pH as a Predictor of Flavor, Juiciness, Tenderness and Texture in Pork from Pigs in a Niche Market System

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Summary and Implications

This report focuses on pork quality in a free range pork production system. The positive relationship found between pH and eating quality in earlier research is supported by this study. An increase in the pH level was positively associated with a more desirable value for each of the eating quality variables: flavor, juiciness, tenderness, and texture. The implication here is that production strategies which improve pH will lead to an increase in the quality for each of the measured eating quality characteristics.

This study found further that although pH is a good predictor of quality, measuring two other key variables of Instron (Star probe) and marbling can improve the prediction of eating quality characteristics.

Introduction

Studies have shown that pH is a good predictor of the color, Minolta score, and drip loss of meat. There is a high correlation between these measures and pH level. pH has significant correlations with many meat quality traits. A higher pH is associated with improved sensory tenderness, juiciness and flavor. The meat also has a darker color, lower Hunter L-values, lower drip loss, greater firmness, and lower Instron. The movement today for leaner and heavier muscled carcasses can lead to chops with less marbling, less firmness, less tenderness and less flavor.

The pork industry continues to have an emphasis on pork quality and factors influencing pork quality. While pH is a good predictor of eating quality, information on Instron and marbling further improves the prediction of eating quality characteristics. An issue is assessing the value of the additional information and the cost of obtaining that information.

This report focuses on the relationships between pH and meat quality traits for meat from animals which are produced in a free range system.

Materials and Methods

The objective of this study is to evaluate how much of the variation on the quality characteristics is explained by carcass pH measured 24 hours after slaughter in pork produced in a non-confined production system without the use of antibiotics and/or hormones. The system can be considered as free range and serves a niche market. Under this system:

- the animals don't receive hormones or antibiotics,
- the handling practices are oriented to considerably decrease the stress of the animals which affects pH and quality,
- there is more room per animal and animals are permitted to go outside, which decreases stress but exposes the animals to higher temperature variation,
- the breeds used are usually meat quality oriented rather than production efficiency oriented. These breeds usually produce fatter carcasses with lower yields but higher pH and quality, and
- the transportation of the animals also requires more space per animal.

A company which specializes in producing pork where the pigs are in a free range type system provided objective pork quality measures such as pH, LEA (loin eye area), Instron, shear force, drip loss, and Minolta for producers pigs for the 11/01/2001 through 04/28/2004 time period. There were a total of 1374 observations or pig carcasses represented. Subjective pork quality such as color, marbling, eating quality (flavor, juiciness, tenderness, and texture) was also available. This is niche market pork. The eating quality characteristics of flavor, juiciness, tenderness and texture were measured by ranking the quality from 10 to 1 where 10 is very desirable and 1 is bad.

The number of observations (samples) where flavor, juiciness, tenderness or texture values were equal to or lower than 3 was low. Therefore they were aggregated to the category value of 4. Also, there were few samples with a value of 10 for flavor, juiciness, tenderness or texture. They were aggregated to the category value of 9. Given this, the final ranges of values for the eating quality characteristics were: less than or equal to 4, 5, 6, 7, 8, and greater than or equal to 9. The distribution of most of the discrete variables is concentrated in two or three values which affects the goodness of fit of the predictions.

Information is provided to show the relationship between pH and the eating quality characteristics as well as with color and marbling that are also ordinal variables. In this information the quality characteristics appear in the Y-axis while pH appears in the X-axis. A t-statistic evaluation was done controlling for the False Discovery Rate (FDR) by the method of Benjamini and Hochberg to identify if the expected value of pH is different between different levels of the quality measure.

Additionally a chi-square test was done to identify if the ordinal and cardinal quality characteristics are independent of pH. For that purpose the following pH ranges were established: pH<5.5, 5.5≤pH<5.7, 5.7≤pH≤5.9, pH>5.9. An ordered logit regression was run to identify how well pH predicts the expected value of the eating quality characteristics.

Results and Discussion

Figures 1 to 4 provide information that shows a clear relationship between higher pH values and flavor, juiciness, tenderness and texture. An increase in pH improves all of these eating characteristics.

A t-statistics test controlling for the False Discovery Rate (FDR) by the method of Benjamini and Hochberg shows that the differences in the expected values of pH were significant between different levels of the quality variables for most of the cases. The only pH levels which were not significantly different were flavor, juiciness, and tenderness between pH 4 and 5; and tenderness and texture between pH levels 5 and 6.

Table 1 shows that the goodness of fit of using pH as a predictor of quality through an ordered logit model is moderately reliable. Approximately 30 to 40 percent of the observations were correctly predicted by this method while about 75 percent of the observations were predicted within an error of ± 1. A value of -1 means that the predicted quality value was greater (better) than the actual quality value. For example, a chop that was actually a quality value of 5 was predicted to be a value of 6. Values which were plus would have a predicted value less than the actual value. More than 95 percent of the observations were predicted within an error of ± 2. There was a high concentration of values around the mean for the quality characteristics. For tenderness and texture the prediction error tended to be on the negative side. There were overestimates of predicted eating quality.

When Instron and marbling are combined with pH in the analysis, the accuracy of predicting eating quality increases dramatically. Approximately 50 percent of the observations were correctly predicted by this method. More than 94 percent of the observations were predicted within an error of ± 1, while more than 99 percent of the observations were predicted within an error of ± 2. Information on pH, Instron, and marbling provides a very good indicator of eating quality. However, with the three measures of information the errors tend to be on the positive side rather than negative side. An issue is the added value of the improved accuracy that Instron and marbling provides. Figures 5 to 8 provide information on the distribution of flavor, juiciness, tenderness and texture for the different ranges of pH. These figures show that low flavor, juiciness, tenderness and texture scores are dramatically greater for pH values less than or equal to 5.5. Most samples with pH greater than or equal to 5.9 scored high for the quality measures.

The chi-square test showed that none of these variables are independent of pH. It can be seen that as pH increases, the proportion of desired values for the quality characteristics increase and the proportion of undesired values of the quality characteristics decrease.

Acknowledgement

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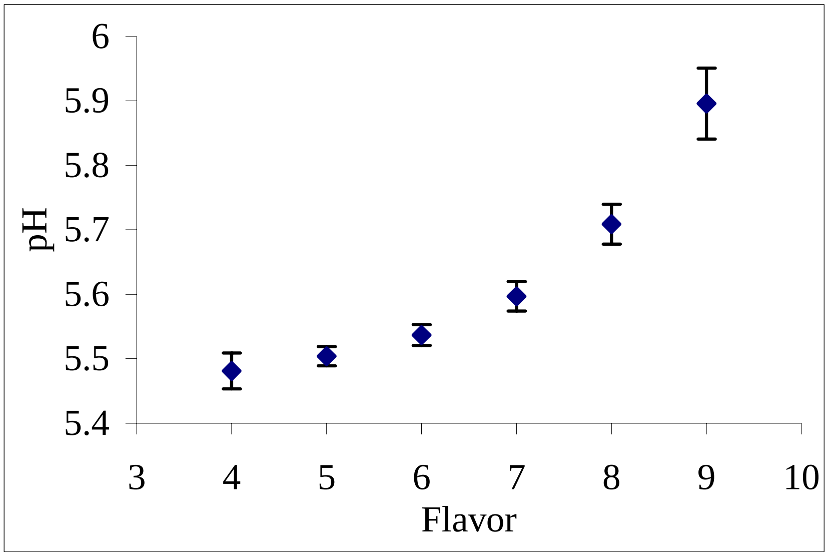
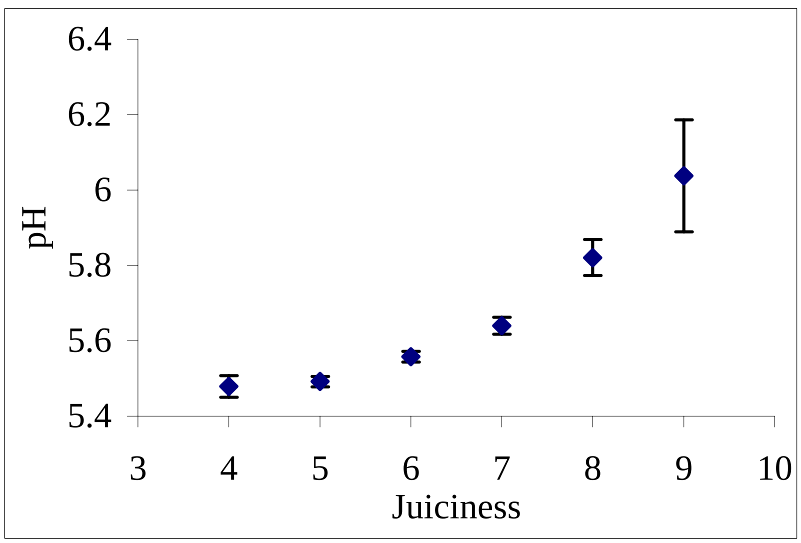
Figure 1. Relationship between pH and Meat Flavor



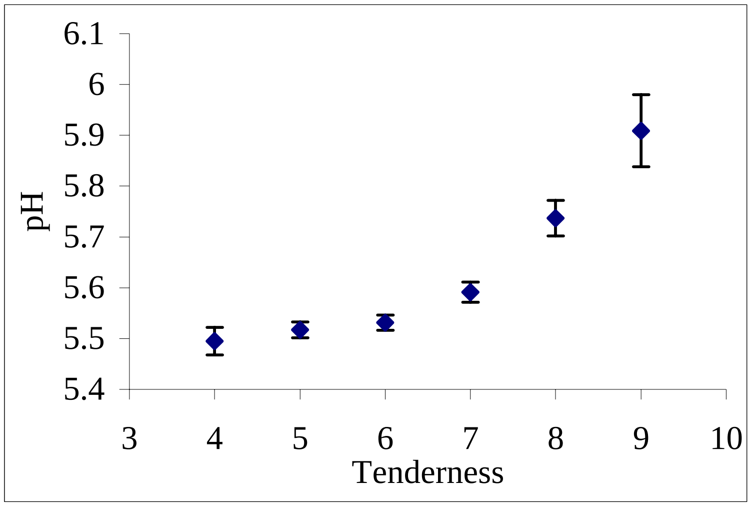
Note: Vertical lines are 95% C.I. for the expected value of pH

Figure 2. Relationship between pH and Meat Juiciness



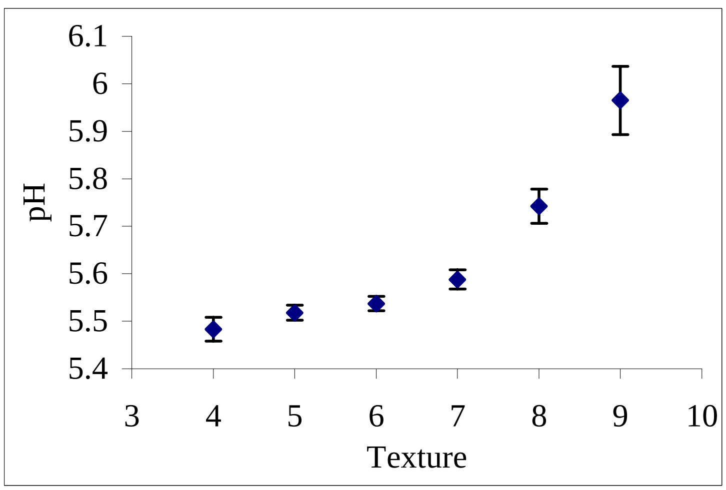
Note: Vertical lines are 95% C.I. for the expected value of pH

Figure 3. Relationship between pH and Meat Tenderness



Note: Vertical lines are 95% C.I. for the expected value of pH

Figure 4. Relationship between pH and Meat Texture



Note: Vertical lines are 95% C.I. for the expected value of pH

Figure 5: Distribution of meat flavor value by pH range

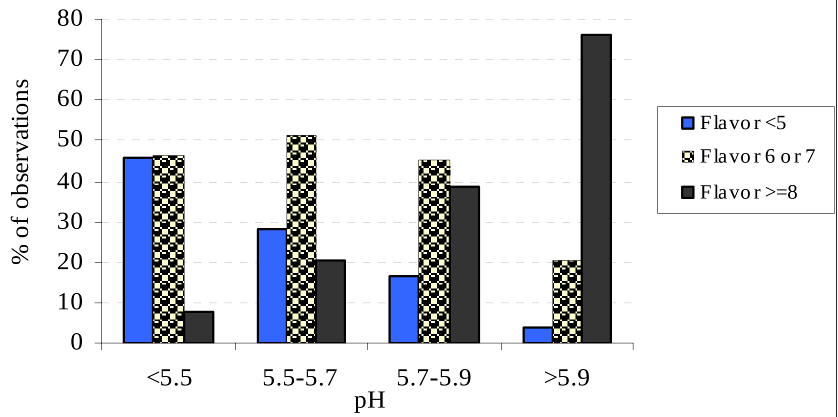


Figure 6: Distribution of meat juiciness value by pH range

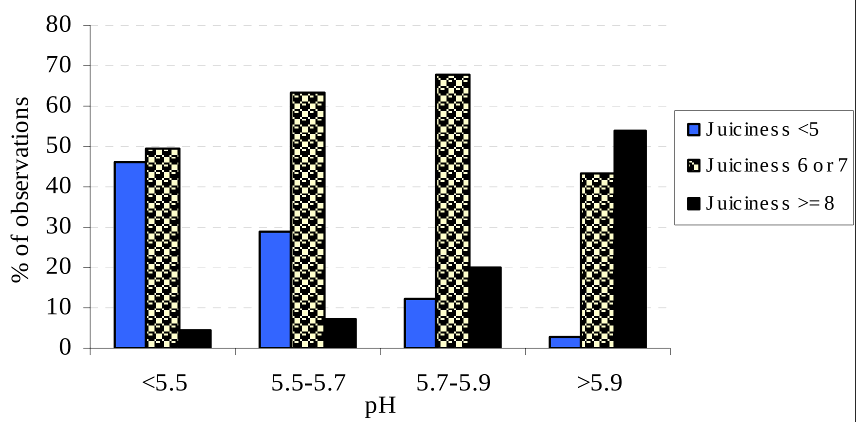
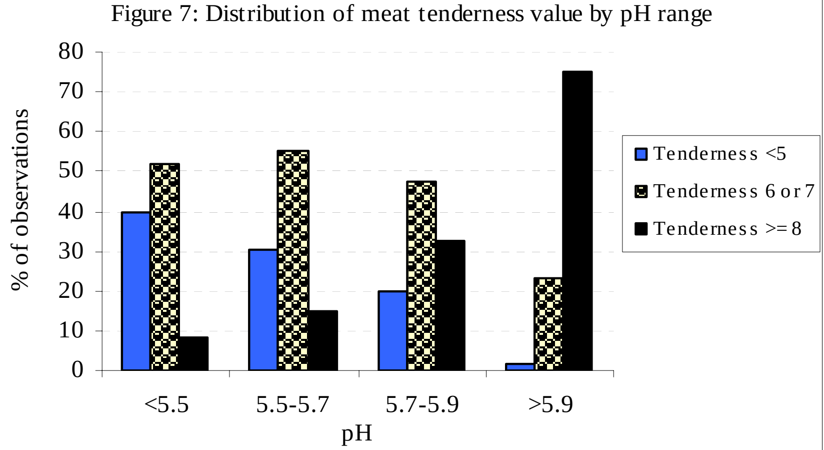


Figure 7: Distribution of meat tenderness value by pH range



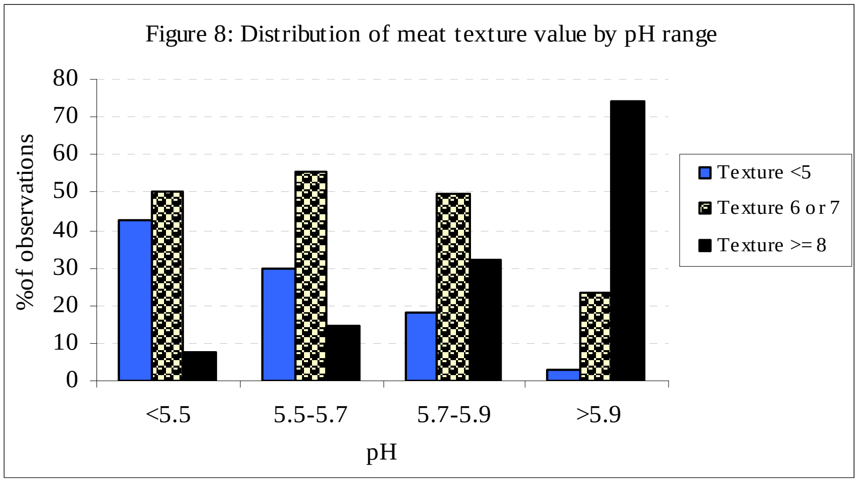


Figure 8: Distribution of meat texture value by pH range
80
70
60
50
40
30
20
10
0
%of observations
<5.5
5.5-5.7
5.7-5.9
>5.9
pH
Texture <5
Texture 6 or 7
Texture >= 8

Table 1. Difference between real and predicted dependent variable using only pH as explanatory variable.

Difference between real and predicted	Dependent variable is:							
	Flavor		Juiciness		Tenderness		Texture	
	Number of Observation	Percent	Number of Observation	Percent	Number of Observation	Percent	Number of Observation	Percent
-4	3	0.2	1	0.1	3	0.2	3	0.2
-3	35	2.5	8	0.6	40	2.9	30	2.2
-2	118	8.6	96	7.0	181	13.2	186	13.5
-1	304	22.1	341	24.8	349	25.4	353	25.7
0	422	**30.7**	505	**36.8**	401	**29.2**	412	**30.0**
1	306	22.3	318	23.1	296	21.5	294	21.4
2	152	11.1	95	6.9	91	6.6	88	6.4
3	31	2.3	10	0.7	10	0.7	7	0.5
4	3	0.2	0	0.0	3	0.2	1	0.1

Table 2. Difference between real and predicted dependent variable using pH, Instron and marbling as explanatory variables.

Difference between real and predicted	Dependent variable is:							
	Flavor		Juiciness		Tenderness		Texture	
	Number of Observation	Percent	Number of Observation	Percent	Number of Observation	Percent	Number of Observation	Percent
-3	4	0.3	1	0.1	2	0.1	1	0.1
-2	47	3.4	21	1.5	38	2.8	29	2.1
-1	292	21.3	308	22.4	278	20.2	272	19.8
0	689	**50.1**	732	**53.3**	685	**49.9**	676	**49.2**
1	310	22.6	295	21.5	330	24.0	362	26.3
2	32	2.3	17	1.2	39	2.8	32	2.3
3	0	0.0	0	0.0	2	0.1	2	0.1