.65.E-03 2.60.E-03 9.46.E-03 7.94.E-03 3.08.E-02		Meat and Carcass QTL (Fat thickness at the 12th rib: QTLID22880) Meat and Carcass QTL (Longissimus muscle area: QTLID22848) Meat and Carcass QTL (Intramuscular fat: QTLID22864)
10	CHR10:67538919 -67694539	155620	1.35E-07	1.11.E-03	ARS-BFGL-NGS-247 ARS-BFGL-NGS-44563 BTA-74241-no-rs ARS-BFGL-NGS-32233 ARS-BFGL-BAC-15431	67538919 67586540 67626007 67648206 67694539	3.41.E-03 1.31.E-03 1.39.E-02 4.67.E-03 2.15.E-02	ENSBTAG00000040151 (GCH1) ENSBTAG00000019120 (WDHD1)	
10	CHR10:71105511 -71318080	212569	1.55E-06	1.27.E-02	ARS-BFGL-NGS-94765 BTB-00434073 BTB-01449482 ARS-BFGL-NGS-116012 BTB-01449316	71105511 71137516 71226626 71266946 71318080	2.47.E-01 3.66.E-03 3.65.E-02 2.14.E-03 1.60.E-03	ENSBTAG00000019421 (DACT1) ENSBTAG00000043611 (U6)	
10	CHR10:73739496 -74011076	271580	1.18E-06	9.66.E-03	ARS-BFGL-NGS-36378 Hapmap26103-BTA-125742 Hapmap41352-BTA-75284 ARS-BFGL-NGS-68102 ARS-BFGL-NGS-69839	73739496 73798107 73884120 73920310 74011076	9.82.E-01 2.39.E-04 2.00.E-04 1.89.E-03 9.16.E-01	ENSBTAG00000003276 (PRKCH)	Meat and Carcass QTL (Palmitoleic acid content: QTLID31768) Meat and Carcass QTL (Stearic acid content: QTLID31759)
10	CHR10:77339732 -77518423	178691	5.22E-07	4.28.E-03	Hapmap50095-BTA-76251 ARS-BFGL-NGS-18574 ARS-BFGL-NGS-23713 ARS-BFGL-NGS-22656 ARS-BFGL-NGS-114908	77339732 77391821 77423941 77495125 77518423	6.04.E-05 3.36.E-04 1.61.E-01 1.02.E-01 9.19.E-02	ENSBTAG00000017994 (MAX) ENSBTAG00000003469 (CHURC1) ENSBTAG00000003474 (RAB15) ENSBTAG00000005897 (FNTB) ENSBTAG00000048112 (GPX2)	
10	CHR10:80181163 -80567844	386681	3.06E-07	2.51.E-03	ARS-BFGL-NGS-117202 ARS-BFGL-BAC-11003 ARS-BFGL-NGS-41880 BTB-00437473 ARS-BFGL-NGS-3980	80181163 80410977 80525247 80546262 80567844	6.10.E-01 1.31.E-04 9.13.E-04 1.78.E-01 1.25.E-03	ENSBTAG00000045041 (7SK) ENSBTAG00000018971 (RAD51B) ENSBTAG00000014334 (ZFYVE26)	

10	CHR10:80857205 -80986865	129660	7.43E-07	6.10.E-03	ARS-BFGL-NGS-104852 ARS-BFGL-NGS-32379 Hapmap53872-rs29020120 BTB-00437636 ARS-BFGL-NGS-106025	80857205 80910121 80942486 80963535 80986865	2.20.E-05 5.38.E-02 3.36.E-02 5.23.E-02 2.25.E-02	ENSBTAG00000025434 (ZFP36L1)	
11	CHR11:105593624 -106067128	473504	1.66E-06	1.36.E-02	ARS-BFGL-NGS-108104 ARS-BFGL-NGS-31810 ARS-BFGL-NGS-64275 Hapmap42853-BTA-15475 ARS-BFGL-NGS-45339	105593624 105631144 105699664 106019172 106067128	3.09.E-02 6.85.E-03 3.98.E-03 4.29.E-02 3.37.E-03	ENSBTAG00000045734 (LRRC26) ENSBTAG00000047202 (GRIN1) ENSBTAG00000004095 (FAM166A) ENSBTAG00000047061 (NDOR1) ENSBTAG00000021861 (COBRA1) ENSBTAG00000023788 (EXD3) ENSBTAG00000030246 (ENTPD8) ENSBTAG00000017851 (RXRA) ENSBTAG00000039138 (MRPL41) ENSBTAG00000047357 (RNF208) ENSBTAG00000046379 (SLC34A3) ENSBTAG00000046122 (NRARP) ENSBTAG00000047715 (TPRN) ENSBTAG00000038691 (DPH7) ENSBTAG00000030247 (NSMF) ENSBTAG00000045711 (CYSRT1) ENSBTAG00000012121 (NOXA1) ENSBTAG00000046215 (TMEM203) ENSBTAG00000012126 (PNPLA7) ENSBTAG00000025274 (TUBB4B) ENSBTAG00000046223	Meat and Carcass QTL (Stearic acid content: QTLID31760)

								ENSBTAG00000046416 ENSBTAG00000047964 (TMEM210) ENSBTAG00000046415 (SSNA1) ENSBTAG00000046418 (RNF224) ENSBTAG00000023787 (TOR4A)	
13	CHR13:1278678-1559165	280487	1.99E-07	1.64.E-03	ARS-BFGL-BAC-12483 Hapmap47208-BTA-15912 Hapmap60144-rs29013559 Hapmap45253-BTA-15908 ARS-BFGL-NGS-115902	1278678 1299992 1397454 1477972 1559165	4.87.E-03 4.15.E-01 3.00.E-04 2.15.E-03 7.54.E-03	ENSBTAG00000008338 (PLCB1)	
13	CHR13:1867669-1982591	114922	1.90E-06	1.56.E-02	BTB-01324240 Hapmap39731-BTA-23124 BTB-01324017 ARS-USMARC-Parent-EF026087-rs29011643 UA-IFASA-5150	1867669 1912749 1966648 1982209 1982591	3.63.E-04 7.28.E-01 5.88.E-01 1.02.E-03 9.06.E-04		
20	CHR20:58292591-58592622	300031	8.57E-08	7.03.E-04	Hapmap38462-BTA-110556 ARS-BFGL-NGS-110091 ARS-BFGL-NGS-111931 ARS-BFGL-NGS-96125 Hapmap41960-BTA-74781	58292591 58362004 58405641 58449212 58592622	1.10.E-01 1.92.E-04 1.95.E-03 1.24.E-03 7.21.E-02	ENSBTAG00000013391 (ANKH) ENSBTAG00000003186 (OTULIN) ENSBTAG00000045869 ENSBTAG00000045215 (U6)	
22	CHR22:10563792-10684294	120502	5.62E-06	4.61.E-02	Hapmap47325-BTA-55227 Hapmap49219-BTA-55225 ARS-BFGL-NGS-34178 ARS-BFGL-NGS-115144 ARS-BFGL-NGS-11037	10563792 10593931 10633248 10657184 10684294	3.66.E-03 4.01.E-03 4.74.E-04 1.46.E-01 5.24.E-01	ENSBTAG00000022733 (EPM2AIP1) ENSBTAG00000021452 (TRANK1) ENSBTAG00000016758 (MLH1)	Reproduction Association (Male Fertility: QTLID15798) Reproduction Association (Male Fertility: QTLID15806) Milk Association (Milk alpha-casein percentage: QTLID15787) Milk Association (Milk alpha-casein percentage: QTLID15788) Meat and Carcass Association (Intramuscular fat: QTLID15263) Meat and Carcass QTL (Intramuscular fat: QTLID22874) Health QTL (Heat tolerance: QTLID31194)
24	CHR24:33137570-33309954	172384	4.09E-06	3.36.E-02	BTB-01853924 ARS-BFGL-NGS-102290 ARS-BFGL-NGS-10333 ARS-BFGL-NGS-114808 ARS-BFGL-NGS-28791	33137570 33205943 33246227 33272897 33309954	2.89.E-02 1.42.E-03 5.53.E-02 8.71.E-03 1.83.E-02	ENSBTAG00000027181 (LAMA3)	Meat and Carcass Association (Lean meat yield: QTLID37121) Meat and Carcass Association (Lean meat yield: QTLID36715)

