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and Chester White lines had higher backfat thickness and lower loin eye area and were thus fatter and lighter muscled than the other breeds (Table 1), a result different from previous reports that light muscle and fat lines had lower percent pump. In this study, the lowest pumping yield was observed in the Duroc pigs which had the largest loin eye areas and low backfat content. Pigs in this study were comparatively leaner than some in previous work.

Genetic line had a highly significant effect ($P < 0.01$) on smokehouse yields. Berkshire line had the highest yields and were different ($P < 0.05$) than all other lines. Landrace had the lowest smokehouse yield and was significantly different than all other lines. Berkshire pigs had the highest backfat, Landrace, Yorkshire and Duroc pigs the lowest backfat. These results are in agreement with the previous studies that reported fatter bellies tended to lose less weight during the heating process. Genetic line had a significant effect on total bacon yield. Bacon slabs from Berkshire pigs had the best total yield performance, followed by the Poland China and Chester White pigs. These three lines had the highest backfat thickness, again showing the relationship between fat content and total yield.

Sex Effect

Sex had no statistical influence on pumping percent or smokehouse yield, important measurements followed during the manufacturing process in many commercial bacon plants. Sex had a significant impact on slicing yield with barrows having a greater slicing yield than gilts ($P < 0.05$). Barrows had significantly higher total bacon yield than gilts ($P < 0.05$). Barrows were fatter than gilts (Table 1). Slicing yield increases with bacon slabs that are fatter.

¹Carmina Robles is a graduate student, and Roger Mandigo, is a professor in the Department of Animal Science.

Fatty Acid Composition of Fresh Pork Bellies — Implications to Bacon Production?

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Summary and Implications

Commercial bacon processors often raise concerns regarding the management practice of frozen storage of the bellies prior to curing and processing for sliced bacon. Deterioration of quality measures is a concern and is usually attributed to freezer storage. A secondary issue, in the production of bacon including those processed from frozen bellies, is the effect of breed and sex of pigs. Therefore, an experiment was conducted to determine the effect of a 15-day frozen storage time, the genetics, and sex of the pig on the quality and fatty acid profile of pork bellies. Frozen storage of fresh pork bellies did not pose any significant quality problems. However, significant differences in the fatty acid profile of fat from the bellies were observed between breeds of pigs. Fat accounts for about 60% of the composition of a slice of bacon. Thus, fatty acid differences of fresh bellies due to breed effects may have a significant impact on bacon fatty acid composition.

Introduction

Consumer demand for lean meat products certainly has extended to cured and smoked sliced bacon. Consumer purchases of bacon are based on leanness, rather than brand name reputation and price. The largest growth in demand for sliced bacon has been in the food service industry recently, where

bacon is seen as a flavor contributor for sandwiches, casseroles, salads, and other condiment uses. Consumers say that the amount, composition and consistency of fat are very important to their purchasing decision-making process. Sliced bacon quality problems are associated with fat separation, color of fat, color of lean, consistency and flavor.

Understanding the role of fat in bacon begins with an understanding of the variables that impact the amount and quality of the fat found in the bacon. The fatty acid composition of the fat found in the belly will potentially impact the processing characteristics of the belly, such as the slicing, cooking and eating quality of the bacon. Many factors can influence fatty acid composition including the breed and sex of the pigs as well as other management strategies.

This study is a continuing effort of the National Pork Board to characterize lean growth in pigs and the production of pork products. Additionally, the bellies were evaluated to understand the impact of freezing of raw bellies prior to production of bacon. Frozen storage of fresh bellies is a common practice to manage the cyclical and seasonal supplies of pork bellies. Yet freezing does not usually improve the quality of meat and certainly not the quality of fat and its role on the ultimate eating quality of the bacon.

Procedures

The animals in this study included barrows and gilts ($n=578$) from six genetic lines: Chester White, Berkshire,

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**Table 1. Least square means \pm S.E. of the fatty acid profile for sex, line and treatment effects.**

Effect	14:0	16:0	16:1	18:0	18:1	18:2	18:3	20:1
Barrows	1.35 \pm 0.01	24.04 \pm 0.15 ^a	2.64 \pm 0.03	11.59 \pm 0.13	44.98 \pm 0.27	11.27 \pm 0.31	0.69 \pm 0.03	0.80 \pm 0.01
Gilts	0.32 \pm 0.01	23.17 \pm 0.13 ^b	2.58 \pm 0.03	11.36 \pm 0.11	45.27 \pm 0.23	12.06 \pm 0.26	0.69 \pm 0.02	0.77 \pm 0.00
Berkshire	1.36 \pm 0.01 ^b	25.09 \pm 0.14 ^a	2.88 \pm 0.03 ^b	11.89 \pm 0.12 ^{ab}	45.78 \pm 0.27 ^{ab}	9.45 \pm 0.27 ^b	0.42 \pm 0.03 ^b	0.76 \pm 0.00 ^b
Chester White	1.49 \pm 0.02 ^a	24.84 \pm 0.27 ^{ab}	3.07 \pm 0.06 ^a	11.45 \pm 0.24 ^b	45.48 \pm 0.48 ^c	9.74 \pm 0.54 ^b	0.45 \pm 0.06 ^b	0.80 \pm 0.01 ^{bc}
Duroc	1.30 \pm 0.01 ^c	22.27 \pm 0.12 ^d	2.13 \pm 0.02 ^c	11.99 \pm 0.11 ^a	41.90 \pm 0.22 ^c	15.66 \pm 0.25 ^a	1.15 \pm 0.02 ^a	0.78 \pm 0.00 ^b
Landrace	1.28 \pm 0.02 ^{cd}	23.20 \pm 0.33 ^c	2.61 \pm 0.07 ^c	11.27 \pm 0.30 ^b	47.28 \pm 0.66 ^{ab}	10.17 \pm 0.67 ^b	0.46 \pm 0.07 ^b	0.77 \pm 0.02 ^{bc}
Poland China	1.30 \pm 0.03 ^{cd}	24.31 \pm 0.35 ^b	2.66 \pm 0.08 ^c	11.54 \pm 0.32 ^{ab}	47.35 \pm 0.63 ^a	9.25 \pm 0.71 ^b	0.46 \pm 0.08 ^b	0.80 \pm 0.02 ^{ac}
Yorkshire	1.26 \pm 0.01 ^d	21.95 \pm 0.14 ^d	2.30 \pm 0.03 ^d	10.69 \pm 0.12 ^c	42.98 \pm 0.25 ^d	15.73 \pm 0.28 ^a	1.18 \pm 0.03 ^a	0.81 \pm 0.01 ^{ac}
Fresh	1.33 \pm 0.01	23.79 \pm 0.13 ^a	2.63 \pm 0.03	11.59 \pm 0.12	45.12 \pm 0.25	11.36 \pm 0.27	0.67 \pm 0.03	0.78 \pm 0.00
Frozen	1.34 \pm 0.01	23.42 \pm 0.14 ^b	2.59 \pm 0.03	11.35 \pm 0.12	45.14 \pm 0.26	11.97 \pm 0.28	0.70 \pm 0.03	0.78 \pm 0.00

a,b,c,d,e Means within a column with different superscripts are significant $P < 0.05$.

Table 2. Least square means \pm S.E. for saturated and unsaturated fatty acid content by sex, line and treatment effect.

	Unsaturated Fatty Acids - %	Saturated Fatty Acids - %
Barrows	61.43 \pm 0.26 ^a	37.71 \pm 0.27 ^a
Gilts	62.51 \pm 0.22 ^b	36.59 \pm 0.23 ^b
Berkshire	60.20 \pm 0.23 ^c	39.05 \pm 0.24 ^a
Chester White	60.51 \pm 0.46 ^c	38.57 \pm 0.47 ^a
Duroc	62.89 \pm 0.21 ^b	36.22 \pm 0.22 ^c
Landrace	62.40 \pm 0.57 ^b	36.64 \pm 0.59 ^{bc}
Poland China	61.46 \pm 0.60 ^c	37.82 \pm 0.62 ^{ab}
Yorkshire	64.35 \pm 0.24 ^a	34.60 \pm 0.25 ^d
Fresh	61.69 \pm 0.23	37.44 \pm 0.23
Frozen	62.24 \pm 0.24	36.86 \pm 0.25

a,b,c Means with a column for an effect with different superscripts are significant $P < 0.05$.

Duroc, Landrace, Poland China and Yorkshire, slaughtered at markets weights starting at 245 pounds. After slaughter, the bellies were fabricated according to industry standards. Bellies were randomly assigned a treatment of fresh (stored only under refrigeration) or frozen (stored frozen for a minimum of 15 days). Prior to processing, frozen bellies were defrosted, removed from the storage packaging, a fat sample removed from the anterior end of the belly for fatty acid analysis. The samples were frozen for subsequent methylation and fractionation by gas chromatography. The fatty acid composition was determined for saturated fatty acids including myristic (C14:0), palmitic (C16:0), stearic and unsaturated fatty acids including palmitoleic (C16:1), oleic (C18:1) linoleic (C18:2), linolenic

(C18:3), and 11-ecosenoic (C20:1). These were selected as they account for over 95% of the total fatty acids typically found in pork bellies. Each fatty acid was reported as a percentage of total.

Results and Discussion

Barrows and Gilts Comparisons

The only difference ($P < 0.05$) observed between sexes (Table 1) showed a minor difference for palmitic (C16:0) acid, although this may not be of biological significance. Barrows had greater levels ($P < 0.05$) of unsaturated fatty acids (Table 2) with 61.43% for barrows and 62.51% for gilts and saturated fatty acids 37.71% for barrows compared to 36.59% for gilts. Gilts had 1.08% more unsaturated fatty

acids than barrows ($P < 0.05$). This difference becomes part of the variability often seen during packaging of sliced bacon. This is well within the range that impacts slicing efficiency found in commercial slicing operations.

Breed Comparisons

Fatty acid profiles for the six different breeds were compared. Yorkshire pigs had the most unsaturated fat (64.35%), Landrace and Duroc were intermediate (62.40% and 62.89%) and the Poland China, Chester White and Berkshire were lower in unsaturated fatty acids (61.46%, 60.51% and 60.20%, respectively). The range for unsaturated fatty acids within the 6 breeds evaluated was 4.15 percentage units (Table 2).

The breed influence illustrated in the five largest percent fatty acids reflects the breed differences for specific fatty acids. For C 16:0 palmitic acid there was 3.14 percentage unit variation between the Berkshire (25.09%) and the Yorkshire pigs (21.95%). The other saturated fatty acid, C 18:0, stearic had low variability between the breeds represented in this study with a difference of only 1.40 percentage units from the Durocs (11.99%) to the Yorkshire pigs (10.69%). The most variation was found for fatty acids C 18:1 and 18:2, oleic and linoleic, both unsaturated fatty acids. The variation was 5.45 percentage units for the oleic and 6.48 percentage units



for the linoleic acid within the breeds evaluated. These results clearly show differences exist between breeds in the fatty acid profile belly fat. The magnitude, while statistically significant, would be hard to use for sorting and/or altered processing conditions in the commercial setting due to management problems associated with sorting or knowing the genetic background of the pigs. Understanding and recognizing this source of variation can aid management in refining processes and adjusting the machinery used to slice bacon.

Fresh vs. Frozen Bellies

The characterization of fresh and frozen storage involved a minimal freezing time of at least 15 days before processing. There was no significant ($P>0.05$) difference found between the fresh and frozen bellies. As would be expected, much longer freezing times would likely be needed to measure loss in quality, particularly of fat as a result of freezer storage. This was not possible in this study. It can be concluded that short time frozen storage had no effect of the bacon quality in this study.

While longer storage times are often encountered, they would certainly be more likely undesirable. This study did demonstrate that the act of freezing the bellies posed little quality damage to the bacon nor changes in the fatty acid profiles, often a concern to processors.

¹Carmina Robles and Betsy Booren are graduate students, and Roger Mandigo is a professor in the Department of Animal Science.

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Effect of Post-Cooking Holding Time on Consumer Taste Panel Ratings of Enhanced Pork Loins

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Summary and Implications

Sensory evaluation of food products is a valuable means of learning about their characteristics. Consumer taste panels are regularly used to evaluate properties of meat products such as pork loins. The objective of this research was to evaluate the effect of post-cooking holding time on the taste panel ratings of enhanced pork. The loins used in this project were enhanced with varying percentages (close to 10 %) of solutions containing water, salt, phosphates and natural juices or flavors. The loins came from 10 different suppliers and were served in randomly allotted groups of seven, throughout twenty, one-hour taste panel sessions. The meat was cooked, diced and kept in double boilers in order to maintain a steady temperature of approximately 122°F

throughout the duration of the one-hour taste panel. Eight-point hedonic scales were used for juiciness, tenderness, flavor and overall acceptability. The order in which the panelists attended the taste panel throughout the hour was recorded. Significant first-degree interactions between time and tenderness, juiciness, flavor and overall acceptability were found. As expected, the ratings given by the panelists to the meat decreased as post-cooking holding time in the double boilers increased. Empirically, holding time should be minimized and samples should be replaced after no more than 30 minutes. Results showed that current American Meat Science Association (AMSA) guidelines for meat evaluation should be revised whereby samples are cooked while the taste panel is conducted. As such, it is important that proper facilities be used and positive air flow in the panel booths be maintained to minimize any carry-over effects from the aroma of cooking meat.

Introduction

In current taste panel practices samples are cooked, cut and kept warm in double boilers until they are served to panelists, according to AMSA Research Guidelines (AMSA, 1995). People that come at the end of a taste panel session get meat that has been in the double boilers for an hour.

It is rational to speculate about the physical and chemical transformations that the meat undergoes in the time that it is kept warm in double boilers throughout the hour that taste panels last. These alterations in the products' organoleptic properties may have an impact on the panelists' ratings with respect to juiciness, tenderness, flavor and overall acceptability.

Previous research has shown lower sample temperatures have significantly deleterious effects on flavor and juiciness of the product being tested. They recommended maintaining 122°F sample temperature in the double boilers, but no effort was made to look at the effects of holding time.

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