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Effects of Delayed Slaughter on the Quantitative and Qualitative Traits of Pork Carcasses

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To the Graduate Council:

I am submitting herewith a thesis written by Stanley G. Miller entitled "Effects of Delayed Slaughter on the Quantitative and Qualitative Traits of Pork Carcasses." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

William R. Backus, Major Professor

We have read this thesis and recommend its acceptance:

Robert R. Schrode, Melvin R. Johnston

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

May 20, 1969

To the Graduate Council:

I am submitting herewith a thesis written by Stanley G, Miller entitled "Effects of Delayed Slaughter on the Quantitative and Qualitative Traits of Pork Carcasses." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

Wm R. Backus
Major Professor

We have read this thesis
and recommend its acceptance:

Robert R. Shrode

Melvin R. Johnson

Accepted for the Council:

Hilton A. Smith
Vice Chancellor for
Graduate Studies and Research

EFFECTS OF DELAYED SLAUGHTER ON THE QUANTITATIVE AND QUALITATIVE TRAITS OF PORK CARCASSES

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Stanley G. Miller

June 1969

DEDICATED

to the memory of Professor J. William Cole, Major Professor, without whose guidance and friendship this study would not have been possible. His wise counsel lightened the load for many in his life of service.

"Prof" Cole will always be remembered as a dedicated researcher and gifted teacher who gave his best at all times for students and colleagues.

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To the officers and personnel of East Tennessee Packing Company, Knoxville, for their interest and help in collecting these data.

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ABSTRACT

One hundred and twenty market hogs were used to study the effects of delayed slaughter and methods of decreasing liveweight shrinkage and deterioration of the quantitative and qualitative traits of pork carcasses. All hogs were secured from a commercial feedlot and slaughtered under commercial conditions.

Groups were held for 0, 24, 48, and 72 hours without feed. Two other groups were held for 72 hours with limited feeding to decrease liveweight shrinkage. Water was provided to all groups ad libitum.

Quantitative measurements and weights were taken to determine the effects of delayed slaughter on the important economic traits. Delayed slaughter had a significant ($P < .05$) effect on preslaughter shrinkage and carcass yield. Lean cut yields were not significantly affected. However, belly yields were decreased after 48 hours of delayed slaughter. Quality of lean was not significantly affected.

Cured hams were subjected to chemical and organoleptic evaluation. No discernable trends due to delayed slaughter were noted.

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CHAPTER I

INTRODUCTION

The pork packing industry, because of a sporadic supply of hogs and labor conditions, has found it necessary to hold over hogs to guarantee sufficient numbers to operate. Transportation of hogs from point of production to point of slaughter has added to this problem. Delays in slaughter may be only a few hours but often may extend to three days or more. During holdovers of one day or more it has been an established practice of many packers to make feed available to the hogs to decrease liveweight shrinkage.

One major packer allows four bushels of shelled corn per 100 hogs for one day holdover or six bushels if the delay is for 48 hours. Another feeds at the rate of three bushels per day for 100 head. Such practices result in sizable expenditures for feed and labor each year.

It has been reported that tissue shrinkage begins to occur by the thirteenth hour of transit in market hogs (Bjorka, 1938). However, Henning and Stout (1932) found that hogs slaughtered after periods of up to five days after removal from feed had carcass yields very similar to those slaughtered immediately. Yields showed a linear downward trend for each additional day exceeding five. Bowland and Standish (1966) credit fasting for a period of 68 hours with causing a significant reduction in backfat thickness and dressing percentage. However, it should be noted that water was also withheld in this study. Davidson et al. (1968) found that a 68- to 70-hour fasting period resulted in

significant losses in weight of carcass, four lean cuts, ham and loin, and individual cuts exclusive of the Boston butt and spareribs.

A linear, but nonsignificant decrease in dressing percentage, was reported by Saffle and Cole (1960) for fasting periods up to 96 hours. No significant differences were found among fasting lengths with respect to yield of wholesale cuts.

This study was designed to evaluate the effect of some commonly employed methods of decreasing liveweight shrinkage in holdover hogs on quantitative and qualitative traits in the carcass.

CHAPTER II

EXPERIMENTAL PROCEDURE

Source of Data

One hundred and twenty market hogs of various breeds and crosses were selected for this experiment from a commercial swine feedlot located near Sevierville, Tennessee. The origin of the hogs varied, but all had been originally purchased in Tennessee Livestock Association feeder pig sales. During the growing-finishing period all hogs were subjected to the same feeding and management regime. Animals used in this study were selected to be a representative cross-section of the market hogs available to the pork packing industry in this country.

The hogs were transported by truck a distance of approximately 20 miles to the holding pens of East Tennessee Packing Company, Knoxville, Tennessee. The hogs were randomly assigned to six treatment lots of 20 hogs each without regard to breed, sex, and genetic background. Treatment lots were, however, similar in composition as to breed, and in each treatment the ratio of barrows to gilts approached equality. It was the intent of this study to introduce wide genetic heterogeneity in each treatment to insure that abnormal stress reactions which might be characteristic of only one breed or strain would be minimized.

Preslaughter Treatment

Individual weights were taken to the nearest pound using a portable Paul scale, Model S 500. Four lots were slaughtered after 0, 24, 48, and 72 hours holding time. Two other lots were slaughtered after 72 hours to simulate a week-end holdover. One, designated 72(F) received corn during the first 24 hours and the other, designated 72(S), received corn during the last 24 hours; both at the rate of 2.5 pounds per hog. All groups had access to water ad libitum during holdover. Individual weights were taken again immediately prior to slaughter.

Carcass Data

Following slaughter, the carcasses were dressed packer style, and carcass weights were taken to the nearest 0.1 pound. Carcass length and backfat were measured to the nearest 0.1 inch according to the procedures of the American Meat Science Association (1967).

Following a 24-hour chilling period at 34-38°F., carcasses were divided into wholesale cuts according to standardized packing house procedures. Cutting was done by the employees of East Tennessee Packing Company on the pork cutting line, using normal processing methods. The fore foot was removed approximately one inch above the knee joint. The rough shoulder was removed by cutting through the third thoracic vertebra at right angles to the general line of the back, thus leaving two and one-half ribs with the rough shoulder. Trimming the rough shoulder was done by lifting out the neck bones, removing the excess brisket flap and cutting off the jowl at the shoulder crease, parallel to the

shoulder cut. The clear plate was removed, leaving a New York style shoulder. The ham was removed by cutting between the second and third sacral vertebrae, perpendicular to the general line of the leg. The rear foot was removed approximately one-half inch above the hock joint. Hams were trimmed by removal of the flank following the natural seam, removal of the tail and sacral vertebrae, and removing the subcutaneous fat from the anterior two-thirds to a thickness of no more than 0.25 inches. The rough loin was separated from the rough belly by cutting along a line next to the ventral side of the psoas major muscle at the posterior end of the loin and just ventral to the backbone on the anterior end. Backfat was removed from the loin to a thickness of no more than 0.25 inches. The spareribs were lifted from the rough belly, and the belly was squared on both ends and the teat line removed.

Individual weights of hams, loins, shoulders, and bellies were taken to the nearest 0.1 pound. The method outlined in Wisconsin Special Bulletin 9 (Anon., 1963) was used to score ham and loin quality. The loin score was determined on the lean cut surface of the longissimus dorsi at the third rib.

Chemical Studies

Hams received an 18 percent initial pump using an Anco Bone-in Ham Injector with a cold brine solution of 75°Salometer, then smoked for 15 hours and heated to an internal temperature of 155°F.

Ten cured right hams from each treatment group were selected at random and two one-half inch center slices obtained for chemical and organoleptic analyses. Ham slices for organoleptic evaluation were

wrapped and frozen at 0°F. until analyses were conducted. Cooking and sensory panel evaluation was done by personnel of the Food Science and Institutional Management Department of the College of Home Economics.

Ether extract, moisture, and ash content were determined by A.O.A.C. methods (1960). Crude protein was estimated by macro-Kjeldahl nitrogen determination. Analyses were performed in duplicate.

Organoleptic Studies

Ham slices for organoleptic evaluation were fully thawed, weighed, and broiled in a household type oven. Samples were broiled for ten minutes on one side, turned and broiled for five minutes on the other side. The slices were weighed again and cooking losses determined. Two one-half inch cores were taken from the *semimembranosus*, *semitendinosus*, and *biceps femoris* muscles for Warner-Bratzler shear score determinations. Sections of the remaining slices were presented to a six-member trained sensory panel for palatability scoring. Flavor, juiciness, and appearance were scored on a nine-point scale (1 = extremely poor, 9 = excellent), and a ten-point scale (1 = extremely tough, 10 = extremely tender) was used for tenderness determinations.

Statistical Analyses

The data were statistically analyzed using the method of least squares as described by Harvey (1960). Duncan's (1955) Multiple Range Test was used to test significance of differences between means.

CHAPTER III

RESULTS AND DISCUSSIONS

Liveweight Shrinkage

The average off-feed liveweights (Table I for treatments varied from 230.8 to 217.8 pounds. A three-day interval between selections was partially responsible for the differences in average off-feed weight between the groups held for 72 hours and the 0-, 24-, and 48-hour groups. The hogs which comprised the three 72-hour slaughter groups were selected on March 29, 1968. On April 1, three days later, the groups held for 0, 24, and 48 hours were selected.

Preslaughter shrinkage showed a linear increase with time off-feed. The first 24 hours of delayed slaughter accounted for 47 percent of the total shrinkage. Forty-eight hours delay resulted in 65 percent of the total weight loss. These trends are in close agreement with those reported by Saffle and Cole (1960) and Cole et al. (1967).

Carcass Yield

No reduction in carcass yield was effected by delaying slaughter for 48 hours. Carcass yields were significantly ($P < .05$) lower than from the 48-hour groups for all groups held for 72 hours. When carcass weights were calculated removing the effect of differences in live-weight by covariance analysis methods (Snedecor and Cochran, 1967), the three 72-hour groups tended to yield lighter weight carcasses but differences were not significant. This suggests that shrinkage over

TABLE I

LEAST-SQUARES MEANS FOR LIVE WEIGHT, PRESLAUGHTER SHRINK, AND CARCASS YIELD AS AFFECTED BY DELAYED SLAUGHTER

Delayed slaughter hours	Off feed weight lb.	Slaughter weight lb.	Preslaughter shrinkage %	Carcass yield %	Carcass weight[a] lb.
0	230.8[b]	230.8	0	74.5[b,c]	167.0[b]
24	229.3[b,c]	222.7[b]	2.9	74.0[b]	165.2[b]
48	227.2[b,c]	218.2[b]	4.0	74.7[c]	166.8[b]
72	218.5[c]	205.2[c]	6.1[b]	72.6[d]	162.8[b]
72(F)	217.8[c]	204.6[c]	6.1[b]	72.7[d]	163.2[b]
72(S)	218.0[c]	206.2[c]	5.2	72.5[d]	162.6[b]

[a]Calculated on an initial liveweight constant basis.

[b,c,d]Means within a column bearing the same superscript letter do not differ significantly. All others differ significantly ($P < .05$).

the first 48 hours of delayed slaughter is the result of excretory loss rather than tissue shrinkage. Lower yields and reduced carcass weight of the 72-hour groups suggest that tissue shrinkage begins sometime after the 48-hour of delayed slaughter. Limited feeding of hogs held for delayed slaughter had no significant effect on carcass yield.

The trend of shrinkage losses agrees with those reported by Saffle and Cole (1960), Bowland and Standish (1966), Cole et al. (1967), and Davidson et al. (1968), although the magnitude is slightly less than reported by these workers.

Significant differences were found between treatment groups for average backfat thickness and carcass length (Table II). The differences may be due to the trend in average off-feed weights of treatment lots. No consistent pattern due to treatment effects is shown.

Primal Cuts Yield

Yields of ham, loin, and total lean cuts (Table III), the three most important measures of pork carcass value, were not affected by delayed slaughter treatment. These findings are in agreement with results reported by other workers (Saffle and Cole, 1960, and Davidson et al., 1968). Significant differences ($P < .05$) were found between treatments for yield of shoulder and belly; however, only the belly yield showed a decrease obviously related with time off-feed. This suggests that if an energy source is required to support life processes after 48 hours of delayed slaughter, adipose tissue may be mobilized. Limited feeding had no effect on the yield of any primal cut.

TABLE II

LEAST-SQUARES MEANS FOR AVERAGE BACKFAT THICKNESS AND CARCASS LENGTH

Delayed slaughter hours	Backfat thickness in.	Carcass length in.
0	1.57^{a}	30.7^{a}
24	$1.52^{a,b}$	$30.5^{a,b}$
48	1.63^{a}	$30.0^{b,c}$
72	1.41^{b}	$30.1^{b,c}$
72(F)	$1.52^{a,b}$	29.8^{c}
72(S)	$1.56^{a,b}$	$30.2^{a,b,c}$

^{a,b,c}Means within a column bearing the same superscript letter do not differ significantly. All others differ significantly ($P < .05$).

TABLE III

LEAST-SQUARES MEANS FOR YIELD OF PRIMAL CUTS
AS AFFECTED BY DELAYED SLAUGHTER

Delayed slaughter hours	Ham %	Loin %	Shoulder %	Belly %	Total Lean cuts %
0	14.3[a]	12.1[a]	10.3[a]	11.0[a]	36.8[a]
24	14.0[a]	12.0[a]	10.4[a]	10.8[a,b]	36.5[a]
48	14.2[a]	11.6[a]	9.8[b]	11.0[a]	35.7[a]
72	14.0[a]	12.2[a]	10.1[a,b]	10.3[a,b]	36.3[a]
72(F)	14.1[a]	11.7[a]	10.2[a]	10.4[a,b]	36.0[a]
72(S)	14.1[a]	11.9[a]	10.1[a,b]	10.1[b]	36.2[a]

[a,b]Means within a column bearing the same superscript letter do not differ significantly. All others differ significantly ($P < .05$).

Quality Considerations

Delayed slaughter was not demonstrated to be a stress factor sufficient to cause a significant change in the quality of fresh pork (Table IV) as subjectively measured by the Wisconsin standards (Anon., 1963), although the groups held for more than 48 hours possessed slightly lower ham quality scores (slightly more pale, soft, and exudative).

It has been suggested that delay of slaughter; i.e., allowing market hogs an overnight rest period at the slaughtering facilities, might reduce the incidence of pale, soft, and exudative pork (Gahne, 1968). However, Hall et al. (1961) reported that feed and a 16-hour rest period at the slaughter plant had little effect on the chemical and physical properties, palatability factors, and keeping quality of pork loins and sausage.

The results of this study tend to support Hall's position, since neither the 24- nor the 48-hour groups displayed lean quality superior to that of the control.

Ten cured right hams for chemical and organoleptic analysis were randomly taken from each treatment and individually weighed after chilling.

Cured Ham Yields

The off-feed and slaughter weights of the three 72-hour treatment groups were significantly ($P < .05$) lower than those of the control (0-hour) treatment; however, weight of cured hams did not differ significantly ($P < .05$) between these two holding periods. The yield of

TABLE IV

LEAST-SQUARES MEANS FOR HAM AND LOIN QUALITY AS AFFECTED BY DELAYED SLAUGHTER

Delayed slaughter hours	Ham quality score[a]	Loin quality score[a]
0	2.8[b]	3.1[b]
24	2.8[b]	2.9[b]
48	2.8[b]	3.0[b]
72	2.7[b]	2.9[b]
72(F)	2.6[b]	2.9[b]
72(S)	2.5[b]	3.1[b]

[a]1 = Muscle extremely pale, soft, and watery; 5 = Muscle dry, very firm, and very dark.

[b]Means within a column bearing the same superscript letter do not differ significantly. All others differ significantly ($P < .05$).

cured ham, calculated by dividing one-half the warm carcass weight into cured ham weight, followed the pattern of yield of fresh hams and was likewise, nonsignificantly different between treatments (Table V).

Chemical Composition of Hams

Proximate analysis results (Table VI) showed no consistent or linear trends for any of the chemical components, although there were significant differences among the treatments. As expected, hams with higher ether extract values exhibited lower moisture content.

Crude protein, as measured by the macro-Kjeldahl technique, may not be indicative of actual protein content as the concentration of nitrite nitrogen introduced with the curing pickle into the hams may vary and thus affect total nitrogen content.

Evaluation of Palatability

Panel scores (Table VII) for tenderness showed no significant differences. Warner-Bratzler shear scores, an objective measure of tenderness, revealed significant differences ($P < .05$); however, these differences indicated no trends, and all treatment values were well within the acceptable range. Panel scores for juiciness, flavor, and appearance failed to reveal any discernable trends due to treatment, although some significant differences were observed.

For all palatability factors the scores for all treatments were well within the acceptable range to insure consumer satisfaction.

TABLE V

LEAST-SQUARES MEANS FOR WEIGHTS AND YIELD OF CURED HAMS AS AFFECTED BY DELAYED SLAUGHTER

Delayed slaughter hours	Cured weight lb.	Yield[a] %
0	16.4[b]	14.7[b]
72	15.5[b]	14.4[b]
72(F)	15.9[b]	14.4[b]
72(S)	15.3[b]	13.9[b]

[a]Calculated as percent of one-half carcass weight.

[b]Means within a column bearing the same superscript letter do not differ significantly ($P < .05$).

TABLE VI

LEAST-SQUARES MEANS FOR PROXIMATE ANALYSIS OF CURED HAM AS AFFECTED BY DELAYED SLAUGHTER

Delayed slaughter hour	Moisture %	Ether extract %	Crude protein %
0	69.2[a,b]	5.6[a]	19.1[a]
24	70.3	4.4	19.9[d]
48	69.5[b]	4.9	19.8[c,d]
72	69.1[a]	6.2	19.5[b,c]
72(F)	69.1[a]	5.8[a]	19.3[a,b]
72(S)	68.9[a]	5.4	20.4

[a,b,c,d]Means within a column bearing the same superscript letter do not differ significantly. All others differ significantly ($P < .05$).

TABLE VII

LEAST-SQUARES MEANS FOR INDICES OF BROILED CURED HAM PALATABILITY AS AFFECTED BY DELAYED SLAUGHTER

Delayed slaughter hours	Shear score lbs.	Sensory Panel Scores			
		Tenderness	Juiciness	Flavor	Appearance
0	4.8	7.6[a]	7.2[a]	7.4[a]	7.5[a]
24	5.5[a]	7.5[a]	6.5[b]	7.5[a]	7.3[b]
48	6.9	7.0[a]	6.6[b]	7.4[a]	7.0
72	5.5[a]	7.6[a]	7.1[a]	7.5[a]	7.4[a,b]
72(F)	5.5[a]	7.3[a]	6.6[b]	7.7[a]	7.2[b]
72(S)	5.5[a]	7.3[a]	6.9	7.5[a]	7.4[a,b]

[a,b]Means within a column bearing the same superscript letter do not differ significantly. All others differ significantly ($P < .05$).

CHAPTER IV

SUMMARY

One hundred and twenty market hogs were used to study the effects of delayed slaughter and methods of decreasing liveweight shrinkage and deterioration of the quantitative and qualitative traits of pork carcasses. All hogs were secured from a commercial feedlot and slaughtered under commercial conditions.

Groups were held for 0, 24, 48, and 72 hours without feed. Two other groups were held for 72 hours with limited feeding to decrease liveweight shrinkage. Water was provided to all groups ad libitum.

Quantitative measurements and weights were taken to determine the effects of delayed slaughter on the important economic traits. Delayed slaughter had a significant ($P < .05$) effect on preslaughter shrinkage and carcass yield. Lean cut yields were not significantly affected. However, belly yields were decreased after 48 hours of delayed slaughter. Quality of lean was not significantly affected.

Cured hams were subjected to chemical and organoleptic evaluation. No discernable trends due to delayed slaughter were noted.

This study indicates that delaying slaughter while holding hogs at slaughter facilities for a period of up to 48 hours had no significant effect on any of the carcass traits studied. If delay is extended to periods over 48 hours, the practice of limited feeding was not found to affect carcass yields. Based on the results of this study, limited

feeding of holdover hogs is not practical because of feed and labor costs and the failure of these animals to respond to such treatment.

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VITA

Stanley George Miller was born in San Antonio, Texas, on August 8, 1945. He attended primary and secondary school in Lexington, Texas, and graduated from Lexington High School in May, 1963.

In September, 1963, he enrolled in Texas A & M University, College Station, and received a Bachelor of Science degree in May, 1967, with a major in Animal Science. He was a member of the Meats and Livestock judging team, Alpha Zeta, Saddle and Sirloin, Gamma Sigma Delta, and Phi Kappa Phi.

He enrolled in The University of Tennessee in September, 1967, in pursuit of a Master of Science degree, majoring in Animal Husbandry, specializing in Meats.

He was wed to the former Miss Joan Zieschang of Taylor, Texas, on August 10, 1968.