cent ham + loin. Ham + loin percentage was more closely correlated with the other traits than was percent ham alone. Loin eye area was less closely associated with total lean-cut weight and percent lean cuts than was the other measures of meatiness. Carcass backfat thickness accounted for only a small percentage of the variation in total lean weight or percent lean cuts.

Ham-loin index accounted for 71 percent of the variation in percent lean cuts of slaughter weight, while percent ham of slaughter weight accounted for 69 percent of the variation in the percent lean cuts of slaughter weight. However, loin eye area accounted for only 31 percent of the variation in percent lean cuts of slaughter weight. Ham-loin index was also more closely correlated with total lean cut weight than was either percent ham or loin eye area.

Some Genetic Aspects of Pork Quality[1]

I. T. Omtvedt, V. G. Arganosa and L. E. Walters

Story in Brief

Data from 650 pigs sired by 89 sires from seven lines of breeding were used to estimate heritabilities and to calculate genetic and phenotypic correlations among various measurements of carcass quality. Backfat thickness, carcass length, loin eye area, lean cut yield, ether extract, and total moisture were highly heritable ($h^2 \geqslant .40$) while marbling score, firmness determinations, and shear value were moderately heritable ($.20 \leqslant h^2 \leqslant .45$). In these data color score was lowly heritable ($h^2 = .20$).

Based on genetic relationships obtained, it was concluded that backfat thickness can be decreased and muscling increased and still have an acceptable degree of marbling and firmness through proper selection procedures. The results indicated that selection for less backfat thickness would increase percent lean cuts without significant effects on loin eye area, color, firmness or moisture content. Selection for larger loin area would tend to increase lean cut yields, but would decrease color score

[1]This study was supported by a grant-in-aid from the American Meat Institute Foundation Chicago, Illinois.

In cooperation with USDA Agri. Research Service, Animal Husbandry Research Division.

and increase softness. Most of the genetic relationships among quality traits were moderately high and compatible. For example, selection for marbling would increase ether extract, firmness and color.

The results obtained in this study provide justification from a genetic standpoint for including pork quality as a trait to consider in the selection of breeding stock.

Introduction

The swine industry has made tremendous strides in increasing the lean-to-fat ratio of their product in recent years. But now the industry is concerned about the possibility that the increased incidence of pale, soft, watery pork may be a result of intense selection against fat and for greater muscling. For all practical purposes, meat quality has been completely ignored by swine breeders in selection. But before we can justify placing emphasis on quality characters in our breeding programs, we need to know how heritable these traits are and how they are related to other traits being considered.

Quality has been described in many ways, but perhaps it may most appropriately be defined as the combination of characteristics that provide for an edible product that looses a minimum of constituent, free of spoilage during processing, attractive, appetizing, nutritious and palatable. Marbling, firmness, color and tenderness are some of the most important predictive guides presently used in appraising pork quality.

This study was initiated in 1964 to estimate the heritabilities of various carcass quality measurements and to determine the genetic and phenotypic associations between quality factors and other carcass measurements.

Methods and Materials

Carcass data from 650 pigs sired by 89 boars from seven lines of breeding in the Oklahoma swine breeding project were used in this study.

All pigs were self-fed in confinement in groups of six pigs per pen from approximately 8 weeks of age to 200 lb. live weight. Carcasses were evaluated 48 hours after slaughter. Quality was evaluated in terms of fat content, water content, marbling, color, firmness and tenderness of the loin eye muscle (*l. dorsi*) at the 10th rib. A committee of at least two persons scored each loin for marbling, color and firmness using a scoring system ranging from one (extremely low quality) to seven (high quality). Ether extract and total moisture determinations were obtained on samples taken at the 10th rib. In addition to using the firmness score, penetrometer determinations were also used to evaluate firmness. Tenderness was measured in terms of the shear force required to cut a one-inch core of deep-fried meat cooked to an internal temperature of 160° F.

Backfat measurements were taken at the first rib, last rib and last lumbar vertebra approximately 1½ inches from the midline on the live pig and at the midline on the carcasses. Loin eye area was measured between the 10th and 11th ribs. Lean cuts represented the weights of closely trimmed hams, loins and shoulders.

Since no large differences in variances were noted for sex or lines of breeding, the data were adjusted for sex and analyzed on a within line of breeding basis and pooled over breeding groups. Heritability estimates were based on the paternal half-sib correlations obtained.

Results and Discussion

The means and standard deviations for the traits evaluated are presented in Table 1. It should be noted that the pigs used in this study were considered to be of average quality and meatiness with very few individuals exhibiting extremely low quality carcasses.

Heritability Estimates. Table 2 shows the heritability estimates for the various traits studied. With the exception of color scores, most of the measurements of pork quality were considered moderately heritable .20 $\leqslant h^2 \leqslant .45$) indicating that selection could be effective in changing quality. Variations in color score were lowly heritable ($h^2 = .10$). It should be noted that quality attributes had lower heritabilities than did lean cut yield, loin eye area, backfat thickness or carcass length, which all tended to be highly heritable ($h^2 \geqslant .45$).

Table 1. Means and Standard Deviations for Traits Studied.

Trait	Mean	Standard Deviation
Marbling score[1]	3.78	1.05
Ether extract, %	5.12	1.66
Firmness score[1]	4.41	1.07
Penetrometer, mm.	4.08	0.89
Color score[2]	3.90	0.81
Total moisture, %	70.7	1.49
Shear value, lb.	11.9	1.97
Probe backfat, in.	1.40	0.12
Carcass backfat, in.	1.37	0.12
Loin eye area, sq. in.	4.02	0.39
Carcass length, in.	29.6	0.56
Total lean cut wt., lbs.	76.0	2.89
% lean of full wt.	37.0	1.30
% lean of carcass wt.	52.5	1.69
Ham-loin index[3]	81.6	8.48

[1] A score of one indicates extremely low quality and a score of seven represents exceptionally high quality with a score of four considered average.
[2] Color scored from one to seven with one being extremely pale, four being moderately pink and seven being dark.
[3] Ham-loin index = 10 (% ham of full wt. − 10) + 10 (loin eye area).

Table 2. Heritability Estimates and Standard Errors for Various Carcass Traits Studied.

Trait	$h^2 \pm$ S. E.
Marbling score	0.28 ± .12
Ether extract	0.42 ± .16
Firmness score	0.30 ± .13
Penetrometer value	0.30 ± .14
Color score	0.10 ± .10
Total moisture	0.52 ± .18
Shear value	0.33 ± .18
Probe backfat thickness	0.62 ± .19
Carcass backfat thickness	0.53 ± .16
Loin eye area	0.47 ± .15
Carcass length	0.96 ± .23
Total lean cut wt.	0.68 ± .18
% lean of slaughter wt.	0.62 ± .18
% lean of carcass wt.	0.64 ± .18
Ham-loin index	0.69 ± .18

Genetic and Phenotypic Correlations. The correlations between various traits are presented in Table 3. Phenotypic correlations represent the observed associations between various traits while genetic correlations measure the extent to which two traits are affected by the same genes. Both are important considerations in a breeding program in that both influence the amount of selection progress possible.

In most cases the genetic relationships between traits were similar to the phenotypic relationships obtained. However, there was a tendency for the genetic correlations to be slightly higher than the phenotypic correlations.

The correlations obtained reveal that reduced backfat thickness was associated with increased carcass length and higher yield of lean cuts but that backfat thickness was not closely related to the various measurements of pork quality. Loin eye area was favorably correlated with lean yield, but the phenotypic correlations indicated that increased lion eye area was associated with decreased quality. An increase in lean cut yield was associated with decreased firmness, increased toughness and lower color scores. The genetic and phenotypic relationships among most of the quality measurements were moderately high and compatible. These data show that selection for marbling should result in an increase in ether extract and firmness and a decrease in total moisture.

Conclusions

Additional studies are needed before drawing final conclusions on the inheritance of pork quality factors, but based on the data available

Table 3. Genetic and Phenotypic Correlations Among Various Traits Evaluated.

Traits Correlated	Genetic Correlations	Phenotypic Correations
Carcass Backfat and:		
carcass length	— .62 ± .12	— .33**
loin eye area	— .22 ± .21	— .05
lean cut yield	— .58 ± .14	— .49**
marbling score	— .56 ± .18	— .04
ether extract	— .18 ± .26	— .02
firmness score	— .16 ± .25	0.06
color score	— .05 ± .39	0.04
shear value	— .17 ± .31	— .17**
Loin Eye Area and:		
carcass length	— .51 ± .14	— .19**
lean cut yield	0.77 ± .09	0.47**
Marbling score	— .01 ± .27	— .18**
ether extract	0.37 ± .23	— .23**
firmness score	— .39 ± .22	— .25**
color score	— .73 ± .19	— .18
shear value	0.41 ± .28	0.16**
Lean Cut Yield and:		
marbling score	0.48 ± .19	— .08
ether extract	0.36 ± .21	— .08
firmness score	— .11 ± .24	— .22**
color score	— .54 ± .26	— .14**
shear value	0.41 ± .28	0.19**
Marbling Score and:		
ether extract	0.94 ± .05	0.66**
firmness score	0.75 ± .14	0.48**
color score	0.53 ± .34	0.29**
shear value	0.36 ± .33	— .12*
moisture content	— .71 ± .18	— .48**
Firmness Score and:		
penetrometer reading	—1.00 ± .06	— .65**
ether extract	— .58 ± .20	0.36**
color score	0.35 ± .40	0.35**
shear value	0.13 ± .33	0.00
moisture content	— .60 ± .18	— .27**
Shear value and:		
color score	0.00 ± .63	0.06
moisture content	0.18 ± .31	0.05

* Differences were significant ($P < .05$)

** Differences were significant ($P < .01$)

at the present time, it appears that most measures of quality are moderately to highly heritable. Although these heritability estimates for quality traits tend to be lower than most estimates for length, backfat thickness and loin eye area, they are high enough to justify exerting selection pressure on them in a breeding program if their economic importance justifies considering them.

The concern that selection for less backfat thickness increases the probability of lower quality is not fully justified. Most of the genetic relationships between backfat thickness and quality factors obtained were in an unfavorable direction, but fortunately these correlations were of a quite low magnitude. The data indicates that superior meat-type hogs with acceptable quality can be produced, but attention must be given to quality as well as meatiness in order to accomplish the goal. The relationships between backfat thickness and quality factors are similar to those believed to exist between backfat thickness and growth rate, but unfortunately quality can not be appraised in the live animal.

Although it would be desirable to analyze additional data involving breeding groups with greater variation in the expression of quality aspects, the current results provide justification for placing some emphasis on these traits in swine breeding programs at the present time.

Wheat vs. Milo for Growing-Finishing Swine

W. G. Luce, I. T. Omtvedt, D. R. Rule, D. F. Stephens and S. D. Welty

Story in Brief

Three hundred twenty crossbred pigs were fed at the Fort Reno Livestock Research Station to compare the value of wheat vs. milo for growing-finishing swine. The pigs were fed in confinement from eight weeks of age to an average weight of 204.1 pounds.

Wheat tended to support similar gains as milo especially when equal amounts of supplemental protein were used. However, significantly more feed was required per pound of gain when wheat replaced all the milo. When only 50 percent of the milo was replaced with wheat, feed utilization was not appreciably affected. The type of grain used had little apparent effect on average daily feed intake or backfat thickness.

Introduction

Wheat is an important economic crop in Oklahoma. In 1968, 5,374,-000 acres were harvested with a yield of 123,602,000 bushels. This is a yield of approximately three times the rest of the cereal grains combined.

Appreciation is expressed to T. E. Nelson for assistance in conducting laboratory analysis.
This project was conducted by the Department of Animal Sciences and Industry in cooperation with the Regional Swine Breeding Laboratory, U. S. D. A., ARS, AH.

In cooperation with USDA Agri. Research Service, Animal Husbandry Research Division.