# Estimation of the Necessary Sample Size for Predicting Meat Quality Characteristics for Producers

## A.S. Leaflet R2182

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**Summary and Implications**

The pork production industry is moving toward payment methods that are based on pork quality. To do so creates the need for collecting pork quality measurements. It is typically not cost effective to take pork quality measurements on all pork carcasses to determine quality payments for a pork producer. To determine a cost effective prediction of a pork quality grade for a producer it is necessary to know how many samples should be taken. Information is presented for the percent of pigs which will need to be tested for a 90 percent confidence level. These vary by pork quality measurement. It ranged from 10 percent for color to 62 percent for drip loss. The projected cost of obtaining a pH measurement on 2,000 hogs per week was $0.057 per hog.

**Materials and Methods**

The objective of this study is to identify the proportion of animals to be tested to get a 90 percent confidence that the resulting value of the traits for a certain producer are within the determined arbitrary ranges[1]. The confidence level directly impacts the number of samples needed. There are trade offs between reliability and costs.

The primary focus of this study is to determine the necessary sample size for predicting meat quality for selected levels of confidence. Pork quality information from a niche pork production company is used for the analysis. The company which specialized in producing pork for a niche market provided objective pork quality measures such as pH, LEA (loin eye area), drip loss, and Minolta. These measurements were taken from loin chop samples. Measurements were available from 1374 pigs. Subjective pork quality such as color, marbling, eating quality (flavor, juiciness, tenderness, and texture) were also available. Flavor is the combination of the taste and aroma that the cooked meat provides to the consumer. Juiciness is the amount of moisture that is retained in the muscle fibers during the cooking process. Tenderness is interpreted as how easy it is to cut a piece of meat. Texture defines how easy it is to chew the piece of meat.

The eating experience characteristics were measured by ranking the quality from 1 to 10 where 10 was very desirable and 1was a poor eating experience. This nature of the measurement makes the variables ordinal and not cardinal. A cardinal measurement is a measurement where it is known that 6 is twice as much as 3 such as, for example, 6 pounds is twice as much as 3 pounds. With ordinal measurements it is not known that 6 is twice as much as 3 such as, for example, it is not known that a meat cut with a flavor score of 6 is twice as flavorful as a meat cut with a flavor score of 3. Therefore the magnitude of the difference between 4 and 5 is not necessarily equal to the magnitude of the difference between 5 and 6. This characteristic of the variables put some restrictions on the models that can be used for the analysis.

The sample size ($n$) necessary to assure that the value of each of the characteristics for a producers hogs will be within a desired range can be calculated for each of the quality variables using the following procedure:

$$n = \frac{2^2 \times 1.645^2 \times S^2 \times N}{r^2 \times N + 2^2 \times 1.645^2 \times S^2}$$

where $S$ is the population standard deviation of hog's quality, $N$ is the number of hogs marketed by each producer, 1.645 is the $z_{90}$ from the Normal distribution and $r$ is the desired width of 90 percent confidence interval. Note that this calculation is based on a 90 percent confidence interval.

The results of the sample size for variables that are ordinal such as flavor, juiciness, tenderness and texture should be interpreted with caution because the calculus for the necessary sample size relies on the variance of the variable and therefore it uses the variables as if they were cardinal.

**Results and Discussion**

Information in Table 1 shows the distribution of meat quality measurements. Information in Table 2 shows the mean and standard deviation of the pork quality trait characteristics along with the percent of pigs which will need to be tested for a 90 percent confidence. The necessary number of carcasses tested was estimated using these values and the size of the deliveries made by producers. If the 90 percent confidence level is selected, and that the mean value

[1] Note: the resulting proportion of animals that should be tested is specific to the size distribution of a company's producers

of the producer will be in a range of ± 0.5 units, it is necessary to sample:

- 10% of the hogs for color
- 14% of the hogs for firmness
- 17% of the hogs for LEA and marbling
- 39% of the hogs for flavor
- 32% of the hogs for juiciness
- 39% of the hogs for tenderness and texture

Quality parameters of Minolta, pH, and drip loss had measurement score ranges different from 1 to 10. The range for the Minolta measurement was 1 to 100. Therefore the confidence interval of 90 percent should be measured in a range of ±3 and a total of 13 percent of the hogs delivered must be sampled. The range of pH measurements was 5 to 6.95, so that the confidence interval of 90 percent should be measured in a range of ±0.05 and a large proportion (approximately 57 percent) of the total hogs delivered must be sampled. The range of drip loss measurement was 1 to 99, so that the confidence interval of 90 percent should be measured in a range of ±5 and a large proportion (approximately 62 percent) of the total animals delivered must be sampled. A much lower percentage of hogs tested is necessary if it can assumed that all the loads sent by a producer are homogeneous.

The importance of pH as a predictor of pork quality has been documented in several studies. In order to asses the cost of measuring pH, the following information is used. This information is obtained from a plant that processes niche market hogs. The cost of each machine and probe runs about $500. The cost for each data recording device is about $250. This is a storage device that is linked to the probe. One person can take one reading per hog at a rate of 200-300 head per hour. This is also about the number of hogs which will be processed in about one hour in the plant. Thus, in order to take 3 measurements per hog, it would require 3 people with 3 sets of equipment. Considering an amortization of the total cost of the equipment in one year and collecting measurements on approximately 2000 hogs per week, the equipment cost of taking one measurement of pH is around $0.0072 per hog or $0.0027 per cwt.

Measuring only 200 head per hour as the worst case scenario and considering a salary of $10.00/hour for the person collecting the data, the labor cost of taking one measurement of pH is around $0.05 per hog or $0.019 per cwt. of liveweight and $.025 per carcass cwt.

The total cost of taking one measurement of pH for 2000 hogs delivered each week is approximately $0.057 per hog or $0.021 per cwt. of liveweight and $0.029 per carcass cwt.

For an acceptable accuracy level at least 3 pH measurements are needed per hog which represents a total cost of $0.17 per hog. Following the same reasoning and measuring 57 percent of the hogs would decrease the sampling cost by $2236/year or $0.065/hog but at the expense of a lower accuracy.

Further research must be done to estimate the cost of sampling for all the quality characteristics actually measured by the firm to determine the level of accuracy and the cost of measuring key variables such as pH, Instron and Marbling to reach a similar level of accuracy.

**Acknowledgement**

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Example cost calculation for measuring pH:
HogsPerYear = 2,000(*hogs/week*)*52(*weeks/year*)= 104,000 (*hogs/year*)
Samples = HogsPerYear = 104,000 (*hogs/year*)
Labor Cost (*$/year*) = $10(*$/hour*)/200(*hogs/hour*)**Samples*= $5,200 *$/year*
Equipment Cost = 750 *$/year*
Total Cost (*$/year*) = Labor Cost(*$/year*)+ Equipment Cost= $5,950 *$/year*
Total Cost (*$/hog*) = Total Cost(*$/year*)/ *HogsPerYear*= $5,950 (*$/year*) /104,000 (*hogs/year*)= $0.0572 *$/hog*

**Table 1. Distribution of the meat quality measurement values.**

| Value | Flavor | Juiciness | Tenderness | Texture | Color | Marbling | Firmness |
|---|---|---|---|---|---|---|---|
| **1** | 0.00 | 0.00 | 0.00 | 0.00 | 0.36 | 0.36 | 0.80 |
| **2** | 0.00 | 0.00 | 0.00 | 0.00 | 7.42 | 13.25 | 18.70 |
| **3** | 0.15 | 0.00 | 0.15 | 0.15 | 78.46 | 52.55 | 64.26 |
| **4** | 1.16 | 0.80 | 2.11 | 2.62 | 12.74 | 29.99 | 15.87 |
| **5** | 11.43 | 13.97 | 11.79 | 14.77 | 1.02 | 3.78 | 0.36 |
| **6** | 30.79 | 34.35 | 28.31 | 30.42 | 0.00 | 0.07 | 0.00 |
| **7** | 31.00 | 33.70 | 31.66 | 30.86 | n/a | n/a | n/a |
| **8** | 20.38 | 15.50 | 19.72 | 17.47 | n/a | n/a | n/a |
| **9** | 4.88 | 1.60 | 5.68 | 3.42 | n/a | n/a | n/a |
| **10** | 0.22 | 0.07 | 0.58 | 0.29 | n/a | n/a | n/a |

n/a = Not applicable.

**Table 2. Pork quality trait information and percentage sampled for the desired 90 percent confidence range width.**

| | Mean | Standard Deviation | Range | Percent Tested |
|---|---|---|---|---|
| Loin eye area | 6.48 | 0.53 | ±0.5 | 17.02 |
| Color | 3.07 | 0.25 | ±0.5 | 10.28 |
| Marbling | 3.24 | 0.55 | ±0.5 | 17.39 |
| Firmness | 2.96 | 0.39 | ±0.5 | 13.61 |
| pH | 5.59 | 0.05 | ±0.05 | 56.82 |
| Flavor | 6.31 | 2.04 | ±0.5 | 39.48 |
| Juiciness | 6.08 | 1.36 | ±0.5 | 31.54 |
| Tenderness | 6.28 | 1.89 | ±0.5 | 38.20 |
| Texture | 6.23 | 1.89 | ±0.5 | 38.20 |
| Drip loss (%) | 29.84 | 587.83 | ±5 | 62.28 |
| Minolta | 46.23 | 12.05 | ±3 | 12.68 |
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