Bioimage analysis for estimation of mid-loin marbling from external marbling on the boneless pork loin

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Swine Innovation Porc

Pork Cluster Project #1787

Introduction

There is considerable variation in the amount of marbling that consumers prefer in their meat, both in domestic and international markets (Ngapo *et al.,* 2007; Uttaro *et al.*, 2008). Since a wide range also exists in the national hog population, this opens opportunities for product differentiation.

The lowest marbling in the pork loin occurs is in the mid-back region, and increases towards the head and tail (Faucitano *et al.,* 2004). Since boneless pork loins are generally sold at the packer level as an intact muscle, the question arises of how closely the marbling visible on the outside of the muscle is related to the internal minimum.

Objective

The objective of this work was to objectively assess the marbling on the exposed surfaces of the boneless pork loin and determine how closely each was related to mid-loin marbling.

Materials & Methods:

The marbling of 240 boneless pork loins, cut to Japanese specifications, was assessed chemically, and with bioimage analysis, using a custom workflow in ImageJ (Schneider *et al.,* 2012). The caudal and cranial ends of the loin were squared with a thin slice, and the exposed surface photographed with a consumer camera (Fig 1). A chop was removed from the approximate center of the loin, the surface photographed, then the percent intramuscular fat (%IMF) chemically determined. Images were analyzed to quantify proportions of marbling on the meat surfaces (Fig 2). On the ventral loin, minimum marbling particle sizes of 16, 30, 40, or 50 continuous pixels were kept.

Results:

The %IMF spanned 1.41-6.33% (mean = 2.70, SD = 0.82). Correlations of % IMF to % image marbling of midloin, cranial, caudal, and ventral loin surfaces were r = 0.86, 0.56, 0.72, and 0.64 respectively. Stepwise regression to explore the combined relationship of externally visible marbling with mid-loin marbling selected variables in the order of caudal, ventral, and cranial surfaces, for a model $R^2 = 0.58$ ($P < 0.0001$; $C_{(p)} = 2.40$), with the cranial surface increasing the R^2 only by 0.01 (Prob > F: 0.02).

Conclusions:

Results suggest that of the exterior surfaces, marbling on the caudal loin is most closely related to mid-loin %IMF, while marbling on caudal and ventral surfaces, combined, are the strongest contributors to estimation of mid-loin %IMF.

Take home:

In intact boneless pork loins, marbling at the exposed caudal surface was the best estimator of mid-loin %IMF. When external sites were combined, caudal and ventral surfaces, together, were moderately strongly related to %IMF at the mid-loin.

Figure 1: Sampling sites on the boneless pork loin

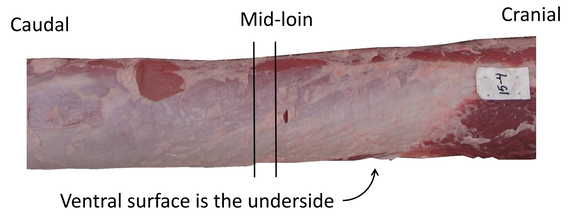
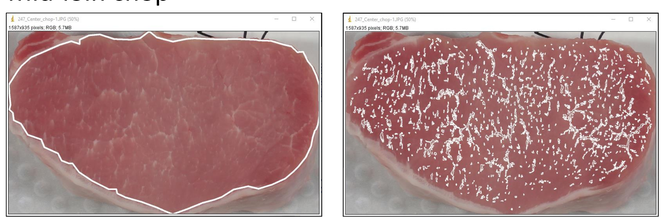


Figure 2: Marbling isolated at different sampling sites

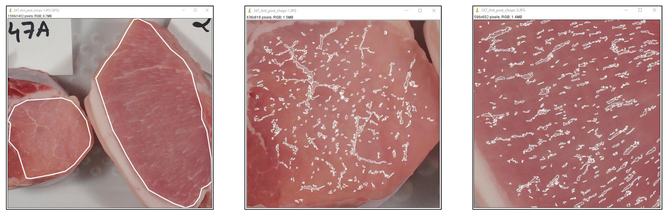
Original images



Mid-loin chop



Cranial & caudal chops



Ventral loin

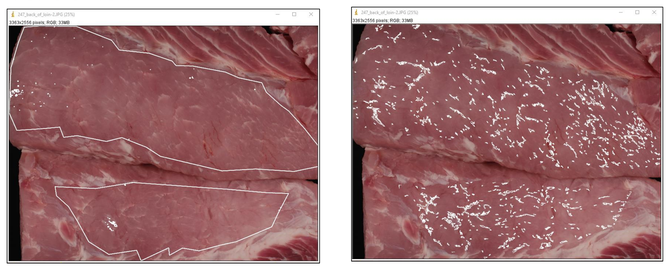


Table 1: Descriptive statistics

Variable	N	Mean	SD	Min	Max
Mid loin %IMF (chem)	240	2.70	0.82	1.41	6.33
% surface marbling in images					
Cranial	239	8.5	3.5	1.8	22.7
Mid	240	7.1	2.7	2.0	18.5
Caudal	240	10.6	4.1	1.9	25.4
Ventral, by minimum particle size selected					
16[1]	240	7.6	2.4	3.0	14.4
30	240	6.7	2.3	2.3	13.4
40	240	6.3	2.2	2.1	12.9
50	240	6.1	2.1	1.9	12.4

[1] Number refers to the minimum number of continuous pixels kept as marbling in the analyzed image.

Table 2: Correlations among %IMF and image-determined % marbling at different sampling sites . All highly significant ($P < 0.0001$).

					Ventral loin, by minimum particle size		
Variable	%IMF	Mid chop	Cranial chop	Caudal chop	16	30	40
Mid chop	0.86						
Cranial chop	0.56	0.57					
Caudal chop	0.72	0.72	0.59				
Ventral loin, by minimum particle size							
16[1]	0.62	0.61	0.56	0.58			
30	0.63	0.64	0.59	0.61	0.98		
40	0.64	0.64	0.60	0.63	0.98	1.00	
50	0.64	0.65	0.60	0.63	0.98	1.00	1.00

[1] Number refers to the minimum number of continuous pixels kept as marbling in the analyzed image.

Table 3: Stepwise regression models for estimation of mid-loin %IMF, from image measurements.

Step	Variable	Partial R^2	Model R^2	$C_{(p)}$	F Value	Prob > F
All variables available						
1	Mid-loin chop	0.73	0.73	27.03	626.61	< 0.0001
2	Caudal chop	0.02	0.74	10.31	18.16	< 0.0001
3	Ventral loin, 16[1]	0.01	0.76	2.73	9.63	0.002
All variables, *except* mid-loin chop, available						
1	Caudal chop	0.49	0.49	45.15	231.50	< 0.0001
2	Ventral loin, 50[1]	0.08	0.57	5.49	41.23	< 0.0001
3	Cranial chop	0.009	0.58	2.40	5.12	0.02

[1] Number refers to the minimum number of continuous pixels kept as marbling in the analyzed image

References:

Faucitano *et al.* (2004) Canadian Journal of Animal Science 84:57-61
Ngapo *et al.* (2007) Food Quality and Preferences 18:26-36
Schneider *et al.* (2012) Nature methods 9(7): 671-675
Uttaro *et al.* (2008) 'Pork Marbling Initiative – first steps', Final Report to Pork Marketing Canada. July 31, 2008

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