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PORK TISSUE GROWTH AND COMPOSITION WITH EMPHASIS ON CONTROL OF SEX ODOR.

A survey paper from the Meat Laboratory Staff[1] of the Ohio State University and the Ohio Agricultural Research and Development Center

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Meat is and has been a most important food product. This part of the world has appreciated lean meat and has used feed most economically to produce as much animal protein as possible for human consumption. Those of us from the Western Hemisphere countries have seen too much feed spent on some hogs and some cattle which resulted in carcass product with higher fat content than is really necessary.

The livestock industry of the world is becoming increasingly interested in the role that sex of the animal and the use of hormonal supplements play in the production of well muscled, quality beef, lamb, and pork. Tradition and established marketing procedures in the United States have served to preserve castration as a common management practice in spite of its proven role in fat deposition.

Some thirty years ago, men became interested in the additional edible portion that was obtained from bulls of similar age and weight as their counterpart steers or heifers. The advantages of growth were expressed in daily gains and amount of meat to eat from each carcass. The muscle was acceptably tender and flavorful.

A basic objective of a project dealing with the "Sex Influenced Performance of Swine" at the Ohio State University Meat Laboratory in cooperation with the Ohio Agricultural Research and Development Center has been to evaluate and compare the boar and barrow in terms of feedlot performance, detailed carcass characteristics, physical quality attributes of the pork, and palatability and chemical relationships within the muscle. The ultimate objective would be to develop a procedure that would eliminate castration in swine and enable the producer to reap the benefits of the ability of boar pigs to grow rapidly and efficiently and to display greater muscular development than barrows or gilts at a market weight of 95.5 kg. (210 lb.). This procedure must incorporate a method for eliminating or preventing the development of the offensive flavor and odor which is associated with the pork from market weight boars.

Usually sex odor in these animals is said to be a manifestation of sexual maturity and glandular development of the male. The German worker Lerche (1936) reported on the sex odor problem of boars and late castrates.

> As soon as the male hog is sexually mature and the testes become capable of functioning, there appears a specific odor in the meat and the fat of the animal, and the odor which by the way is onionlike or unpleasantly perspirative, occurs in all boars with normally developed testes. It is also always present in cryptorchids unless the testes lying in the abdominal cavity are atrophied-the odor substances from the testes are regularly transmitted to the body.

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It would seem then, that castration of male pigs would eliminate the sex odor problem and this is the theory under which many of the swine production people work. Lerche (1936) studied the length of time required for the sex odor to disappear following the castration of boars. When 32 stags were slaughtered at intervals from 8 to 75 days after castration, it was found that the sex odor was reported present up to 22 days after castration with a marked lessening of intensity after 33 and 57 days.

Bratzler et al. (1954) reported that sex odor was eliminated 21 to 44 days after castration of boars at 80.8 kg. (180 lb.) live weight. These late castrates averaged 103.1 kg. (227 lb.) at slaughter.

In the United States, male pigs are castrated and fed as barrows. Boars which have been used in herd service are sacrificed. They along with young boars are discriminated against at the market place. If sex odor is detected in carcass inspection, condemnation follows. Boar product that passes federal inspection is consigned to manufactured meat products which are exposed to cookery at a processing plant.

Attempts had been made to eliminate this boar odor problem by surgical removal of suspected areas of odor production (such as the preputial diverticulm) and by various hormone treatments. These attempts met with failure as did attempts to produce sex odor in barrows by testosterone treatment. It was felt by the Ohio workers at the initiation of this project that hormone balance and maturity of the animal must hold the key to the development of the sex odor.

Our early trials showed that the greater leanness in market weight boars developed after they reached a live weight of 68 kg. (150 lb.). Implantation of barrows with 1.5 mg., 3 mg., or 6 mg. of diethylstilbestrol (DES) at 68 kg. (150 lb.) improved carcass leanness but had only minor effects on feedlot performance. Since 1959, nineteen trials involving over 900 pigs have been conducted for this project. It will be our attempt to only highlight the interesting aspects of these trials for your information.

Trials during 1959 involved attempts to relate performance data, carcass traits and palatability of pork from boars to procedures of castration and various hormone treatments. The initial evaluation of DES treatment of boars as a means of sex odor control, while hopefully leaving the advantages of the boar intact, began with a pilot approach involving implantation of 24-120 mg. DES at live weights of 40.9-77.3 kg. (90-170 lb.). These efforts suggested that levels of 48-96 mg. DES implanted at a weight of 70.4 kg. (155 lb.) might be a promising means of controlling sex odor in boars.

Trials conducted during 1960 and 1961 compared the performance, carcass merits, and palatability differences for littermate barrows and boars and also evaluated the influence that the implantation of boars at 70.4 kg. (155 lb.) with 48 mg. or 96 mg. DES might have on these factors. It was determined at this time that approximately 30 percent of the 95.5 kg. (210 lb.) market weight boars yielded condemnable pork with sex odor scores ranked moderate to high. The carcasses of boars were superior to those of barrows in yield of edible muscle and were quite acceptable in terms of muscle quality (marbling, color, and firmness). The implantation of 96 mg. of DES at a live weight of 70.4 kg. (155 lb.) significantly reduced sex odor development in boars slaughtered at a market weight of 95.5 kg. (210 lb.). Sex odor scores of these implants were consistently no different than those of barrows. In addition, it was determined that DES implantation

significantly increased rate of gain. These implants also required 13.6 kg. (30 lb.) less feed from 70.4 kg. (155 lb.) to the 95.5 kg. (210 lb.) slaughter weight than barrows.

Our Ohio investigators were not satisfied with the apparent specificity of weight at time of implantation. The 70.4 kg. (155 lb.) weight needed investigation as to whether or not it was the specific weight or stage of maturity at which DES could best influence sex odor. Trials were conducted during the 1961-1963 period to evaluate implantation at 65.9 kg., 70.4 kg. and at 75 kg. (at 145 lb., 155 lb., and at 165 lb.) in two herds. One of these was a purebred Duroc herd and the other a crossbred herd of Hampshire, Yorkshire, and Duroc breeding. These trials again showed that barrows were significantly shorter and fatter than control boars or implanted boars and performed with less efficiency in the feedlot. Implantation of boars at either 70.4 kg. (155 lb.) or 75 kg. (165 lb.) did not significantly alter the desirable lean muscling characteristics of the boar carcasses, although earlier DES implantation at 65.9 kg. (145 lb.) did increase the fat deposition and decrease the yield of lean cuts. It was determined that from a consistency standpoint, sex odor control could best be accomplished with implantation at 70.4 kg. (155 lb.).

Because of the nature of DES it was necessary to determine whether residues of this synthetic estrogen could be found in the tissue from implanted boars. A mouse uterine weight bioassay technique, similar to that suggested for the detection of DES residue in beef by Umberger et al. (1958), was used to measure estrogenic activity within the longissimus dorsi muscle tissue of control and implanted boars. The relationship between mouse uterine weight and DES increments, added to establish standard curves, was a typical simoid curve. When plotted as the log response against the arithmetic dose of 0, 3, and 6 ppb. of DES added to the diet including tissue from control and implanted boars, the assay resulted in a straight line relationship. Using the horizontal distance between the parallel control and implanted boar longissimus dorsi tissue response curves to determine the estrogen content, the level was shown to be 0.558 ppb. This level was less than the minimum of 0.620 ppb. determined statistically as the sensitivity for these assays.

If some agent, not necessarily DES, is to be effective as a deterent to sex odor development, information should be obtained as to the development of the odor in relation to animal age, the stages of growth at which this agent might be effective, and the length of its effectiveness after administration. Characteristics of the male animal as to muscle quality and composition and the influence of the agent on quality should also be determined to more accurately ascertain the value of the intact male as a potential economical source of lean pork. From 1961 through 1963, five trials involving 280 pigs were conducted, with pigs slaughtered at weekly intervals from 1-12 weeks after 70.4 kg. (155 lb.) in order to compare patterns of growth, development, and composition of boars, barrows and DES implanted boars. These studies yielded much interesting data.

The implantation of boars with 96 mg. DES at 70.4 kg. (155 lb.) significantly increased rate of gain and rate of lean cut and primal cut deposition as compared to barrows without sacrificing the desirable lean muscling characteristics of the intact male pig as measured over the weight range of 72.7-136.1 kg. (160-300 lb.). The rate of developing lean cuts increased for the treated animals to ten weeks following implantation.

Taste panel evaluation was conducted on the 10th-rib loin chops, which were cooked in air tight aluminum foil containers to an internal temperature of 76.5°C. Sex odor in boars was found to be a significant linear function of age in this study, with a regression equation for control boars of Y = -1.84 + .0377X and for implanted boars of Y = -.09 + .0226X. In both growth periods, the implantation of 96 mg. of diethylstilbestrol at 70.4 kg. (155 lb.) significantly reduced sex odor scores of boar chops. While 58.5 percent of control boars slaughtered at weights from 72.7-136.1 Kg. (160-300 lb.) had chops with sex odor scores rated as medium or higher, with 29.3 percent rated strong, 62.2 percent of the implants at an average weight of 114.6 kg. (252 lb.) and average age of 190 days, had scores rated no higher than 90 percent of the barrows. Sex odor scores of medium or higher were found in 4.4 percent of the chops from barrows in the slaughter weight range of 90.9-136.1 kg. (200-300 lb.).

Sex odor in barrows was significantly correlated with an increase in carcass muscling at heavier weights. In other words, correlations indicated that the barrows which had stronger sex odor scores also possessed other carcass characteristics of the boar.

No significant treatment differences for tenderness or juiciness values were noted during this growth period. Tenderness scores decreased significantly for control and implanted boars as age increased from 4 to 12 weeks past 70.4 kg. (155 lb.). A similar, although nonsignificant, trend was noted in barrows.

There were no significant differences in marbling or color scores of the longissimus dorsi muscle at the 10th rib between control or implanted boars; barrow pork was significantly lighter in color than pork from either boars or implanted boars.

Chemical evaluation of the 11-13th rib section of the longissimus dorsi muscle produced no significant differences between control and implanted boars, slaughtered 1-5 weeks after 70.4 kg. (155 lb.) live weight. Boars slaughtered 4-12 weeks after implantation had a higher percent moisture of the longissimus dorsi sample and less intramuscular fat, expressed as percent ether extract than control boars. No treatment-related differences in percent protein were noted in these trials. For control boars, during the growth period of 1-5 weeks following 70.4 kg. (155 lb.), percent moisture increased significantly and percent protein decreased significantly as age increased. Over the slaughter range of 4-12 weeks past 70.4 kg. (155 lb.) percent protein of control boar samples increased significantly with increasing carcass weight.

No significant relationships between age or weight and chemical composition of the loin samples were noted for the implants or the barrows. A trend of increased marbling score in barrows with increased age or carcass weight was noted. A negative relationship between pH and age or carcass weight for the implants was found.

Data from this study would tend to support the contention that fast gaining, meaty pigs within a sex or treatment group might present a quality problem to the swine industry. During the period representing 4-12 weeks past 70.4 kg. (155 lb.), faster gaining pigs had lighter colored longissimus dorsi muscles. Pooled correlations involving all treatments suggest that loin samples from leaner carcasses had a higher percent moisture and a lower percent ether extract.

Relationships between subjective and objective measures of pork quality were determined. Highly significant correlations between pH and color were obtained in this study ($r = .476$ for the period of 1-5 weeks past 70.4 kg. (155 lb.) and $r = .496$ for the 4-12 week period). Correlations of 0.623 and 0.732 for these two growth periods were obtained between marbling score and percent ether extract on a wet sample basis. A positive linear relationship was demonstrated in this study between tenderness and juiciness scores of pork and the fat content of the muscle.

Comparisons between treatments were made in each growth period at an average age and average weight, as to carcass weight, percent dress, carcass length, backfat thickness measurements, weight and percent of the carcass represented in each of the 4 primal cuts (shoulder, ham, loin and belly), area of the longissimus dorsi muscle at the 10th rib and the percent edible portion, fat and bone of the regular hams. In each growth period, the relationships between these carcass characteristics and age, slaughter interval or carcass weight were determined.

All boars, regardless of treatment, had carcasses that were significantly longer, leaner and yielded a higher percent lean and primal cuts, than littermate barrows of the same weights. Implantation of boars increased the area of the loin muscle, and this implantation produced an increase in percent primal cuts during the 1-5 week slaughter interval. Both boars and implants had a significantly higher yield of edible portion and bone of the regular hams and a lower percent fat than barrows in this study. As age, slaughter interval or carcass weight increased, percent edible portion of the regular ham decreased. For the implants, a trend for decreased percent bone of the ham with increasing slaughter interval through the 10th week was noted.

The effects of rapid fat deposition from 70.4 kg. (155 lb.) to slaughter were reflected in linear regression statistics determined for the 1-5 week period. The regression equation for backfat thickness versus slaughter interval for the control boars was $Y = 0.62 + 0.0039X$ and for the implants was $Y = 0.26 + 0.0055X$.

Measures of growth, such as carcass length and area of the longissimus dorsi muscle, increased in size with increased age, slaughter interval or carcass weight. Differences in carcass composition were most directly related to increased carcass weight.

If consumer demand in the United States dictates the production of carcasses yielding 5.4-6.4 kg. (12-14 lb.) hams and 4.5-5.4 kg. (10-12 lb.) loins, the boar, implanted with 96 mg. of diethystilbestrol at 70.4 kg. (155 lb.) could provide this size cut at a live weight of 72.6-79.4 kg. (160-175 lb.). However, if the preference for cuts of this size is actually dictated by the increased fat deposition in heavier carcasses, then the 104.5 kg. (230 lb.) implant, with no greater fat deposition than its 85.8 kg. (189 lb.) littermate barrow, could produce 8.2 kg. (18 lb.) hams and 6.3 kg. (16 lb.) loins while averaging 0.907 kg. (1.99 lb.) of gain per day from 70.4 kg. (155 lb.).

Diethylstilbestrol, implanted in boars at the level of 96 mg. at 70.4 kg. (155 lb.) in these studies, improved the rate of gain and lean cut deposition, and reduced the sex odor in the pork without sacrificing quality or palatability characteristics of the pork. The desirable muscling and leanness of the boar was retained.

Evidence has been presented in these studies for treatment-related differences in the male pig in the development of carcass composition patterns over a range of weights from 72.7-136.1 kg. (160-300 lb.). Additional study is suggested to determine the hormone relationships and histological characteristics responsible for these differences in carcass composition, with the thought that the control of the hormone mechanisms responsible for lean to fat ratios in livestock would be a most direct approach to lean meat production.

While DES implantation has been demonstrated to be an effective means of curtailing sex odor development in the boar, and its use is popular in beef production, its use in swine is not permitted by The U. S. Food and Drug Administration. For those countries that might be permitted to use DES in swine production, the superior carcass value and improved feedlot performance of sex odor free DES implanted boars would be an attractive means of increasing the efficiency of pork production.

We do not believe that DES is the final answer to the sex odor problem in pork, but we have used this approach to learn more about sex odor and sex influenced performance in swine. While sex odor development can be controlled in the boar with the use of diethylstilbestrol, more detailed study is needed to determine the site of this affect and to ascertain the nature of the odor causing substance.

Currently, we are investigating the relationship of estrogen and androgen levels in the blood and histological characteristics of the endocrine glands to carcass and sex odor development in the boar for ages ranging from 70-175 days.

Sex odor in pork from boars is a very real problem in the United States because it is costing the swine industry millions of dollars in money income lost because we currently cannot make use of boars as market weight producers of pork. In Ohio alone it was determined that over one million dollars could have been saved last year in cost of feed in male pigs had these been implanted with DES rather than having been castrated.

But we cannot present the consumer with boar pork (without some means of curtailing sex odor) that would remind one of urine and onion mixed with an odor of perspiration.

Pork is an important kind of nutritious palatable meat. May we continue to work to improve both quantity and quality in order that more people may share in the abundant life on this earth.