RESEARCH REPORT
PORK QUALITY

Title: BACON STUDY - PHASE II – **NPB #00-147**

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Introduction:

The Bacon Study began in 1997 to take advantage of the bellies and address bacon issues as a part of the **"Quality Lean Growth Modeling Project"**, a large effort that was underway involving fresh pork quality work in progress at Iowa State University and cured ham work underway at Texas A&M University. The charge was to utilize the pork bellies and add another component to the extensive genetics data set being gathered by the then NPPC [National Pork Board - NPB] and its advisory committees under the umbrella project **"Quality Lean Growth Modeling Project"**. In addition to the major objectives of capturing the extensive data set for all the pigs in the main project, supplemental projects were developed to increase the understanding related to issues surrounding the commercial production of bacon. These supplemental projects would address the conversion of bellies to bacon with an emphasis on problems associated with belly composition, curing, smoking, slicing and pre-cooking of bacon at the commercial production level.

Ultimately, two separate, overlapping projects were conducted with their primary goal to expand the data set on the meat from the live hogs in the **"Quality Lean Growth Modeling Project"** and other related sub-sets of pigs in that overall project. The secondary goal of expanding the understanding of commercially processed bacon was to be accomplished with projects that could be superimposed on top of the primary goal and was accomplished through a series of graduate student research thesis projects

Thus the lines between the two major bacon projects were overlapping The two studies are characterized as follows:

A. BACON STUDY - PHASE I The pigs were stratified as follows:

Three replications [550-600 pigs each]
July-September 1996
February-March 1997
September - November 1997
Six different genetic lines of hogs
Four different nutritional regimes (lysine differences)
All data verified for animal identification and data accuracy was transferred electronically to NPPC for the primary goal. The goal of the secondary data includes Masters Thesis data. These data and copies of each of the Masters theses were transferred by hard copies of the individual students thesis to the National Pork Board.

B. BACON STUDY - PHASE II The pigs were stratified as follows:

Bellies from hogs
Two different lines (Purebred Landrace and Duroc) for trials 1 and 2; and
Market hogs from the National Barrow Show in trial 3.
Trial 1 involved 480 bellies frozen and stored
Trial 2 involved 240 bellies, half fresh and half frozen stored
Trial 3 involved 400 bellies, half fresh and half frozen stored

Objectives:

PHASE - I

A. Determine quantitative and qualitative data for sliced bacon demonstrating the impact of the primary design parameters (live animals)**.**

B. Evaluate cured meat color, lean and fat relationships and processing yields at various stages in manufacturing, slicing, packaging and cooking of sliced bacon.

C. Conduct additional evaluation to develop information of sliced retail bacon and sliced food service bacon.

D. Conduct research to focus on additional research questions including the shattering effect observed in sliced commercial bacon, impact of leanness, degree of cooked doneness and the response of sliced bacon to microwave and double-belt pre-cooked bacon.

PHASE - II

A. Determine quantitative and qualitative data for sliced bacon demonstrating the impact of the primary design parameters involving breed, slaughter weight and sex of the pigs.

B. Address specific commercial bacon processing industry questions to evaluate cured meat color, lean and fat relationships, dimensional differences and processing yields at various stages in the manufacturing, slicing, packaging and cooking of sliced bacon.

C. Expand the understanding of temperature of bacon slabs at pressing and slicing and relationships to belly composition, processing variables and acceptance of cooked bacon.

D. Develop greater understanding of pre-cooked bacon yield, color and distortion concerns.

E. Focus additional research related to the shattering effect observed in sliced commercial bacon with emphasis on the impact of leanness, degree of cooked doneness, and the response of sliced bacon to microwave and belt pre-cooked bacon.

Materials and Methods:

Phase - I was designed for up to 1800 bellies, all received frozen were processed by defrosting bellies in cold water, injecting with standard pickles, cooked/smoked in batches of 40 bellies, chilled, pressed, sliced, cooked and evaluated for qualitative/quantitative measures according to the standard procedures for the entire project and with variations for the specific procedures of the individual subsets as outlined in the following Masters of Science thesis citations:

Wenther, Jay B. 1999. The effect of genetic line, diet, sex, slaughter weight and type of bacon on bacon processing parameters. Masters Thesis. University of Nebraska, Lincoln, NE.

Ross, Rebecca A. 1999. Precooked bacon manufactured by microwave and double belt conveyor processing systems. Masters Thesis. University of Nebraska, Lincoln, NE.

McEver, Marshall E. 2000. Precooked bacon manufactured by microwave and double belt conveyor processing systems. Masters Thesis. University of Nebraska, Lincoln, NE.

Mann, Jason E. 2001. The effect of genetic line, diet, sex, slaughter weight and location within the slab on bacon color and proximate composition. Masters Thesis. University of Nebraska, Lincoln, NE.

Garza, Rodolfo. M. 2003 Development of a digital image analysis system for bacon. Masters Thesis. University of Nebraska, Lincoln, NE.

In Phase - II planned for up to 1160 bellies were received either refrigerated or frozen, processed again with the overall standard procedures and with procedural changes as outlined in the following Masters of Science Thesis citations:

Salas-Perez, Pablo Jacinto. 2002. Differences among breeds, diets, slaughter weights and sex type in the shattering of bacon slices. Masters Thesis. University of Nebraska, Lincoln, NE.

Robles, Carmina Citlali. 2004. The effect of fresh and frozen bellies on bacon processing characteristics and bacon quality. Masters Thesis. University of Nebraska, Lincoln, NE.

Results:

The objectives for the bacon research projects was to utilize the pork bellies and add another component to the extensive genetics data set being gathered by the NPPC and its advisory committees under the umbrella project **"Quality Lean Growth Modeling Project"**. Thus all raw data was transferred to the NPPC either electronically or by CD following proofing of the data sets and identity verification to the live pigs with Dr. Rodney Goodwin to be used by several committees of the NPPC related to the **"Quality Lean Growth Modeling Project"**. Several industry presentations were used to present preliminary findings and updates. These meetings included:

Mandigo, Roger W. 1998. NPPC- Lean Growth Modeling Study - Belly Quality Study Update. July 14-15, 1998. Des Moines, IA.

Mandigo, Roger W. 1998. Project Report - Quality Lean Growth Modeling Project - Pumped Bacon Project. November 14, 1998.

Mandigo, Roger W. 1999. Quality Lean Growth Modeling Symposium II.. Progress Report. November 16-17, 1999. Des Moines, IA.

Mandigo, Roger W. 2002. A new look at belly and bacon values. National Hog Farmer Blueprint - Estimating whole hog value. National Hog Farmer, pages 27, 32-34., New York, NY.

Mann, J.E., R.W. Mandigo, D.E. Burson and J.R. Garza. 2002. Factors affecting bacon color and composition. 2002 Nebraska Swine Report. EC-02-219-A, pages 66-69.

Mandigo, Roger W. 2002. Composition and value of belly primal. Whole Hog Value Symposium. National Pork Board, Des Moines, IA. November 20, 2002.
Robles, Carmina; Booren, Betsy and Mandigo, R.W. 2003. Fatty acid composition of fresh pork bellies. - Implications to bacon production. 2003 Nebraska Swine Report, EC-03-219-A, pages 61-63.

Robles, Carmina and R.W. Mandigo. 2003. Fresh vs. frozen bellies for bacon. 2003 Nebraska Swine Report, EC-03-219-A, pages 59-61.

In addition to the major objectives of capturing the extensive data set for all the pigs in the main project, supplemental projects were developed to increase the understanding related to issues surrounding the commercial production of bacon. These supplemental projects would address the conversion of bellies to bacon with an emphasis on problems associated with belly composition, curing, smoking, slicing and pre-cooking of bacon at the commercial production level.

Ultimately, two separate, overlapping projects were conducted with their primary goal to provide the data to expand the data set on the meat from the live hogs in the **"Quality Lean Growth Modeling Project"** and other related sub-sets of pigs in that overall project. The secondary goal of expanding the understanding on commercially processed bacon was to be accomplished with projects that could be superimposed on top of the primary goal and was accomplished through a series of graduate student research thesis projects. Major findings from each of these supplemental projects are drawn from the individual Master Thesis as follows:

The effect of genetic line, dirt, sex, slaughter weight and type of bacon on processing parameters by Jay B. Wenther. M.S. Thesis, 1999.

- Line 3 produced the highest significant smokehouse yield and one of the lowest percent fat values from proximate composition.
- Bellies from pigs fed diet 4 had the highest smokehouse yield and total bacon yield.
- Bacon from barrows was fatter, slice yield was greater than for bacon from gilts.
- As pigs grew larger, smokehouse yield, slice yield and total bacon yields increased.
- Retail bacon had a higher yield than food service bacon
- Genetic lines and diet influenced processing yields.

Precooked bacon manufactured by microwave and double belt conveyor processing systems. by Rebecca A. Ross, M.S. Thesis, 1999.

- Validation of cooking procedures measured cook yield, proximate composition for consistency of the cook procedures.
- The two cooking systems were consistent and valid for testing.
- Lean Bacon had the highest cooking yields..
- Food service bacon (thinner sliced) yielded less that retail bacon (sliced thicker)
- Microwave bacon had less distortion than double belt cooked bacon.

Precooked bacon manufactured by microwave and double belt conveyor cooking systems by Marshall E. McEver, M.S. Thesis, 2000.

- Cooked shrink, dimensional yields (length and width) and distortion score procedures were developed.
- Higher cooked yields were found in leaner genetic lines, leaner locations in the belly, gilts and higher lysine diets. Shrink in bacon slices followed leanness measures.
- Double belt conveyor cooking had less shrink in width than microwave cooking.
- Bacon from gilts had less distortion and bacon from both ends of the slab had higher distortion.

The effect of genetic line, diet, sex, slaughter weight and location within the slab on bacon color and proximate composition. Jason E. Mann, M.S. Thesis, 2001.

- Genetic line had the greatest effect on bacon composition (13% between lines).
- Bacon with increased fat levels had whiter fat, decreasing lysine levels led to fatter bacon.
- Barrows and pigs fatter genetic lines had lighter colored fat.

Differences among breeds, diets, slaughter weights and sex type in the shattering of bacon slices by Pablo Jacinto Salas-Perez, M.S. Thesis, 2002.

- Shattering defined as breaks in the fat portion of the slice occurs perpendicular to the slice.
- Treatments yielding fatter bellies had higher incidence of shattering.
- Leaner pigs, gilts and two genetic lines had less shattering.
- Within the bacon slab, center portions (fatter) had more shattering.

Development of a digital image analysis system for bacon by Rodolfo M. Garza, M.S. Thesis 2003.

- A video imaging system was developed and validated. A computer color classification for lean and fat and a individual muscle percentage of lean in the bacon slice were developed.
- Lean was characterized as Primary and Secondary at five locations within each slab of sliced bacon.
- Color data was combined to characterize the primary and secondary lean from sliced bacon.

The effect of fresh and frozen bellies on bacon processing characteristics and bacon quality. Carmina C. Robles. M.S. Thesis, 2004.

- Frozen bellies (15^oC) for 15 days were compared to fresh bellies from the same hogs (3^oC) for 15 days were compared.

- Fresh bellies had 1.74% higher slicing yields than frozen bellies, total yields were not different.
- No difference were found in total saturated vs. unsaturated fatty acids, gilts had 1.08% higher unsaturated fatty acids than barrows.
- The center of the belly had slices with had higher shatter mark scores than the ends of the slabs.
- Frozen bellies had higher distortion scores than fresh bellies.
- Fresh and frozen (15 days) had similar characteristics due to short freezing times.

Discussion:

This project achieved the goal of obtaining and large set of data on bacon measures that could be included in the genetic analyses to be conducted by the various genetic advisory committees including the **Quality Lean Growth Modeling Project"**. That data has been provided to those committees through electronic and CD means for their further analyses. Master of Science students in the Meat Science program, who provided the extremely large data acquisition and research analyses for this project each wrote specific thesis concerning the development and validation of several new quantitative and qualitative procedures as well as analyses of the data sets from the overall project to complete their degree requirements. Specific questions were addressed to learn more about commercial industry questions where ever possible without compromising the primary goals of the work.

Many of the findings were anticipated and could be expected due to the nature of the biology of the pig, growth and composition understanding that was well known. Confirmation of these differences has been a focus due to the fact that prior research understanding of the belly conversion to bacon was often not considered as important as other aspects including the loin and ham. Bacon has become a very popular, highly demanded component of the mix of products produced from the pig. Pre-cooked bacon for entrees, sandwiches and salads has served to increase the awareness of the powerful role bacon plays in the pork industry. Ironically, what may be best for bacon may also selected against negatively in discussions of leaner, larger animals with less fat bellies can be too lean and thin to produce acceptable bacon. measurements. Fatty acid data on this wide distribution on pigs will be an area for further exploration.

The work of some of the graduate students to develop and validate new analytical procedures will have continuing benefits as some of these approaches are used in other applications. Cooking technology for pre-cooked bacon including distortion and shrinkage issues is an area with little published research results. Visual imaging of lean and fat to determine color and amount of lean and fat offers new potential analytical.