Genetic analyses of haemoglobin levels in pigs and iron content in pork

Susanne Hermesch and Rob M Jones

AGBU webinar, 15 February 2012

Acknowledgements

- Kristy Tickle, Rivalea
- Helen Grigg, Rivalea
- David Paynter, Regional Laboratory Services
- Heather Channon, Australian Pork Limited

Large variation in mean iron content (mg/kg)

	Mean	Range
Pork	6.3	3 - 30
Chicken	5.5	4 - 54
Sheep	11	17 - 36
Beef	18	13 - 61

(Rooke et al. 2010, J. Agric. Sci. 148:603-614)

Iron content in pork has declined

- Total pigment content in *biceps femoris (BF) and longissimus dorsi (LD)* (Barton-Gade, 1990, 4th WCGALP, XV 511-520)
  - BF: 1984: 40.8 vs. 1988: 32.9 (19% reduction)
  - LD: 1986: 21.3 vs. 1988: 18.8 (12% reduction)

Large difference in pigment content between muscles

Iron content in pork has declined

- Australian studies (*m. longissimus dorsi*)
  - Greenfield et al. (2009) 4.60 mg / kg
  - Barnes et al. (1996) 8.00 mg / kg
  - Hutchison et al. (1987) 7.00 mg / kg

"Pork can no longer be promoted as a source of iron"

(Greenfield et al. 2009, Food Chemistry 117:721-730)

Research was needed to improve iron levels in pork

- Dietary avenues have not increased iron content in muscle (Cottam et al. 2007, APL report; Rooke et al. 2010)
  - Iron is not stored in muscle, excess is excreted or stored in liver

- Pigment was heritable
  - in pork (0.39 ± 0.09, Larzul et al. 1997, J. Anim. Sci. 75: 3126-3137)
  - *in vivo* (0.17 ± 0.02, Oksbjerg et al. 2004, Acta Agric. Scand. Sect. A Anim. Sci. 54: 187-192)

- Modern genotype had lower myoglobin content than pigs available in 1970s (Oksbjerg et al. 2000, Anim. Sci. 71: 81-92)

Aims of project

1. Establish whether iron content in pork is heritable
2. Develop simple, cost-effective selection criteria for iron content in pork
   - On-farm measurement: haemoglobin levels in blood
   - Other pork quality traits: colour (L*, a*, b* Minolta chroma meter)
3. Determine whether current selection practices affect iron content in pork

Data recording

- September 2009 until January 2011
- Two sire lines
- Haemoglobin levels at five and 21 weeks
  - HemoCue® equipment used on farm
- Iron and pork quality measures
  - Iron: average of two replicates
- Growth rate, fat and muscle depth

Haematological data

Trait (unit, abbreviation)	N	Mean	SD	CV%
Haemoglobin, 5 weeks (g/L, HAEM5)	4 974	106.6	16.2	15
Haemoglobin, 21 weeks (g/L, HAEM21)	2 405	105.4	13.4	13
Iron content in pork (mg/kg, IRON)	2 253	2.87	0.44	15

SD: Standard deviation, CV%: Coefficient of variation

Measuring iron content in pork

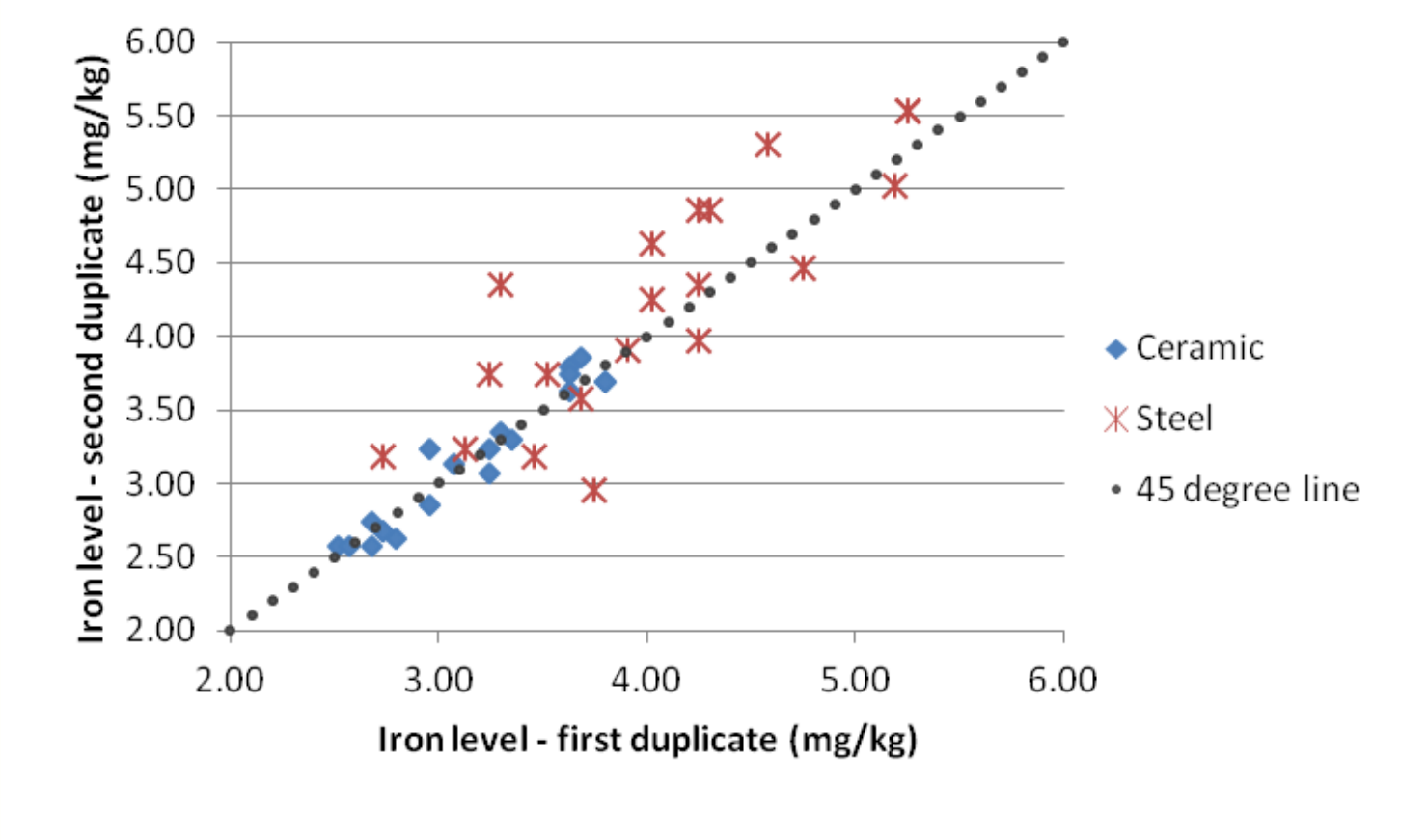
- Duplicate samples were used
- Results from duplicate samples were expected to be within 10% of each other
- This aim was only achieved by
  - Increasing sample weight to 1 gram
  - Using of ceramic knives to prepare samples in lab

Use of steel knives increased iron content

- Use of steel knives during first 3 weeks
  - mean iron content: 4.08 mg/kg
- Ceramic knives were used afterwards
  - mean iron content: 2.87 mg/kg

- Additional small trial (N: 20)
  - Steel knives: 4.04 mg/kg (sd: 0.73)
  - Ceramic knives: 3.15 mg/kg (sd: 0.45)

Plot of first against second measurement using either ceramic or steel equipment



Implications

- For measuring iron content in pork
  - Ceramic knives should be used for preparation of samples
- For any new measurement
  - Replicate measures should be taken to evaluate accuracy of new measurement

Genetic parameters

from standard genetic analyses

Heritability and litter effect estimates for haematological traits

Trait	Heritability (h^2)	Litter effect (c^2)
Haemoglobin, 5 weeks	0.04	0.11
Haemoglobin, 21 weeks	0.09	0.08
Iron content in pork	0.34	0.06

Pork quality traits

Trait	Mean	SD	CV%	Heritability
L*	47.65	2.91	6	0.06
a *	5.62	0.95	17	0.41
b*	2.28	0.95	42	0.13
pH 45 minutes *p.m.*	6.03	0.26	4	0.23
pH at 24 hours *p.m.*	5.64	0.14	3	0.12

N: ~ 2,400 records for all traits; * all colour measurements were based on two replicates

SD: Standard deviation, CV%: Coefficient of variation

Genetic associations between haematological traits

	Haemoglobin – 5 weeks	Haemoglobin – 21 weeks
Iron content in pork	0.39	**0.50**
Haemoglobin – 5 weeks		0.35

No genetic associations were found between haematological and performance traits

	Haemoglobin - 5 weeks	Haemoglobin - 21 weeks	Iron content
Backfat – live	-0.01	-0.34	-0.07
Fat depth – carcase	-0.04	-0.32	-0.17
Muscle depth – live	0.34	-0.03	-0.16
Muscle depth – carcase	0.38	0.02	**-0.26**
Growth rate	-0.26	-0.10	0.17

Does selection for efficient lean meat growth adversely affect iron content in pork?

Yes

- More efficient genotype had lower myoglobin levels than 1970s genotype (Oksbjerg et al. 2000)
- Claims: fast twitch muscle fibres have less iron

No

- Confounding of genotype with
  - pre-test housing
  - age
- Most genetic correlations b/w fibre types and pigment were not significant (Larzul et al. 1997)
  - Indirectly inferred genetic association b/w lean meat growth and pigment was favourable

Have changes in husbandry practices over time adversely affected iron content in pork?

Yes

Husbandry practices = G + E + GxE

- Slaughter day explained 36% of variation in iron content in pork (Tickle et al. 2011; APSA, P198).
- Selection has affected physiology of sows and pigs
  - Sow management and piglet housing
- Larger studies are required to reliably identify single factors

Evaluation of selection strategies

How much genetic gain is possible?

- Livestock breeding programs have achieved annual genetic gain of 10 to 20% of the genetic standard deviation of a trait (Hermesch, 2006, AGBU Pig Genetics Workshop)

- Equivalent of annual genetic gain in iron content in pork of 0.02 – 0.04 mg/kg
  - Given the mean and variation observed in this study
  - Higher genetic gain is expected in muscles with higher iron content due to scaling effects

Selection strategies

- Index calculation that included iron content as only breeding objective trait
  - No interactions with other traits for this evaluation of strategies
- Base scenario: recording iron content in one full sib (of selection candidate)
  - Response: 0.06 mg/kg iron (100%)
  - Costs: $ 35 (100%)
- Alternative 1: Measuring colour traits in two full sibs
  - Response: 127% Costs: 43%

Selection strategies

- Base scenario: recording iron content in one full sib
  - Response: 0.06 mg/kg iron (100%)
  - Costs: $ 35 (100%)
- Alternative 2: Measuring haemoglobin at 21 weeks on the selection candidate and seven full sibs
  - Response: 65% Costs: 57%
- Alternative 3: Same as alternative 2 but assuming a heritability of 0.27 for haemoglobin at 21 weeks
  - Response: 100% Costs: 57 %

Main conclusions

- Colour and haemoglobin levels at 21 weeks can be used as a selection criteria for iron content in pork and pork colour
  - On-farm recording procedures for haemoglobin levels need modification
- There were no unfavourable genetic associations between productivity and iron content in pork
- Any study about iron content in pork should use ceramic knives

Pork facts and recipes at: http://www.pork.com.au