



Exploring the potential of genetic selection for enhanced pork belly quality

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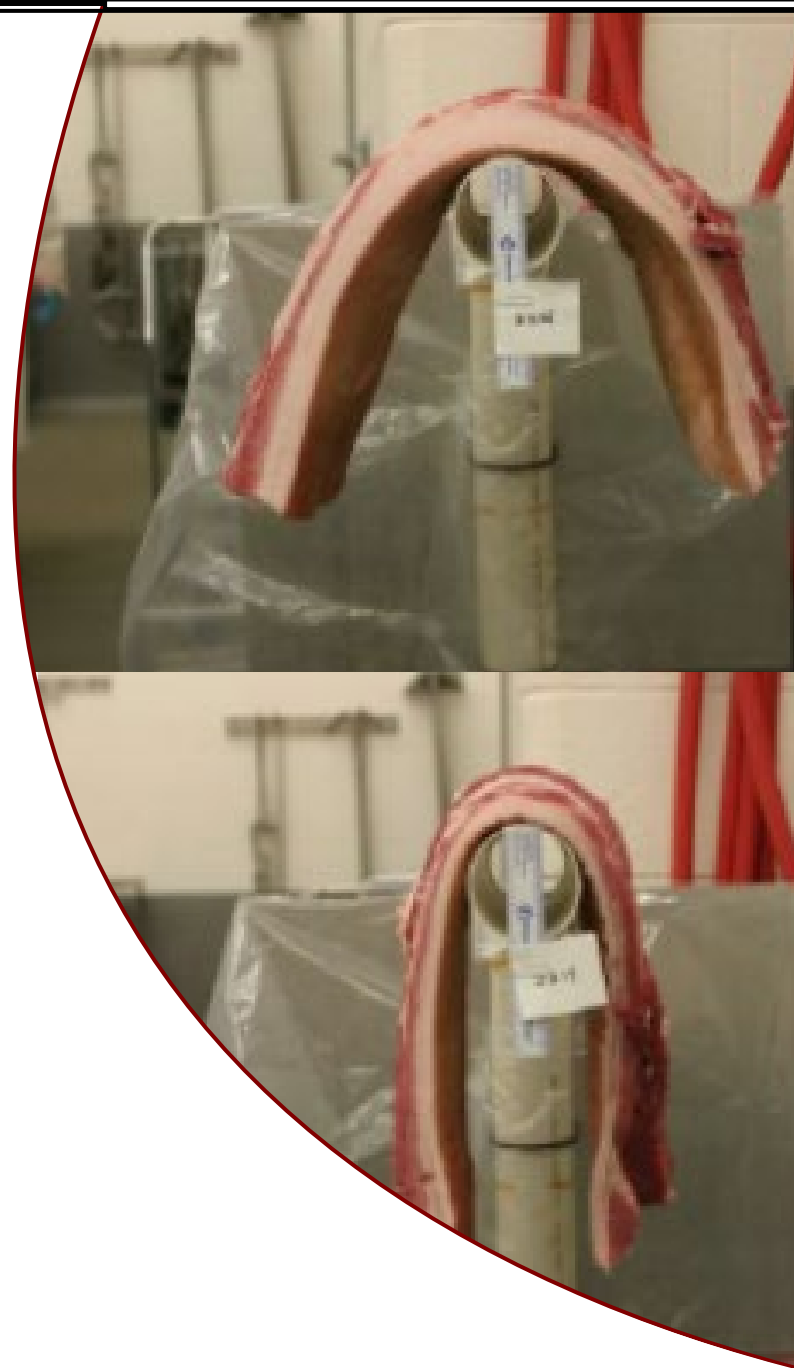
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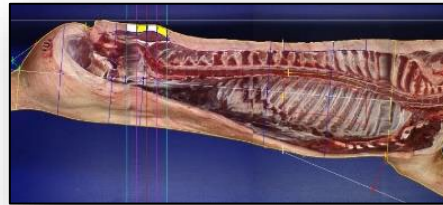


Understanding the need to investigate pork belly quality



Current Means of Carcass Grading

- Grid systems usually focus on the following two parameters:
 1. Carcass weight
 2. Lean meat yield

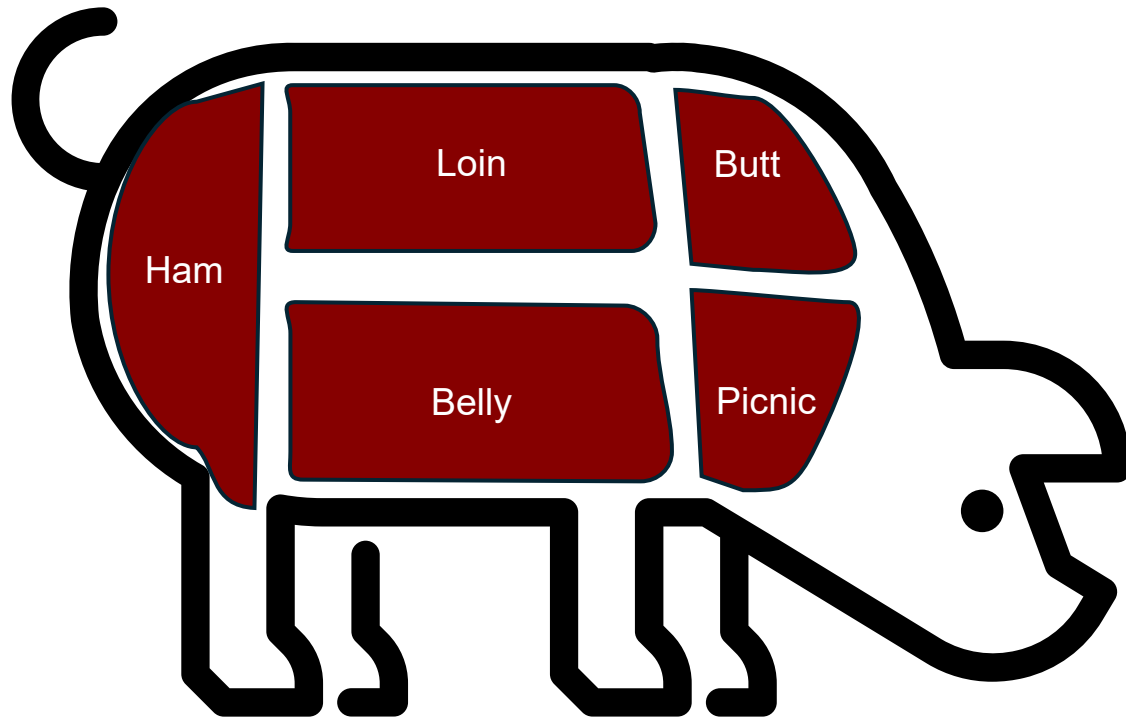


		1	2	3	4	5	6	7	8	9	10	11	12
Yield Class	Estimated Yield %	< 72.9 kg	73-77.9 kg	78-82.9 kg	83-87.9 kg	88-92.9 kg	93-97.9 kg	98-102.9 kg	103-107.9 kg	108-112.9 kg	113-117.9 kg	118-123.9 kg	124 + kg.
1	> 64.29	10	50	90	90	90	95	95	95	95	90	90	50
2	63.0 - 64.29	10	50	90	90	99	98	98	98	98	95	90	50
3	61.8 - 62.99	10	50	90	95	100	100	100	100	100	100	98	50
4	60.7 - 61.79	10	50	90	98	101	102	102	103	103	101	99	50
5	59.6 - 60.69	10	50	90	98	101	102	102	103	103	101	99	50
6	58.6 - 59.59	10	50	90	98	101	102	102	103	103	101	99	50
7	57.7 - 58.59	10	50	90	95	100	101	101	101	101	100	99	50
8	56.9 - 57.69	10	50	90	90	99	99	99	99	99	99	95	50
9	56.1 - 56.89	10	50	90	75	85	85	85	85	85	85	75	50
10	< 56.10	10	50	90	60	75	75	75	75	75	75	65	50

- Most research and selection for pork quality focused on the loin.
- Genetic selection for leanness has impacted belly composition.



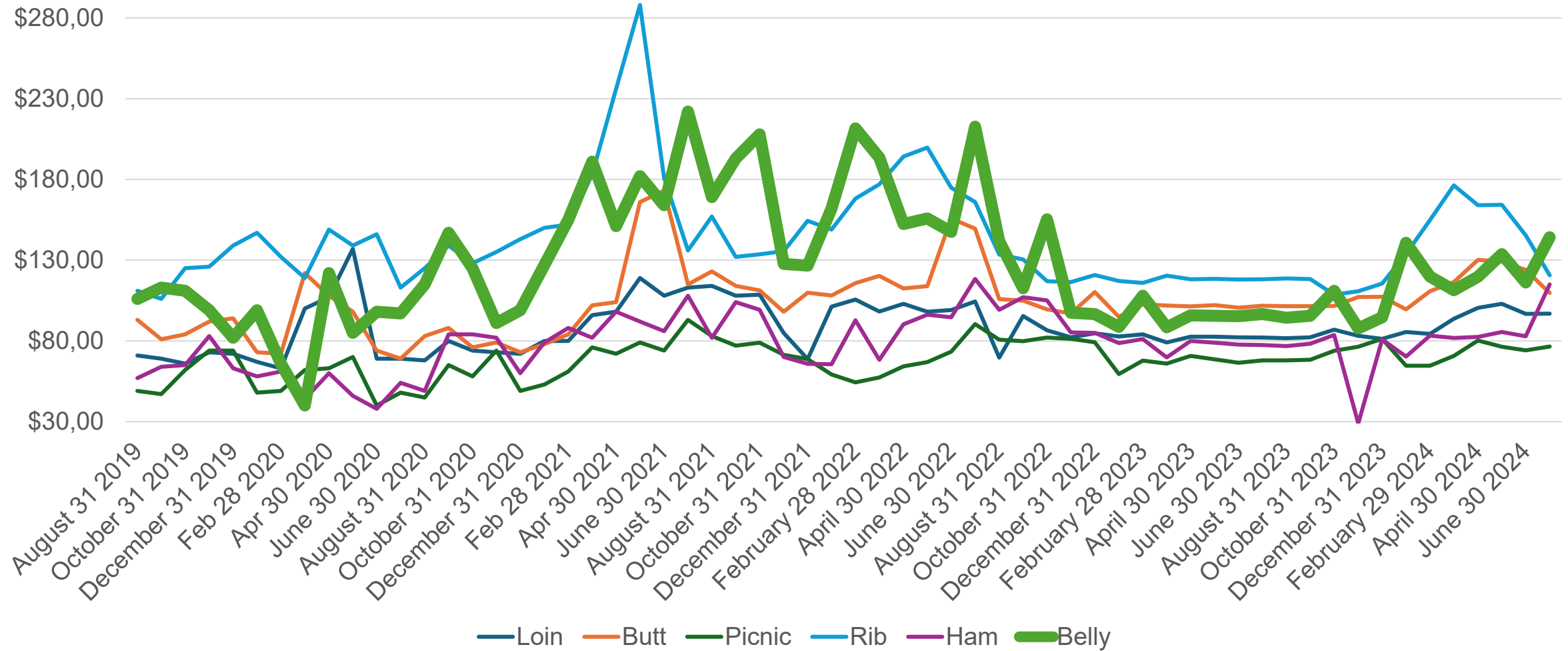
The importance of pork bellies



- Pork belly represents ~12-17% of chilled carcass weight.
- Significant portion of pork carcasses value.

Trends in Pork Primal Cuts Prices

2019-2024



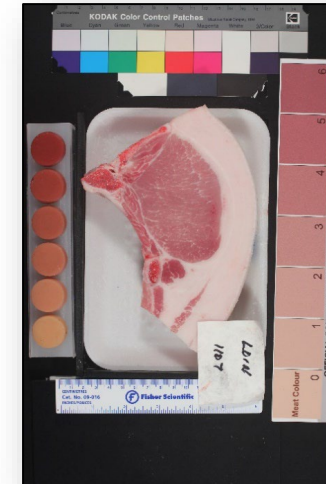
Pork loin quality is not indicative of
fresh belly or fresh and cured ham quality^{1,2,3}

DOI: 10.2527/jas.2016-0886

Low colour-low marbling chops

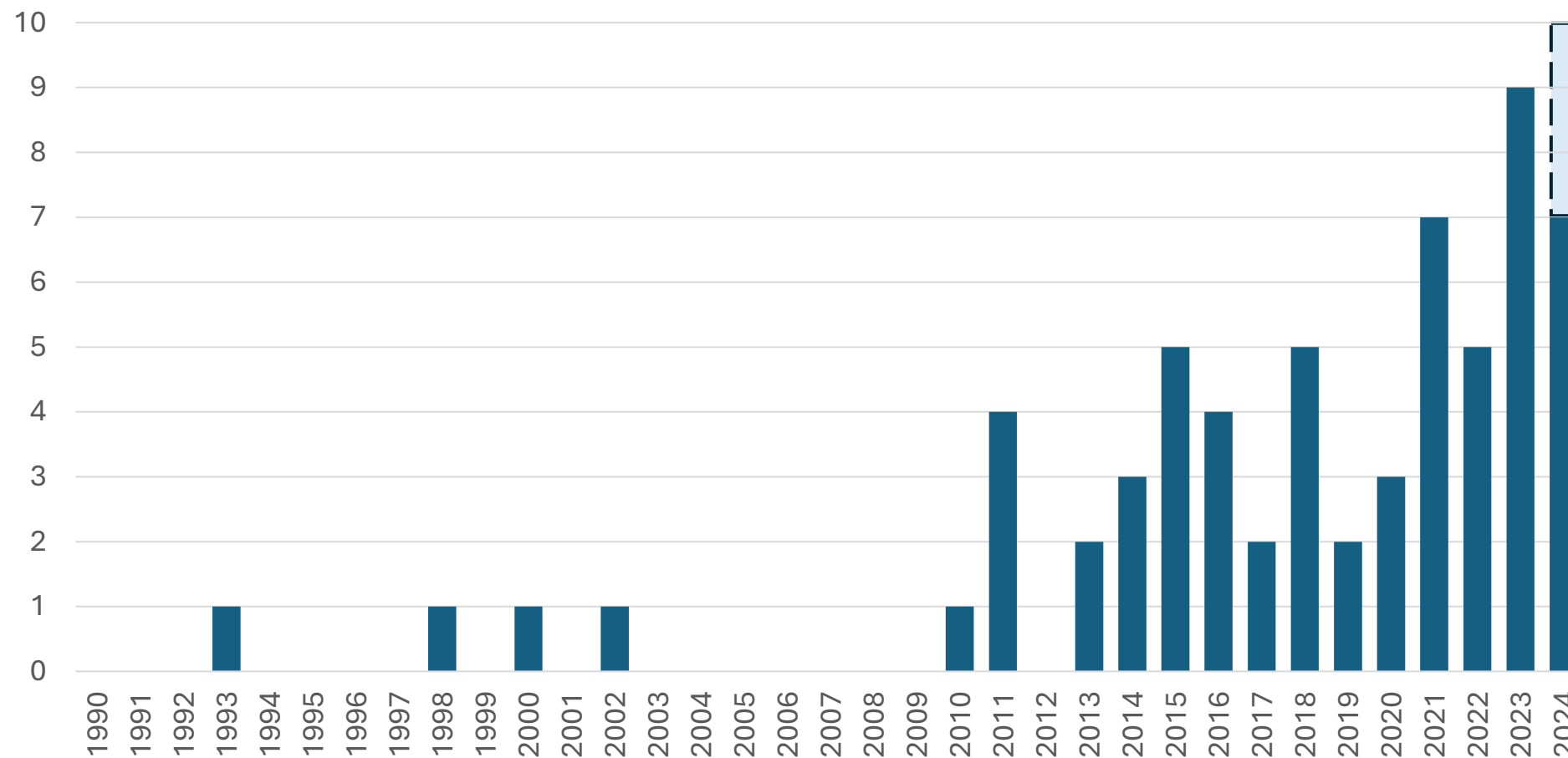


High colour-high marbling chops



Scientific manuscripts reporting fresh pork belly quality data

1990-2024



Objective of the study

To estimate genetic and phenotypic correlations, and heritability values for pork belly quality traits (in relation to other carcass attributes) in commercial crossbred pigs.

Material and methods

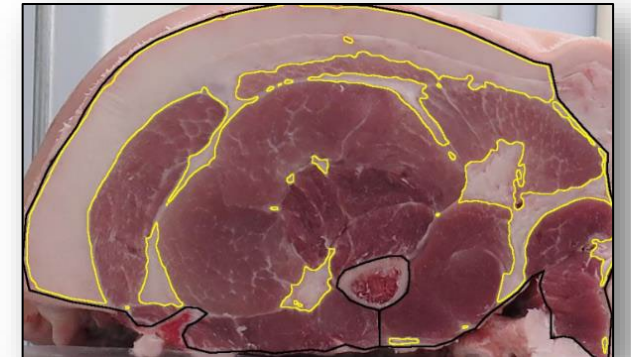
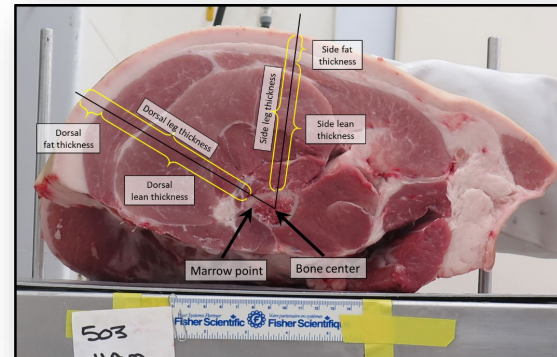
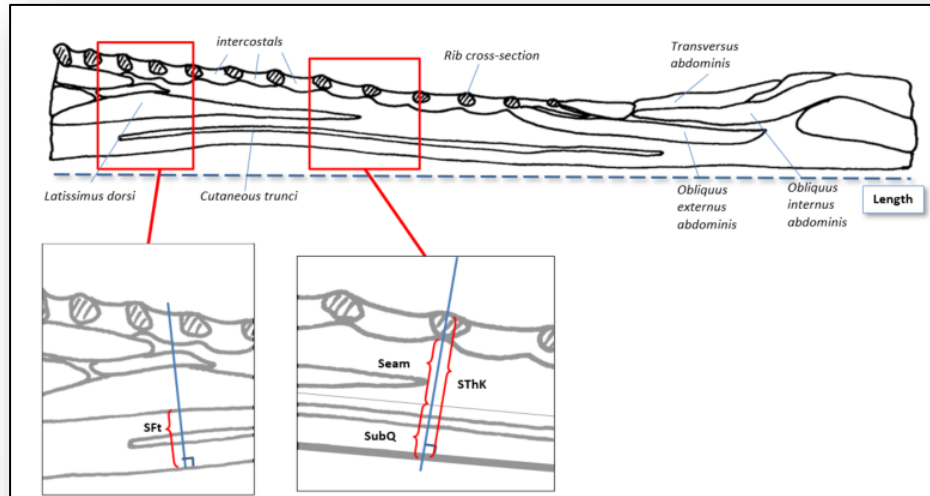


Phenotypes

- 1,118 animals (498 females; 620 males) commercial crossbred pigs (~125 kg), Duroc sires and F1 hybrid (Landrace × Large White) dams (Genesis Genetic Technology).
- Carcass weight, backfat depth between 3rd and 4th last ribs using grading probe.
- Primal cuts (IMPS, 2014), scanned using dual energy x-ray absorptiometry (Soladoye et al., 2016).
- Intramuscular fat (IMF) in centre chop.
- Fatty acid analyses in backfat (Turner et al., 2014).

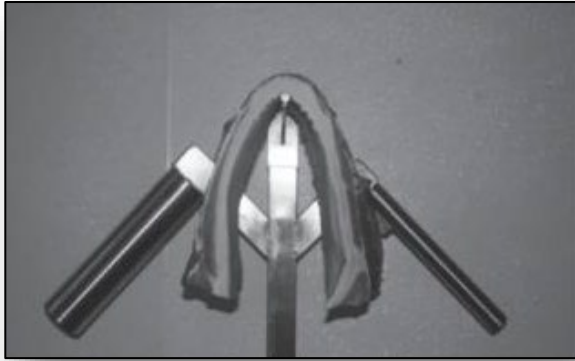


Linear measurements in primal cuts



Belly classification.

Firmness



Genotypes and statistical analyses

- Genotyped for 36,566,734 single nucleotide polymorphism (SNP) markers using low-pass sequencing (SkimSeek).
- Assessment of fixed and random effects using REML in R lmer4 package (version 1.1.35), or maximum likelihood estimation.
- Plus BLUPf90+ for genomic heritability and phenotypic and genetic correlation analysis.

Results and discussion



Descriptive statistics for carcass and primal traits

Trait	mean	SD	min	max
Backfat depth (mm)	20.4	4.31	10.3	41.4
Picnic fat %	26.4	3.33	17.4	37.4
Butt fat %	37.5	4.42	23.9	55.0
Loin fat %	33.6	4.87	18.6	51.7
Ham fat %	27.2	2.97	18.2	38.8
Total fat %	31.2	3.72	19.4	46.2
IMF centre chop (%)	3.87	1.20	1.49	9.96
Ham dorsal fat thickness (mm)	17.8	4.01	7.16	32.6
Ham side fat (mm)	18.0	3.71	5.16	32.2
Ham % fat area	25.3	4.9	7.89	41.8
Shoulder fat area %	35.8	6.81	15.7	56.9
Shoulder dorsal fat (mm)	21.4	5.85	7.2	58.6

IMF: intramuscular fat

Descriptive statistics for belly quality traits

Trait	mean	SD	min	max
Belly fat %	32.6	3.96	18.3	46.3
Belly side fat (mm)	2.50	0.45	0.95	4.00
Belly SThK (mm)	3.71	0.58	2.00	5.49
Belly Seam (mm)	2.12	0.58	0.40	4.07
Belly Subq (mm)	1.36	0.23	0.82	2.50
IV	60.3	3.34	50.9	75.7
SFA (%)	42.1	2.53	30.8	49.3
MUFA (%)	44.1	2.04	36.0	54.4
PUFA (%)	13.5	2.02	5.68	24.1
Belly firmness (°)	132	26.4	69.8	177

SThK: total side thicknesses; Subq: subcutaneous fat; Seam: intermuscular fat; IV: iodine value; SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids

Estimates of heritability (h^2) for carcass and pimal cut quality traits

Trait	h^2	VarG	VarG(SE)	VarE	VarE(SE)
Backfat depth	0.52±0.07	7.403	1.355	6.738	0.848
Picnic Fat %	0.55±0.08	3.866	0.786	3.101	0.499
Butt Fat %	0.46± 0.09	5.639	1.362	6.556	0.912
Loin Fat %	0.46± 0.15	6.769	1.620	7.865	1.091
Ham Fat %	0.48± 0.09	2.655	0.634	2.795	0.417
Total Fat %	0.51±0.08	4.440	0.925	4.126	0.587
IMF %	0.53±0.07	0.551	0.090	0.472	0.060
Ham dorsal fat thickness	0.31±0.07	4.044	1.165	8.976	0.876
Ham side fat thickness	0.34±0.08	3.781	1.004	7.059	0.736
Ham % fat area	0.41±0.07	8.354	1.912	11.71	1.292
Shoulder % fat area	0.51±0.07	17.65	3.500	16.65	2.194
Shoulder dorsal fat	0.38±0.07	9.230	2.187	15.06	1.591

Estimates of heritability (h^2) for belly quality traits

Trait	h^2	VarG	VarG(SE)	VarE	VarE(SE)
Belly Fat %	0.55±0.08	6.361	1.309	5.018	0.827
Belly side fat	0.47±0.07	0.063	0.012	0.071	0.008
Belly SThK	0.31± 0.08	0.064	0.019	0.130	0.013
Belly Seam	0.18±0.07	0.043	0.017	0.190	0.015
Belly Subq	0.32±0.07	0.011	0.003	0.023	0.002
IV	0.55±0.07	3.720	0.704	2.948	0.420
SFA	0.55±0.07	2.085	0.392	1.668	0.235
MUFA	0.42±0.07	0.834	0.181	1.125	0.121
PUFA	0.44±0.08	0.889	0.196	1.100	0.127
Belly firmness	0.54± 0.13	31.39	1.547	24.84	1.028

Genetic (below diagonal) and phenotypic correlations (above diagonal) for carcass traits

Traits	Backfat depth	IMF	Picnic fat %	Butt fat %	Loin fat %	Ham fat %	Belly fat %	Total fat %
Backfat depth	1	0.38±0.03	0.58±0.03	0.70±0.02	0.78±0.02	0.63±0.03	0.68±0.02	0.74±0.02
IMF	0.44±0.11	1	0.58±0.03	0.52±0.03	0.50±0.03	0.46±0.04	0.52±0.03	0.53±0.03
Picnic fat %	0.61±0.10	0.61±0.12	1	0.84±0.01	0.79±0.01	0.84±0.01	0.84±0.01	0.86±0.01
Butt fat %	0.71±0.08	0.75±0.10	0.89±0.04	1	0.91±0.008	0.83±0.01	0.83±0.01	0.94±0.05
Loin fat %	0.79±0.06	0.69±0.11	0.84±0.05	0.92±0.03	1	0.84±0.01	0.87±0.01	0.97±0.02
Ham fat %	0.58±0.11	0.63±0.12	0.95±0.04	0.89±0.03	0.89±0.04	1	0.83±0.01	0.91±0.08
Belly fat %	0.64±0.08	0.76±0.10	0.92±0.03	0.88±0.02	0.92±0.03	0.89±0.04	1	0.76±0.03
Total fat %	0.74±0.06	0.72±0.09	0.75±0.03	0.96±0.01	0.98±0.007	0.94±0.02	0.75±0.01	1

Genetic (below diagonal) and phenotypic correlations (above diagonal) for belly quality traits

Traits	Backfat depth	IMF	Belly Fat %	IV	Belly firmness	Belly side fat	Belly SThK	Belly Seam	Belly Subq
Backfat depth	1	0.38±0.03	0.68±0.02	-0.51±0.03	0.25±0.01	0.43±0.03	0.66±0.02	0.48±0.03	0.42±0.03
IMF	0.44±0.11	1	0.52±0.03	-0.22±0.04	0.35±0.05	0.27±0.04	0.27±0.04	0.22±0.04	0.36±0.21
Belly Fat%	0.64±0.08	0.76±0.10	1	0.47± 0.02	0.43±0.02	0.63±0.02	0.63±0.03	0.48± 0.03	na
IV	-0.56±0.10	-0.27±0.13	0.50± 0.1	1	-0.45±0.04	-0.44±0.02	-0.51±0.03	-0.37±0.03	-0.28±0.03
Belly firmness	0.35±0.05	0.66±0.25	0.63±0.09	-0.54±0.12	1	0.50±0.04	0.48±0.04	0.36±0.05	0.29±0.05
Belly side fat	0.67±0.11	0.37±0.12	0.68± 0.08	-0.49±0.03	0.74±0.15	1	0.70±0.02	0.49±0.03	0.47±0.03
Belly SThK	0.81±0.09	0.22±0.18	0.77± 0.1	-0.75±0.11	0.66±0.16	0.81±0.07	1	0.77±0.01	0.53±0.03
Belly Seam	0.52±0.18	0.26±0.23	0.62± 0.2	-0.53±0.26	0.52±0.24	0.61±0.18	0.83±0.18	1	0.09±0.04
Belly Subq	0.66±0.11	0.50±0.56	na	-0.60±0.13	0.56±0.23	0.55±0.12	0.55±0.15	-0.10±0.41	1

Genetic (below diagonal) and phenotypic correlations (above diagonal) for primal quality traits

Traits	Ham dorsal fat ThK	Ham side fat ThK	Ham % fat area	Shoulder % fat area	Shoulder subq fat	Belly side fat	Belly SThK	Belly Seam	Belly Subq
Ham dorsal fat ThK	1	0.66±0.02	0.57±0.02	0.46±0.03	0.36±0.03	0.47±0.03	0.56±0.03	0.36±0.03	0.29±0.04
Ham side fat ThK	0.78±0.09	1	0.66±0.02	0.49±0.03	0.40±0.03	0.50±0.03	0.59±0.02	0.40±0.03	na
Ham % fat area	0.81±0.09	0.90±0.06	1	0.61±0.02	0.41±0.03	0.64±0.01	0.57±0.03	0.40±0.03	0.37±0.03
Shoulder % fat area	0.75±0.09	0.80±0.09	0.83±0.07	1	0.60±0.02	0.52±0.03	0.52±0.03	0.43±0.03	0.23±0.04
Shoulder subq fat	0.63±0.15	0.67±0.13	0.73±0.09	0.40±0.08	1	0.44±0.03	0.41±0.03	0.30±0.03	0.23±0.04
Belly side fat	0.56±0.13	0.62±0.13	0.82±0.09	0.66±0.08	0.72±0.10	1	0.70±0.02	0.49±0.03	0.47±0.03
Belly SThK	0.65±0.19	0.63±0.04	0.81±0.10	0.83±0.11	0.71±0.15	0.81±0.07	1	0.77±0.01	0.53±0.03
Belly Seam	0.25±0.34	0.49±0.26	0.60±0.21	0.68±0.22	0.65±0.28	0.61±0.18	0.83±0.18	1	0.09±0.04
Belly Subq	0.69±0.15	na	0.60±0.10	0.45±0.14	0.43±0.17	0.55±0.12	0.55±0.15	-0.10±0.35	1

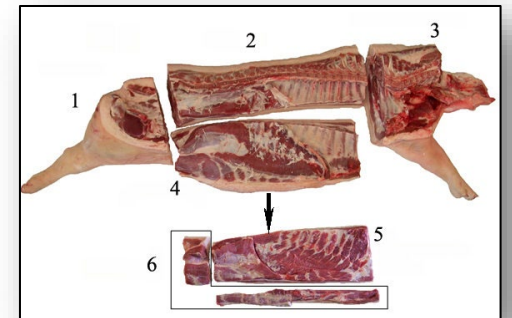
Conclusions



Pork belly quality can be improved by including direct and correlated traits in selection objectives in pig breeding programs.



Impact on other selection objectives needs to be considered and balanced to maximize efficiency and profitability.





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