**Sucrose Feeding Improves Animal Carcass; Gossypol Influenced by Environment and Cotton Variety**

## FEED SUPPLEMENTS—SUGAR

# Influence on Animal Carcass of Feeding Sucrose

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From 1 to 3 pounds of sucrose plus a basal ration was fed to 197 beef cattle for 3, 5, or 6 days and to 104 swine for 3, 6, or 12 days prior to slaughter. Sucrose feeding increased the daily gain in weight per animal and liver weights for all groups of animals with one exception. Dressing percentages were increased for the steers in Series I which were fed sucrose 3 days and for the pigs which were fed sucrose 6 days. The percentage of carbohydrate in the liver was not consistently increased by sucrose feeding. Carbohydrate values of the muscle were similar for all animals. In general, the livers of high total carbohydrate content were preferred for their flavor and texture when cooked. Quality appraisal scores by the panel of judges and shear force values were similar for all lots of beef and pork. Further study on larger numbers of animals is needed, as the response of individual animals varied considerably and the number of animals per treatment was relatively small.

That the quality of the carcass can be altered by feeding and management practices prior to slaughter is indicated by studies by Bate-Smith (*1*), Madsen (*4*), and Gibbons and Rose (*3*). Initial studies on the feeding of sucrose to beef cattle and swine prior to slaughter have been reported (*5*). Slight increases in dressing percentages, liver weights, and total carbohydrate content of the muscle and liver were noted.

This paper reports additional data on the effect of feeding beef cattle and swine varying levels of sucrose for varying periods of time prior to slaughter on gain in weight during sucrose feeding, dressing percentage, color, texture, flavor, total carbohydrate content, and pH of the muscle and liver.

### *Experimental Procedure*

**Beef Cattle** In Series I, 100 grade Hereford steers of uniform size and conformation, 2 to 3 years of age, had been grain-fed for about 300 days prior to purchase in Montana by Swift and Co. The animals were shipped to the Ogden, Utah, plant, held overnight without feed but with access to water, divided into eight lots, weighed for the initial weight, and fed according to the treatments outlined in Table I. Some of the lots were fed sucrose 3 or 6 days. All lots were fed a basal ration composed of a chopped hay and grain mixture containing 12% molasses. The sucrose was placed on top of the ground feed, with the animals in each lot being fed as a group. The steers had access to drinking water during the sucrose-feeding period. Feed was withheld from all animals for about 1 day prior to slaughter. All carcasses graded choice by commercial graders of Swift and Co. and by federal inspectors.

In Series II, 97 grade Hereford heifers of uniform size and conformation, 2 to 3 years of age, had been grain-fed for about 100 days prior to purchase in Idaho by Swift and Co. The grain mixture, which had been fed, was composed of equal quantities of wheat and barley plus chopped alfalfa, protein, and mineral supplements. The animals were shipped to Swift's Ogden plant, held 36 hours without feed but with access to water, divided into nine lots, weighed, and fed according to the treatments outlined in Table I. Lot 1 did not receive any basal ration during 2 days prior to slaughter. The carcasses graded choice and good.

Liver samples for the two series were taken from each carcass at the time of slaughter. The wholesale rib cut was procured from the same side of two representative carcasses from each lot after 48 hours' storage in Swift's refrigerator at 38° to 40° F. Chemical and organoleptic tests were then made on the liver and muscle.

**Swine** The 64 swine which were fed sucrose 3 and 12 days were of mixed breeds consisting primarily of crosses of Duroc-Jersey and Poland China and/or Spotted Poland China, purchased on several farms in Cache County, Utah. The average purchase weight was 82 (31 to 149) pounds. One per cent sodium fluoride was used in the grain mixture for 1 day to help control internal parasites and lindane was employed to control external parasites.

The basal ration consisted of the following on a percentage basis: alfalfa meal 10, Aurofac 0.5, salt 0.5, meat scraps (50% protein) 5, ground wheat 50, ground barley 27, and soybean oil meal 7. The pigs were fed this ration until a weight of approximately 200 pounds was reached. Fresh water was always available. The pigs were then divided into eight groups and fed sucrose sweepings (sucrose from bags that had been broken) for 3 or 12 days as described in Table II. During the sucrose-feeding period, the basal ration was in pellet form. Sucrose sweepings were fed in separate metal containers for each group but not individually to each pig.

The 40 grade Duroc-Jersey swine

which were fed sucrose 5 or 6 days were selected at random from 10 different litters which were born from Aug. 15 to 22, 1952. A registered Duroc-Jersey boar was the sire of all of the pigs. The sows and young pigs were pastured in a grain field and had access to alfalfa, barley, protein, and mineral supplements. After removal from the pastures, the young pigs were fed a ration consisting of the following constituents on a percentage basis: ground barley 49, soybean meal 5, chopped peas 7, meat meal 2, shorts 10, wheat bran 5, alfalfa meal 10, screenings 10, bone meal 0.4, calcite 0.6, trace minerals 0.5, and Aurofac 0.5. The feed was placed in self-feeders. Fresh water was always available. When the pigs weighed about 190 pounds, they were divided into eight groups and fed sucrose for 5 or 6 days as described in Table II. Sucrose sweepings were fed in separate metal troughs for each group but not individually to each pig. The pigs fed sucrose had access to self-feeders containing the basal ration. Feed was withheld from the pigs for about 20 hours prior to slaughter.

The liver of each carcass and a loin roast from two or six carcasses of each group of pigs were taken for chemical and organoleptic tests. The carcasses were of high quality and were inspected by a trained meat inspector.

The methods of analyses for total sugars and details of the roasting of the meat and judging the quality of the meat and liver have been described (*5*).

Color of the fresh muscle was measured by the use of a reflectance attachment to the Beckman spectrophotometer. The method has been described by Eastmond (*2*). Absorbance was plotted against wave length in millimicrons (500 to 700). A piece of muscle 4 cm. square and 1 cm. thick was used in the color measurements.

**Table II. Average Gain in Weight, Dressing Percentages, Liver Weight, and Percentage of Carbohydrate in Muscle and Liver of Swine**

| Days | Sucrose Fed[a], Lb. | No. of Animals | Gain in Wt., Lb./Day[b] | Dressing Yield, % | Warm Liver Wt., Lb. | Carbohydrate Calcd. as Dextrose: Liver, % | Carbohydrate Calcd. as Dextrose: Muscle[c], % | Shear Force[d], Lb. |
|---|---|---|---|---|---|---|---|---|
| 3 | 0 | 8 | −0.6 | 76.6 | 3.3 | 0.706 | 0.107 | 7.2 |
| 3 | 1 | 8 | +1.6 | 76.0 | 3.5 | 1.208 | 0.152 | 7.9 |
| 3 | 2 | 8 | +1.9 | 75.0 | 3.8 | 1.237 | 0.180 | 8.8 |
| 3 | 3 | 8 | +1.8 | 76.3 | 3.5 | 1.190 | 0.188 | 6.0 |
| 6[e] | 0 | 10 | +0.5 | 78.2 | 3.0 | 0.850 | 0.206 | 8.4 |
| 6[e] | 1 | 10 | +0.9 | 80.1 | 3.4 | 0.601 | 0.180 | 7.0 |
| 6[e] | 2 | 10 | +1.7 | 79.9 | 3.6 | 1.084 | 0.199 | 7.9 |
| 6[e] | 3 | 10 | +1.6 | 79.4 | 3.5 | 1.402 | 0.317 | 8.0 |
| 12 | 0 | 8 | +1.5 | 76.2 | 4.2 | 0.712 | 0.100 | 8.0 |
| 12 | 1 | 8 | +1.8 | 75.8 | 4.3 | 0.635 | 0.309 | 8.5 |
| 12 | 2 | 8 | +2.5 | 77.9 | 4.3 | 0.864 | 0.096 | 6.8 |
| 12 | 3 | 8 | +2.1 | 77.2 | 4.0 | 0.606 | 0.144 | 9.4 |

[a] Pounds of sucrose fed per animal per day.
[b] Gain in weight per animal per day during sucrose-feeding period.
[c] Two animals per treatment for 3- and 12-day feeding period; 6 animals per treatment for 6-day feeding period.
[d] Low score indicates meat is more tender.
[e] Half of pigs were fed sucrose for 5 days and half 6 days.

## Results and Discussion

**Beef Cattle** The results of feeding sucrose in Series I and II are summarized in Table I. Feeding 1, 2, or 3 pounds of sucrose for 3 days increased slightly the daily gain in weight per steer in Series I for the sucrose feeding period by 3 to 5 pounds more than in the groups fed the basal ration. Gain in weight of the steers fed 2 and 3 pounds of sucrose for 6 days was slightly less than that shown by the animals not fed sucrose. Gains in weights by the heifers in Series II were also slightly greater for the 3-day feeding period than for the 5-day period when compared with the gain for the groups fed the basal ration (4 to 6 *vs.* 3 pounds). The over-all gains in weights for all of the cattle are high. It is believed that a substantial part of this gain resulted from intestinal fill, since the animals were off feed for 24 hours before the initial weight was taken. However, the comparative gains among the groups are valid, as all animals were treated alike.

Feeding sucrose for 3 days to the animals in Series I increased the average dressing percentage by 0.2 to 1.8%, except for the lot fed 3 pounds of sucrose. Almost no increase occurred when the feeding period was for 6 days. The feeding of sucrose in Series II did not increase dressing yields. However, those animals which were not fed prior to slaughter had a lower dressing percentage than either the 3- or 5-day sucrose-fed heifers or those fed the basal ration.

The liver weights in Series I and II, with one exception, gradually increased with an increase in the quantity of sucrose fed. These differences were highly significant (Table III). The length of feeding time did not influence the weights of the livers. Approximately 75 to 80% of the livers were free of abscesses or other abnormalities. The differences in weights of livers noted in this study applied to normal livers as well as to all livers. In general, the abnormal livers were heavier than the normal livers. However, the distribution of abnormal livers was similar for all lots of animals.

The percentage of carbohydrate in the

**Table I. Average Gain in Weight, Dressing Percentages, Liver Weights, and Percentage of Carbohydrate in Muscle and Liver of Steers and Heifers**

| Lot No. | Days Fed | Sucrose Fed[a], Lb. | No. of Animals | Gain in Weight, Lb./Day[b] | Dressing Yield, % | Warm Liver Wt., Lb. | Carbohydrate Calcd. as Dextrose: Liver, % | Carbohydrate Calcd. as Dextrose: Muscle, % | Shear Force[c], Lb. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Series I Steers | | | | | |
| 1 | 3 | 0 | 14 | 6.3 | 60.5 | 12.7 | 2.38 | 0.15 | 13.9 |
| 2 | 3 | 1 | 12 | 11.5 | 61.3 | 12.8 | 2.84 | 0.16 | 12.8 |
| 3 | 3 | 2 | 12 | 9.3 | 62.3 | 13.7 | 2.53 | 0.16 | 12.8 |
| 4 | 3 | 3 | 12 | 9.2 | 60.2 | 15.7 | 2.89 | 0.13 | 14.2 |
| 5 | 6 | 0 | 14 | 6.5 | 60.9 | 12.0 | 2.54 | 0.15 | 11.4 |
| 6 | 6 | 1 | 12 | 6.9 | 59.9 | 13.5 | 2.52 | 0.16 | 10.6 |
| 7 | 6 | 2 | 12 | 4.8 | 61.6 | 13.9 | 2.50 | 0.15 | 11.0 |
| 8 | 6 | 3 | 12 | 5.2 | 60.5 | 14.8 | 2.92 | 0.14 | 12.2 |
| | | | | Series II Heifers | | | | | |
| 1 | 0 | 0 | 17 | .. | 56.5 | 12.4 | 2.10 | 0.26 | .. |
| 2 | 3 | 0 | 10 | 4.5 | 58.8 | 12.8 | 2.63 | 0.23 | .. |
| 3 | 3 | 1 | 10 | 10.8 | 59.1 | 12.7 | 2.99 | 0.22 | .. |
| 4 | 3 | 2 | 10 | 8.2 | 57.8 | 14.2 | 2.84 | 0.26 | .. |
| 5 | 3 | 3 | 10 | ..[d] | ..[d] | ..[d] | ..[d] | ..[d] | .. |
| 6 | 5 | 0 | 10 | 3.1 | 60.1 | 12.0 | 2.52 | 0.19 | .. |
| 7 | 5 | 1 | 10 | 5.7 | 58.4 | 12.8 | 3.00 | 0.13 | .. |
| 8 | 5 | 2 | 10 | 4.2 | 58.4 | 13.7 | 2.96 | 0.24 | .. |
| 9 | 5 | 3 | 10 | 6.2 | 57.9 | 14.2 | 3.42 | 0.27 | .. |

[a] Pounds of sucrose fed per animal per day.
[b] Gain in weight per animal per day during sucrose-feeding period.
[c] Low score indicates meat is more tender.
[d] Lots fed 2 and 3 lb. of sugar were accidentally mixed just prior to slaughter at stockyards.

**Table III. Analyses of Variance for Steers and Heifers**

| Source | D. F. | Steers, Mean Square: Weight of liver | Steers, Mean Square: Carbohydrate in liver | D. F. | Heifers, Mean Square: Weight of liver | Heifers, Mean Square: Carbohydrate in liver |
|---|---|---|---|---|---|---|
| Time interval | 1 | 0.0067 | 0.2646 | 1 | 0.280 | 0.5114 |
| Quantity of sucrose | 2 | 27.1090[a] | 1.0396[a] | 2 | 11.734[a] | 0.1644 |
| Quantity × time | 2 | 3.7543 | 0.2022 | 2 | 0.242 | 0.5348 |
| Fed basal ration *vs.* sucrose-fed | 1 | 60.0080[a] | 1.0919[b] | 2[c] | 16.872[a] | 6.1182[a] |
| Fed basal ration *vs.* not fed | .. | .... | .... | 1 | 0.010 | 2.4997[a] |
| Error | 93 | 2.2449 | 0.1798 | 88 | 2.100 | 0.1626 |

[a] Highly significant at $P < 0.01$.
[b] Significant at $P < 0.05$.
[c] Groups included in this comparison are those fed sucrose, those fed basal ration, and those not fed.

livers of the animals fed sucrose 3 days in both Series I and II was slightly higher than for those fed the basal ration or those receiving no food (0.15 to 0.89%). Similar increases were observed in the livers of the heifers fed sucrose 5 days but not in those of the steers fed 6 days. Differences in total carbohydrate content of the livers were significant for the steers when values for the groups fed the basal ration were compared with the sucrose-fed groups and when the quantity of sucrose was considered. The differences, resulting from the feeding of sucrose to the heifers, were highly significant when values for all the animals not fed sucrose were considered or when only values for the animals fed the basal ration were used in the comparison with the sucrose-fed groups. Length of time of feeding did not increase the carbohydrate content of the livers of either Series I or II.

Carbohydrate values for the muscle were similar for all lots of animals of either series. Values for all heifers were slightly higher than for the steers.

There were no apparent differences in pH values of the liver or muscle as a result of the sucrose feeding in either series of animals.

Color of the fresh muscle was a somewhat brighter red in the sucrose-fed meat than in the meat from animals not fed sucrose.

Tenderness of the prime rib roast from the steers is shown by the shear force values in Table I. Differences were slight and were not consistent, which indicated that the treatments had little effect on the tenderness. Quality scores by the panel of judges were also similar. A group of 164 people sampled the livers from Series I and 153 people those from Series II, for tenderness and flavor in a consumer acceptance test. Instructions for cooking and scoring the livers, using a scale of 1 to 5, were given. In general, livers of high total carbohydrate content were preferred to the livers of low carbohydrate content on the basis of tenderness and flavor. In general, the livers of sucrose-fed animals had a higher total carbohydrate content and a milder flavor than the non-sucrose-fed animals. Many other factors influence the flavor and texture of liver, among which are age of animal, nutritional state of animal, diet fed, and presence of certain insecticides and other chemicals with a bitter or undesirable flavor.

These findings on beef cattle are in agreement with previous results obtained in this laboratory (*5*). Studies on 96 beef cattle had shown slight increases in dressing percentages, in carbohydrate content, and in improvement in color of the fresh muscle. The sucrose-fed livers were larger and contained more carbohydrate than those not fed sucrose. The sucrose-fed livers were also preferred for their flavor and texture.

**Swine** The results of feeding 1, 2, or 3 pounds of sucrose to swine are presented in Table II. Sucrose feeding increased the average gain in weight during the 3-, 6-, or 12-day feeding periods from 0.3 to 2.4 pounds. These differences were significant (Table IV). Although increased dressing yields were obtained from the pigs fed 6 and 12 days, with one exception, the pigs fed sucrose for 3 days showed a loss (−0.4 to 2.1% gain *vs.* −0.6 to −1.6% loss). The differences in dressing yields between the control group and the group fed sucrose for 6 days were significant; differences for other periods of feeding were not significant. However, when the pigs which were fed sucrose for 3 days were first put into the feeding pens, they fought until they were exhausted, which probably influenced the results for this group of pigs.

Liver weights were increased by 0.2 to 0.6 pound as a result of sucrose-feeding for all lots of pigs except those fed 3 pounds of sucrose for 12 days. The differences shown by the pigs fed sucrose for 6 days were significant, while the differences for other feeding periods were not. Livers of all the pigs were normal. Heart weights were similar for the controls and the sucrose-fed pigs. Previous studies (*5*) on 12 sucrose-fed swine showed increased dressing percentages, and gains in liver weights.

Sucrose feeding did not consistently increase the percentage of carbohydrate in the livers or muscles of these pigs (Table II). Significant differences in the liver values were observed between the control and the pigs fed 3 days and as a result of increasing the quantity of sucrose for the groups fed 6 days. In an earlier study (*5*) the total carbohydrate content of the liver was doubled and of the muscle almost doubled by the feeding of 2 pounds of sucrose daily, which is not in agreement with the findings in this study.

The data for the pigs fed 6 days were more consistent than for the other groups of pigs. These pigs received more uniform treatment in respect to breeding, initial weight, and management than did the other groups of pigs.

Only slight changes occurred in the pH

**Table IV. Analyses of Variance for Swine**

| Source | D. F. | Gain in Weight[a], Mean Square | Dressing Percentage, Mean Square | Liver Weight, Mean Square | Carbohydrate in Liver, Mean Square |
|---|---|---|---|---|---|
| | | Fed 3 Days | | | |
| Control *vs.* treated | 1 | 33.61[b] | 3.56 | 0.37 | 1.53[c] |
| Quantity of sucrose | 2 | 0.12 | 3.54 | 0.24 | 0.01 |
| Replications | 7 | 7.75[c] | 16.19[c] | 0.14 | 0.68[c] |
| Error | 21 | 2.74 | 5.16 | 0.13 | 0.25 |
| | | Fed 6 Days | | | |
| Control *vs.* treated | 1 | 5.51[b] | 19.44[c] | 1.44[b] | 0.24 |
| Quantity of sucrose | 2 | 1.73[c] | 1.32 | 0.10 | 1.62[c] |
| Replications | 9 | 1.26[c] | 1.00 | 0.33[c] | 0.43 |
| Error | 27 | 0.42 | 4.30 | 0.11 | 0.48 |
| | | Fed 12 Days | | | |
| Control *vs.* treated | 1 | 2.41[b] | 3.45 | 0.01 | 0.00 |
| Quantity of sucrose | 2 | 0.92[c] | 9.17 | 0.14 | 0.16 |
| Replications | 7 | 0.27 | 3.80 | 0.38 | 0.31 |
| Error | 21 | 0.24 | 3.05 | 0.17 | 0.29 |

[a] Gain in weight during sucrose-feeding period.
[b] Highly significant at $P < 0.01$.
[c] Significant at $P < 0.05$.

values as a result of sucrose feeding. Color readings were similar.

Differences in shear force values of the roast loin were slight and inconsistent. Quality scores by the panel of judges were also similar. In general, livers of high total carbohydrate content were preferred to the livers of low carbohydrate content on the basis of tenderness and flavor.


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# GOSSYPOL IN COTTONSEED

# Influence of Variety of Cottonseed and Environment


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**Considerable variation was found in the gossypol content of the kernels from seed of 8 varieties of cotton grown at 13 locations during 3 years. Both variety of seed and environment significantly influenced the gossypol content. Gossypol in the kernels was found to be negatively correlated with temperature and positively correlated with rainfall. Individual varieties differed in response to environmental factors of temperature and rainfall.**


THE GROWING USE OF SCREW PRESSING and solvent extraction for the processing of cottonseed and the increased interest in improving the nutritive value and utility of cottonseed meal have focused attention on the role of gossypol in contributing to oil color and to reduction of the protein value of the meal (*1, 7, 8, 11*). Knowledge of the variability in the gossypol content of cottonseed kernels and the agronomic factors which contribute to such variability is basic to the solution of these problems. Several investigators (*5, 9, 13, 16*) have reported considerable variations in the gossypol content of cottonseed kernels which were attributed to environmental factors. Schwartze and Alsberg (*13*), while reporting values ranging from 0.4 to 1.2% for seed grown at widely scattered locations, were unable to assess the effect of the varietal characteristics. Gallup (*5*) concluded that rainfall during the growing season influences the gossypol content of the seed. Other investigators (*6, 14*) attributed variability in gossypol content to genetical characteristics. As no systematic investigation of the influence of variety and environment on the gossypol content of cottonseed kernels has been reported, such an investigation was undertaken. The purpose of this report is to record the findings.

### Samples and Methods of Analysis

The seed used in the investigation were from 8 commercial varieties of cotton grown at 13 locations during 1947, 1948, and 1949 by the Division of Cotton and Other Fiber Crops and Diseases of the Bureau of Plant Industry, Soils, and Agricultural Engineering. The varieties and locations are listed in Table I. The experimental plots were irrigated at State College, N. M., Sacaton, Ariz., and Shafter, Calif. The cottons were grown in replicated plots from which representative samples of seed cotton were picked from recently opened bolls. The samples of cottonseed containing less than 8.5% moisture were stored in sealed containers at 0° F., conditions which have been shown to produce no significant changes in the chemical composition of cottonseed (*12, 15*).

The kernels were separated from the hull and residual lint and ground to pass a 2-mm. screen to provide analytical samples.

The samples were analyzed for moisture, oil, and free gossypol by use of official methods of the American Oil Chemists' Society (*2*, Ba 2-38, Ba 3-38, and Ba 7-50, respectively). The analytical values for free gossypol are equivalent to total gossypol in fresh cottonseed samples, such as those analyzed, and include any gossypollike pigments such as gossypurpurin (*10*), if present in the samples. Hereafter in this report the combined content of gossypol and gossypollike pigments is termed gossypol.

### Results and Discussion

The gossypol contents of the moisture-free kernels (Table I) varied considerably, ranging from 0.39 to 1.70%. The analysis of variance (Table II) discloses that both variety of cottonseed and the environment have a highly significant influence on the gossypol content of the kernels.

The variety means indicate that the gossypol content of the kernels may be a genetical characteristic. The values for Rowden 41B are consistently high and those for Acala 4-42 and Coker Wilds are consistently low. The 3-year mean