Relationships between Intramuscular Fat Content and other Muscle Quality Traits in Western Canadian Pigs

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Background

During the past several years, as pigs have become very lean, levels of intramuscular fat and marbling have continually decreased. It is accepted that factors such as breed, sex and nutrition can affect intramuscular fat content. Intramuscular fat content is lower in pigs carrying the halothane gene (Murray et al. 1994), and may (Garrido et al. 1994) or may not (Pedauve et al. 1994) be related to the PSE condition in pork. Intramuscular fat is correlated to marbling (Vanderwal et al. 1992) but the correlation of marbling with fat is too low to be used for predictive purposes (Taylor and Johnson 1992). Yet Jones et al. (1994) indicate that the PSE condition tends to be associated with lower marbling scores.

Objectives

The current study was conducted to determine current intramuscular fat levels within commercial pigs in Western Canada and to investigate the relationship of fat and marbling levels with other muscle quality traits.

Methods

Over an 8 month period, pork backs from each of 30-40 pigs were sampled during each of 15 trips to each of 2 commercial packing plants (designated plants A and B) in Alberta, Canada. A total of 1006 pigs were assessed. Each group of wholesale backs was composed by selecting every 20th pig back passing on the breaking line. A cube of fat, at least 1 cm x 1 cm, was saved for DNA testing. The longissimus muscle was then removed and a 10 cm portion was cut from the anterior end of the muscle. After the freshly-cut cross-sectional surface was allowed to bloom for 15 min, L*, a* and b* were measured in duplicate. Hue angle (h_{ab}) and chroma (C*) were calculated as arctan (b*/a*) and $(a^{*2} + b^{*2})^{0.5}$, respectively. Marbling score (devoid to abundant) was then assessed as described by Jones et al. (1992).

The muscle tissue was ground 3 times through a #12 grinding plate (3 mm diameter pore size) and stored at –20 C until analysis of protein solubility (Murray et al. 1989), moisture and fat contents. Moisture content was obtained as the percentage of weight lost after heating of ground tissue at 105 C for 24 h. Fat content was measured as total fat extracted from 4 g of dried ground muscle during a 10 min extraction at 105 C in petroleum ether, using a Soxtec 1040 (Tecator Ltd., Hoganas, Sweden) extraction system. All fat contents are reported by wet weight as g/kg of muscle tissue.

Analyses of fat samples for halothane genotype used the approach and primers of Fujii et al. (1991) to distinguish three genotypes with respect to the ryr-1 mutation (halothane genotypes): *nn* - homozygous carrier, *NN* - homozygous non-carrier or *Nn* - heterozygous carrier. The thermocycler program consisted of 1 min at 95 C and 1 min at 65 C for 35 cycles, followed by a final extension at 72 C for 7 min. The restriction enzyme, HinP I and Bsi HKA I (New England BioLabs) were used.

Results and Discussion

The frequencies of halothane genotypes, *Nn* and *nn*, were 9.4 and 0.3%, respectively. Because of the low frequency of *nn* pigs, this genotype was eliminated from all statistical analyses. Analysis of variance, using packing plant (A,B) and halothane genotype (*NN*, *Nn*) as classification variables, indicated that fat content was affected by packing plant, with meat samples from plant A having 5 g/kg muscle less than plant B (Table 1). In contrast to what has been reported previously (Murray et al. 1994), fat content was not affected by halothane genotype. Within this commercial population 25% of fat samples were ≤ 20 g/kg and 90% were ≤ 50 g/kg of longissimus muscle.

Table 1. Effect of plant, genotype and intramuscular fat on several other quality traits.

Quality Trait	Packing Plant		Halothane Genotype		β_1 (Fat)	R^2
	A	B	Nn	NN		
n	*495*	*502*	*92*	*905*		
Fat (g/kg muscle)	26.8 ± 1.1 *	31.2 ± 1.1	27.9 ± 1.8	30.6 ± 0.6	-	0.02
Moisture (g/kgmuscle)	743.8 ± 0.4	744.3 ± 0.4	743.6 ± 0.7	744.5 ± 0.2	-0.62 ± 0.01*	0.72
L*	54.6 ± 0.4	54.0 ± 0.4	55.3 ± 0.6 *	53.2 ± 0.2	0.05 ± 0.01*	0.04
Hue	27.7 ± 0.4 *	25.8 ± 0.5	27.9 ± 0.7 *	25.5 ± 0.2	0.09 ± 0.01*	0.06
Chroma	12.1 ± 0.2	12.2 ± 0.2	12.3 ± 0.3	12.0 ± 0.1	0.04 ± 0.004*	0.06
Protein Solubility (g/kg muscle)	161.7 ± 1.8 *	157.4 ± 1.9	154.1 ± 3.1 *	165.0 ± 1.0	-0.25 ±0.05*	0.04

Model Trait = $Genotype_i + Plant_j + \beta_1 * Fat + e_{ij}$

* - Plants differ, genotypes differ, slope (β_1) differ from 0 ($P<0.05$).

The relationship of moisture, reflectance and protein solubility to fat content was investigated using a statistical model containing packing plant and halothane genotype as classification variables and fat as a covariate. Packing plant affected hue angle and protein solubility. Genotype affected L*, hue angle and protein solubility with muscles of Nn genotype having properties tending toward PSE pork (Murray et al. 1994). Intramuscular fat was related to all quality traits. All of these effects with the exception of the effect of fat on moisture content, although statistically significant, accounted for a very small proportion of the variation in quality traits (R^2 = 0.04-0.06) and are thus of somewhat limited relevance.

Within the *NN* genotype intramuscular fat and moisture varied from 7 to 146 and from 657 to 773 g/kg muscle, respectively. The R^2 value was 0.75. A very wide range of marbling, from devoid to abundant, was evident within this halothane genotype. Approximately one third of muscles were devoid of marbling or less than the minimum requirement to reach the next marbling level. Although intramuscular fat content accounted for approximately 50% of the variation in marbling score (R^2=0.51), it is obvious that within any marbling score, fat content varied widely. This supports the findings of Taylor and Johnson (1992).

Protein solubility is one of the best indicators of the PSE condition. The frequencies of *NN* muscles with protein solubility values < 140 g/kg muscle are presented in Table 2 by fat class and in Table 3 by marbling class. In agreement with Pedauve et al. (1994) the frequency of muscles with lower protein solubility was not affected by fat class. However, the frequency of muscles with lower protein solubility was very dependent upon marbling level, as suggested by Jones et al. (1992). Whether this apparent discrepancy results from underestimation of marbling content in pale pork, or whether there is a direct link between marbling content and the development of the PSE condition remains to be determined. In either case, selection to decrease visual marbling would be expected to have an undesirable effect on muscle PSE status.

Table 2. Effect of fat class on the frequency of muscles with protein solubility < 140 g/kg.

Fat Class	Frequency (n)	Frequency (%)
<= 20 g/kg	273	19.0
20-30 g/kg	272	21.0
30-40 g/kg	168	20.8
40-50 g/kg	88	22.7
50-60 g/kg	43	20.9
60-70 g/kg	24	25.0
>70 g/kg	-	-

Table 3. Effect of marbling score on the frequency of muscles with protein solubility < 140 g/kg.

Marbling Class	Frequency (n)	Frequency (%)
0-Devoid	322	35.3
1-Trace	299	18.2
2-Slight	229	11.3
3-Small	81	9.2
4-Moderate	-	-
5-Abundant	-	-

Conclusions

The average intramuscular fat content within longissimus muscles of Western Canadian pigs is 3.0 g/kg (on a wet weight basis). Approximately one quarter of muscles had fat contents less than 20 g/kg. Approximately one third of muscles were considered to be devoid of marbling.

The frequency of muscles having protein solubility values less than 140 g/kg was independent of fat content, but was highly related to the marbling score. Within this population, selection to decrease visual marbling could have a very detrimental effect upon the frequency of PSE pork.

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