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The Effect of Feeding Sucrose to Beef and Swine on the Percentage of Carbohydrate, pH, Color, Texture, and Flavor of Muscle and Liver

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THE EFFECT OF FEEDING SUCROSE TO BEEF AND SWINE ON THE PERCENTAGE OF CARBOHYDRATE, pH, COLOR, TEXTURE, AND FLAVOR OF MUSCLE AND LIVER

by

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Margaret B. Merkley

TABLE OF CONTENTS

	Page
INTRODUCTION	1
REVIEW OF LITERATURE	3
METHOD OF PROCEDURE	6
Description and Feeding of Beef Animals	6
Series I	6
Series II	8
Series III	8
Description and Feeding of Swine	9
Chemical Tests	11
Sugar	11
pH	11
Dry solids	11
Fats	11
Quality Tests	11
Color	11
Roasting	11
Shearing	12
Organoleptic	12
RESULTS AND DISCUSSION	13
Beef	13
Series I	13
Series II	14
Series III	16
Swine	20
SUMMARY	32
LITERATURE CITED	35
APPENDIX	37

LIST OF TABLES AND FIGURES

Tables — Page

1. Physical characteristics of beef animals 7
2. Sucrose fed and time of feeding swine 10
3. Carbohydrate and pH in muscle and liver of beef in Series I 13
4. Quality appraisal test on beef in Series I 14
5. Color and carbohydrate in muscle and liver of beef in Series II 15
6. Quality appraisal tests and cooking losses on beef in Series II 16
7. Carbohydrate, dry solids, fats, and pH in beef muscle and liver in Series III 17
8. Analysis of variance--Series III 18
9. Quality appraisal tests and cooking loss on beef with no storage 26
10. Quality appraisal tests and cooking loss on stored beef--Series III 27
11. Carbohydrate and pH of swine and carbohydrate and pH in ham and bacon 28
12. Quality appraisal tests and cooking loss on pork . . 30

Figures

1. Effect of sugar feeding for 3 days on the reflectance curve of beef muscle 20
2. Effect of sugar feeding for 6 days on the reflectance curve of beef muscle 21
3. Effect of sugar feeding for 9 days on the reflectance curve of beef muscle 22
4. Effect of sugar feeding for 12 days on the reflectance curve of beef muscle 23

Figures

5. Effect of feeding 2 pounds sugar for different lengths of time on the reflectance curves of beef muscle 24

Appendix Tables

I. Physical characteristics of beef animals, Series I and II 38

II. Physical characteristics of beef animals Series III 40

III. Physical characteristics of swine 42

IV. Percentage of carbohydrate and pH in beef muscle and liver, Series II 43

V. Percentage of carbohydrate, dry solids, fat, and pH in muscle and liver of beef steers . . . 45

VI. Quality appraisal tests and cooking loss on beef, Series II 47

VII. Quality appraisal tests and cooking loss on beef, Series III 48

Sheet

1. Meat scoring record 50

2. Liver scoring record 51

INTRODUCTION

Carbohydrates have long been a part of animal feeding rations. Grains are included in all animal feeding formulas. The by-products of sugar beets have been used for many years in livestock feeding (Kutish 1950b). The use of molasses in commercial feed mixes in 1899 made possible its extended use in animal feeding practices (Hall 1950).

Protein feeds for cattle are relatively high in price and not available in adequate supply. With these facts in mind Culbertson of Iowa State College set up experiments in 1950 to find out whether part or all of the protein supplement could be replaced with non-protein nitrogen feed in a good steer fattening ratio. The sugar in cane molasses is utilized more readily by animals than starch in corn grain, so molasses was fed to steers in the non-protein nitrogen feed. The growth made by the steers fed on these rations was on a par with the control group and use of these non-protein feeds in rations is likely to be of economical and practical importance. These findings have been verified by feeding large numbers of cattle (Bode 1951).

Direct molasses usage on farms may be divided into two types: direct use as feed; and use as a preservative in making grass silage. At present the first type is more important, the second being used throughout the dairy belt (Kutish 1950a; Aries and Copulsky 1949).

Regarding amounts of molasses which may be fed, the Bureau of Animal Industry of the United States Department of Agriculture (Kutish 1950a) reports:

> At various times and under different circumstances, molasses products are fed to nearly all classes of animals. Larger proportionate amounts are generally fed to beef cattle than to poultry and swine. Generous amounts can be fed to horses, mules, sheep and goats. We have ordinarily advised use of 5 per cent of molasses in mashes for poultry whenever farmers have wishes to use this feed. In the case of swine, 10 per cent can be used although we have fed 20 per cent in test rations. For cattle, a third or more of the corn or other grain can be replaced with molasses. Occasionally much larger amounts are used.

Feeding carbohydrates in the form of sucrose for short periods before slaughtering improved the keeping quality, flavor, and texture of pork as noted by Gibbons and Rose (1950) and Madsen (1950). These investigators indicated a need for further studies on swine and detailed studies on beef.

The purpose of this investigation was to study the effect of feeding sucrose to beef and swine prior to slaughter, on the percentage of carbohydrate, pH, color, texture, and flavor of muscle and liver.

REVIEW OF LITERATURE

Specific foods used in the feeding of animals can make meat more palatable. This is a fact that has long been well known and applied on a practical basis. Feeders of animals have been able to change the flavor, texture, color, and particularly the weight of animals through the feed consumed. It is common knowledge among livestock producers that an animal that is rested and fed produces a superior type of meat than the animal that is hungry and fatigued. Gibbons and Rose (1950) have attributed this difference to the difference in the pH of the muscle. The pH of muscles from the fatigued animals varied widely but that of the rested well-fed animals was relatively uniform. Gibbons and Rose (1950) also found the livers of the fed animals contained more dextrose than the fatigued animals. They also found that color stability appeared to correlate with the pH of the meat and that the color of cured hams from the fed animals was improved over those of the fatigued animals. They found no color differences either on freshly cut or exposed surfaces after smoking.

Gibbons and Rose (1950) reported that Bates and Smith in Cambridge concluded that the keeping quality of meat was dependent upon the amount of acids in the meat. These workers also found that animals which were rested and fed had a larger content of glycogen in both the muscles and liver than if the animals were tired and hungry.

Madsen (1950) has done considerable research on the keeping quality of pork after feeding sugar containing foodstuffs for two days before slaughtering, and observed that bacon from swine fed regularly with sugar-containing foodstuffs kept better. He first observed a decided change in

the liver in the pigs which had received an addition of sugar in the day prior to slaughter. The livers from the animals which had no food before slaughtering were shrunken, unelastic and dark in color while those of animals which received sugar were larger, tight and of a light color. The weight of the liver of the sugar-fed animals had also increased. When the liver was tasted it was found to be sweeter and more pleasant than that of the control animals. The bacon of the sugar-fed animals was also better in flavor and in salted bacon the keeping quality was increased from 11 to 21 days. In taste tests on the meat of the sugar-fed pigs it was found to have better flavor and a more tender consistency.

Gibbons and Rose (1950) showed that when sugar was fed there was a rapid deposition of glycogen in the muscle and in the liver. The cost of the sugar was partially offset by the increased weight of the liver.

The National Livestock and Meat Board (Ramsbottom and co-workers 1949) in researches on dark cutting beef found that as the sugar content of the muscle decreased, cut surface of meat becomes increasingly darker. They concluded that sugar content is directly related to the ultimate color of meat. Removal of all or part of the sugar influenced meat color significantly. Their research also found that pH value was higher in steers which cut dark, and that as the meat became darker the fat became lighter in color. Lighter colored fat results when fat deposits are being depleted. As a general rule, when muscle sugar was reduced 50 per cent, meat graded about one shade darker, and greater reduction of muscle sugar caused the meat to appear two or three shades darker.

Blosser and co-workers (1949) at State College of Washington studied the effect of feeding of wood molasses to dairy heifers and concluded that

adding wood molasses to the basal ration produced highly significant gains in weight over control animals. They did find some difficulties regarding palatability of the molasses.

METHOD OF PROCEDURE

Ninety-five beef and 12 swine were used as experimental animals. Variations were in the amount of sucrose fed and the time of feeding. In Series I, 5 beef animals were used with 1 animal on each of 5 different levels of feeding. The 0, 2, 4, 8, or 12 pounds of sucrose was given by stomach tube 6 hours prior to slaughter; in Series II, 3 groups of 5 heifers and 5 steers were given 0, 6, or 12 pounds of sucrose by stomach tube 30 hours prior to slaughter; and in Series III, 15 animals in groups of 5 were fed 0, 2, and 4 pounds of sucrose for 3 days, while 3 other groups of 15 animals were fed corresponding amounts of sucrose for 6, 9, or 12 days.

The swine in Lot 1, 2 animals in each of 3 groups, were fed 0, 2, or 4 pounds of sucrose 14 days prior to slaughter and in Lot 2, 3 animals in groups of 2 were fed 0 and 2 pounds of sucrose for 3 days prior to slaughter.

The sugar fed was refined sucrose, or table sugar.

The carcass grades, weights, and dressing yields, which show the uniformity of the beef animals in each series, are given in Table 1. The physical characteristics of the individual beef animals in Series II and III are tabulated in Appendix Tables I and II, and of the swine in Appendix Table III.

Description and Feeding of Beef Animals

Series I. Five heifers, approximately 2 years of age, were used in this series. They were raised at Opal, Wyoming, on wild hay and were classified as grass fed. Feed was withheld 44 hours after which 4 of the 5 animals received by stomach tube a sugar solution containing 2, 4, 8, or 12 pounds

of sucrose (Table 1 and Appendix Table I).

Table 1. Physical characteristics of beef animals

Series	Number of animals	Sucrose fed	Time before slaughter	Avg. live weight	Avg. dressing yield	Carcass grade
		lbs.		lbs.	%	
I	1	0	6 hours	905	55.6	utility
	1	2	6 hours	795	54.9	utility
	1	4	6 hours	820	52.3	utility
	1	8	6 hours	775	52.8	utility
	1	12	6 hours	795	52.3	utility
II	5S*	0	30 hours	945	60.2	5 choice
	5H*	0	30 hours	805	58.8	3 choice 2 good
	5S	6	30 hours	1084	61.6	5 choice
	5H	6	30 hours	845	58.8	2 choice 3 good
	5S	12	30 hours	1020	57.1	4 choice 1 good
	5H	12	30 hours	856	52.9	4 good 1 comm.
III	5	0	3 days	1167	59.6	5 choice
	5	2	3 days	1206	60.3	5 choice
	5	4	3 days	1183	61.3	5 choice
	5	0	6 days	1162	59.0	5 choice
	5	2	6 days	1221	58.4	5 choice
	5	4	6 days	1167	55.5	5 choice
	5	0	9 days	1179	59.1	5 choice
	5	2	9 days	1222	59.3	5 choice
	5	4	9 days	1239	61.0	4 choice 1 prime
	5	0	12 days	1161	60.0	1 prime 4 choice
	5	2	12 days	1182	59.7	5 choice
	5	4	12 days	1191	58.2	5 choice

*S = steers
H = heifers

Series II. Thirty grade Hereford steers and heifers were used in this experiment. They were fed in the pens of Swift and Company at Burley, Idaho, for 80 days. The rations fed were as follow:

	Steers lbs.	Heifers lbs.
Raw potatoes	15	15
Wet beet pulp	15	15
Rolled barley	10	8
Ground wheat	2	2
Dried beet pulp	3	3
Cotton seed meal	1	1
Chopped alfalfa hay	8	7
Salt and mineral mixture as desired		

The animals were shipped from Burley, Idaho, to the Ogden plant of Swift and Company. They were divided at random into 6 lots with 5 animals in each lot. One lot of steers and 1 lot of heifers were handled according to current practice of Swift and Company at Ogden, Utah. They were designated as control animals. Two lots of steers and 2 lots of heifers were given 6 and 12 pounds of sucrose per animal by stomach tube as shown in Table 1. The sucrose was added to 3 gallons of water before it was pumped into the animal. Approximately 30 hours later the animals were slaughtered. The control and sugar-fed animals had access to water during the holding period.

Series III. The 60 steers used in this investigation were primarily grade Herefords with a few Shorthorns among them. They were purchased as young feeders in Utah, Idaho, and Wyoming. All steers received a basal ration containing the following constituents: ground alfalfa hay, ground barley, dried beet pulp, minerals and molasses (fed at a 10 per cent level).

The animals were divided at random into 3 lots with 20 animals assigned to each lot. One lot of steers was handled according to current practice

of Western Livestock Feed Association. They were designated as control animals. Two lots of steers were given 2 and 4 pounds of sucrose per animal per day for 3, 6, 9, and 12 days as shown in Table 1. The sugar was placed on top of the basal ration and the animals took it at free will. All food was removed from the animals for approximately 30 hours before slaughter. Fresh water was available at all times. It should be noted that the control group as well as the sugar fed animals received a ration containing 10 per cent molasses during the entire feeding period of about 90 days.

The liver and carcass of each of the animals in Series I, II, and III were weighed at the time of slaughter and inspected by a United States Federal Inspector. A sample of the liver of each animal was taken to Logan, Utah, for chemical and organoleptic tests. The remainder of each carcass was placed in Swift's refrigerator at 38° to 40° F. for about 72 hours.

The carcasses were judged by representatives of Swift and Company and the United States Meat Inspection Service. The wholesale cut of rib roast (6 to 12 ribs, inclusive) was cut from the same side of each carcass. The samples were transferred to Logan for chemical and organoleptic tests. For testing purposes the wholesale rib cut was divided as follows: 12th rib for color and chemical analyses which were done immediately, 9th to 11th rib frozen for roasting within 3 to 4 weeks, and 6th to 8th ribs sold or frozen and stored 3 months for tests.

Description and Feeding of Swine

Two litters of pigs, grade Duroc-Jersey (Lot 1) and Chester-Whites (Lot 2) respectively, were used in this study. They were fed a basal ration

consisting of the following on a percentage basis: protein supplement 15, ground alfalfa 5, ground barley 78.5, bone meal 1.0, and salt 0.5 until they reached a weight of about 200 pounds. An attempt was made to feed the nutrients according to recommendations of the National Research Council, Recommended Nutrient Allowances for Swine. They were self-fed and water was available at all times. Two weeks prior to slaughter the animals in Lot 1 and 3 days prior to slaughter the animals in Lot 2 were placed in individual pens and assigned at random to the control, 2 and 4 pound sugar feeding group (Table 2, and Appendix Table III). All pigs in Lot 1, as well as those in Lot 2, were litter mates. The last feeding of sucrose was about 16 hours before slaughter.

Table 2. Sucrose fed and time of feeding swine

Lot number	No. animals	Sucrose fed daily	Time before slaughter	Avg. live weight	Avg. dressing yield
		lbs.	days		
Lot 1	2	0	14	230	79.7
	2	2	14	235	80.0
	2	4	14	240	80.8
Lot 2	3	0	3	193	74.7
	3	2	3	218	81.1

The pigs were weighed before slaughter and their carcasses were weighed approximately 24 hours after storage in a refrigerated room at approximately 40° F.

The hams and bacon in Lot 1 were cured using the following formula: 50 gallons of water, 20 pounds of salt, 5 pounds sucrose and 5 pounds of Griffith's powder. This curing solution was pumped into the ham. The pork stood 2 weeks in this pickle and was then soaked in fresh water 70

minutes (5 minutes for every day in the brine). The hams and bacon were then washed in hot water. The hams were heated at 125° F. for 8 hours without smoke, 8 hours at 135° F. with hickory sawdust smoke, and 8 hours at 150° F. with smoke. The bacon received similar treatment but applewood smoke with no heat was used. Chemical and quality tests were made after which the hams were roasted and the bacon fried for organoleptic tests.

Chemical Tests

Sugar. One hundred gram samples of muscle or liver were blended with 400 milliliters of water in a Waring blender. Duplicate 25 or 50 gram samples of the resulting slurry were analyzed for total sugars by Oesting and Beach's modification of the Shaffer-Hartman-Somogyi method as described by Koch and Hanke (1935).

pH. The Beckman pH meter was used for determining the pH of the cuts of meat.

Dry solids. Five to 7 grams of ground meat or liver were used for moistures. The samples were placed in a dehydrator at 65° C. for 1 hour and then dried to constant weight under vacuum at 85° C.

Fats. The dried sample was then extracted in the Goldfisch Apparatus 4 hours with ethyl ether for total fat soluble substances.

Quality Tests

Color. Color readings were made on fat and muscle at Swift's Plant with Munsell color plates made by the Munsell Color Company, Inc., Baltimore, Maryland. Color readings were made on the muscle at Logan with a diffuse reflectance accessory attached to the Beckman spectrophotometer made by National Technical Laboratories, South Pasadena, California.

Roasting. The beef was roasted and sampled for judging according to directions given by the National Livestock and Meat Board (Anon. 1942).

The beef muscle (9th, 10th, and 11th ribs) was roasted to a constant temperature of 300° F. and to an internal temperature of 175° F. The pork loin was roasted at a constant temperature of 350° F. to an internal temperature of 185° F. The ham was roasted at a constant temperature of 300° F. to an internal temperature of 175° F.

Shearing. Shearing tests for tenderness were made on the cooked meat on the Warner-Bratzler shearing machine.

Organoleptic. A taste panel of 7 judges scored the cooked meat, using a scale of 1 to 7 with 7 being highest score, for tenderness, texture, flavor of lean, flavor of fat, and juiciness (Appendix Sheet 1). A consumer acceptance test was made on the livers (Appendix Sheet 2), by marking samples which were cooked and judged at home.

RESULTS AND DISCUSSION

Beef

Series I. Feeding the beef varying amounts of sugar 6 hours before slaughter resulted in only a slight increase in the percentage of carbohydrate in the muscle (Table 3). However, the 4 pound sugar-fed animal showed a decrease in the per cent of carbohydrate in the muscle. When 12 pounds of sugar were fed to 1 animal, a markedly higher percentage of carbohydrate was found in the liver, 4.60 as compared to 3.43 in the control. Smaller amounts of sugar showed an equal amount or a decrease in the per cent of carbohydrate in the liver.

Table 3. Carbohydrate and pH in muscle and liver of beef in Series I

Animal number	Sucrose fed	Carbohydrate as dextrose: Muscle	Liver	pH: Muscle	Liver
	lbs.	%	%		
8299	0	0.129	3.43	5.5	6.0
8296	2	0.148	2.04	5.4	6.0
8297	4	0.128	3.30	5.4	6.1
8298	8	0.148	3.46	5.5	6.1
8295	12	0.148	4.60	5.4	6.0

The pH of both muscle and liver showed only a slight change as a result of feeding sugar to the animals.

There was no apparent correlation between quality appraisal tests and the amount of sugar fed (Table 4). The roasts from the animals fed 2 and 8 pounds of sugar were least tender and that of the animal fed 12 pounds was most tender.

The animals fed 0 and 2 pounds of sugar had a reading of 5 on the Munsell color plates and those with higher amounts of sugar, 4, 8, and 12

pounds, read 1 point lower (Appendix Table I).

Inasmuch as these tests were made on only 1 animal in each variation group, more experiments with larger numbers of animals were needed to substantiate these findings.

Table 4. Quality appraisal test on beef in Series I

Animal number	Sugar fed	Shearing test*	Tests by panel of judges***				
			Tender-ness**	Tex-ture	Flavor		Juici-ness
					Lean	Fat	
	lbs.	lbs.					
8299	0	7.6	4.9	4.7	5.8	3.3	5.4
8296	2	9.1	5.4	5.0	6.0	2.8	5.2
8297	4	14.1	5.2	5.1	5.9	2.8	5.8
8298	8	8.4	5.4	4.2	5.5	2.7	6.1
8295	12	13.3	4.3	4.1	5.6	3.0	4.9

*Low score indicates meat is more tender
**High score indicates meat is more tender
***High score is 7

Series II. The feeding of sucrose did not significantly increase the percentage of carbohydrate found in the beef muscle of the animals in this series (Table 5). In all groups except the steers fed 12 pounds sucrose, the values were slightly lower than the control.

The per cent of carbohydrate in the liver was increased by one-tenth to one-third with the feeding of sucrose in comparison with the controls. These differences were not significant, although they did approach significance.

The liver values in Table 5 are for all livers including 11 fluke livers. However, the values for only good livers showed that the increases resulting from sucrose feeding were approximately the same (one-tenth to one-third). The average per cent of carbohydrate in the groups of fluke livers was

consistently lower than for the good livers (0.2 to 1.1 per cent lower). The per cent of carbohydrate in the muscle and liver of steers was higher than that of the heifers.

Table 5. Carbohydrate, pH, and color in muscle and liver of beef in Series II

Number animals	Sugar fed	Carbohydrate calculated as dextrose: Muscle	All livers	Good livers	Fluke livers	pH: Muscle	pH: Liver	Color: Lean ribeye	Color: exterior fat
	lbs.	%	%	%	%				
5S	0	0.190	1.66	1.88	1.46	5.9	5.4	3.2	2.2
5H	0	0.189	1.40	1.60	1.09	6.0	5.4	3.4	2.4
5S	6	0.169	1.92	2.16	1.54	5.9	5.4	3.2	2.2
5H	6	0.165	1.85	2.07	0.95	5.9	5.4	3.6	2.4
5S	12	0.205	2.04	2.18	1.82	6.0	5.4	3.6	2.4
5H	12	0.150	1.55	1.65	1.41	5.9	5.3	3.9	2.8

The pH of both muscle and liver showed only a slight change as a result of feeding sugar to animals.

The Munsell color readings on the beef ribeye muscle and fat showed very little variation (Table 5). The color of the lean ribeye and exterior fat was slightly poorer in the steers than in the heifers. Similar values were obtained for each lot of animals when the color of the muscle was read on the reflectance attachment of the Beckman spectrophotometer.

Similar values for tenderness were obtained in the shearing tests for all animals (Table 6, Appendix Table V). In some instances the meat from the control animals was slightly more tender than the sucrose-fed meat. Roasts from the steers were slightly more tender than those from heifers. The scores for all lots of animals for the quality appraisal tests by the panel of judges were similar. Close agreement was noted between the scores

for tenderness by the shearing machine and the panel of judges, the linear correlation coefficient being -0.942 for the tests. This figure is highly significant.

Table 6. Quality appraisal tests and cooking losses on beef Series II

Animal no.	Sugar fed	Shearing	Test by panel of judges: Tenderness	Texture	Flavor: Lean	Flavor: Fat	Juiciness	Cooking loss: Total	Cooking loss: Drip	Cooking loss: Evap.
								%	%	%
5S	0	8.8	6.0	5.6	6.1	5.7	5.6	25.4	7.1	18.3
5H	0	10.9	5.4	5.4	5.7	5.4	5.3	27.4	8.0	19.5
5S	6	10.7	5.2	5.3	5.7	5.6	5.4	25.6	9.3	16.3
5H	6	10.9	5.2	5.4	5.7	5.6	5.3	28.8	9.5	19.3
5S	12	9.7	5.9	5.6	6.0	5.4	5.4	24.5	7.5	17.0
5H	12	11.1	5.1	5.4	5.6	5.4	5.2	25.3	8.3	17.0

The per cent of cooking loss on roasts (Table 6) was least for the sucrose-fed (12 pounds) animals (24.9 as compared to 26.4 for the controls and 27.2 for the animals fed 6 pounds of sucrose).

The consumer acceptance test of the beef livers showed 91.3 per cent of the 69 people who participated in the test preferred the livers from the sucrose-fed animals (55.1 for the livers from the animals fed 6 pounds of sucrose and 36.2 for the livers when 12 pounds was fed).

Series III. The per cent of carbohydrate in the muscle of the beef in Series III was 0.173, 0.184, and 0.184 for the control, 2 and 4 pound level of sucrose feeding, respectively (Table 7, Appendix Table V). The average per cent of carbohydrate in the muscle showed increases in the 6 day feeding period as compared to the 3 day feeding and decreases with 9 and 12 days of feeding in all groups of animals. The 3 and 6 day feeding periods

appeared to result in a higher per cent of carbohydrate in the muscle than the 9 and 12 day periods. Differences between feeding 2 and 4 pounds of sucrose for each of the feeding periods were slight and inconsistent. Statistical analyses of these data showed that the differences resulting from the length of feeding time and amount of sugar fed times time were highly significant (Table 8).

Table 7. Carbohydrate, dry solids, fats, and pH in beef muscle and liver, Series III

Sucrose fed	Liver Days					Muscle Days				
	3	6	9	12	Avg.	3	6	9	12	Avg.
lbs.	%	%	%	%	%	%	%	%	%	%
					Percentage of Carbohydrate on Moist Basis					
0	2.56	1.86	2.10	2.36	2.22	0.181	0.193	0.147	0.172	0.173
2	2.76	2.37	2.30	2.44	2.47	0.196	0.213	0.143	0.186	0.184
4	2.94	2.20	2.06	2.26	2.36	0.196	0.210	0.143	0.189	0.184
					Percentage of Dry Solids					
0	28.8	28.6	29.0	31.1	29.4	28.0	29.4	29.2	29.8	29.1
2	29.6	30.1	29.8	30.7	30.0	28.5	29.6	28.8	28.8	28.9
4	30.1	28.9	28.6	29.6	29.3	28.6	30.4	30.3	29.1	29.6
					Percentage of Fats (ether extract)					
0	2.3	2.4	4.9	5.9	3.9	5.3	6.3	6.9	7.3	6.5
2	3.7	3.0	2.2	4.3	3.3	6.1	6.3	6.0	8.6	6.8
4	3.0	1.8	4.3	4.3	3.3	6.6	8.0	7.6	6.2	7.1
					pH					
0	5.8	5.8	5.9	5.8	5.8	5.4	5.4	5.5	5.4	5.4
2	5.8	5.8	5.9	5.9	5.9	5.3	5.4	5.4	5.5	5.4
4	5.8	5.8	5.9	5.9	5.9	5.4	5.4	5.4	5.4	5.4

Table 8. Analysis of variance for Series III percentage of carbohydrate in beef muscle

Source	d.f.	Ssqs.	Msq.
Control vs. treatment	1	.001763	.001763
Time	3	.025954	.008651**
Quantity	1	.000000	.000000
Time and quantity	3	.025992	.008664**
Error	51	.033970	.000655
Total	59	.087106	
Percentage of Carbohydrate in Beef Liver			
Control vs. treatment	1	.5082	.5082
Time	3	2.6587	.8862**
Quantity	1	.1071	.1071
Time and quantity	3	3.0576	1.0192**
Error	51	8.9934	.1763
Total	59	15.3250	

**Highly significant at P = .01

The average per cent of carbohydrate in the liver was 2.22, 2.47 and 2.36 for the control, 2 and 4 pound level of sucrose feeding, respectively (Table 7). These differences were highly significant for length of feeding time and amount of sugar fed times length of time (Table 8). The livers of the steers fed 2 pounds of sucrose showed the highest increases in per cent of carbohydrate with one exception, the 4-pound 3-day level. These increases in the 2-pound level of feeding compared to the control ranged from 0.08 to 0.5 per cent. Differences between the 4-pound level of feeding and the control ranged from -0.1 to +0.38. All values for percentage of carbohydrate in the liver for the 3-day feeding period were slightly higher than for the other feeding periods (0.46 to 0.88 per cent higher).

Feeding different amounts of sucrose appeared to have slight effect on the percentage of dry solids in the liver. Feeding sucrose for periods longer than 3 days increased slightly the percentage of dry solids in the

liver of the 2-pound fed animals, while decreases were shown on the 4-pound level for the 6, 9, and 12 day periods.

Feeding different amounts of sucrose and for different periods of time decreased slightly the dry solids in the muscle.

The percentage of fats in the livers decreased slightly and in the muscle increased slightly with the feeding of different amounts of sucrose when the values for the 4 feeding periods were averaged (Table 7).

The pH of both muscle and liver showed only very slight changes as a result of feeding 2 and 4 pounds of sucrose for 3, 6, 9, and 12 days (Table 7).

Munsell color tests were not taken on the animals in this series. When the color of the fresh muscle was read on the reflectance attachment of the Beckman spectrophotometer, the curves which were obtained for the different levels of sucrose feeding during each of the 4 feeding periods are presented in Figures 1 to 4. No level of feeding of sucrose for the 4 feeding periods resulted in a consistently higher or lower curve as compared to that of the control. However, the best color was shown by the curves for the 2 pounds of sucrose-fed beef which were higher in all cases except one, than those for the beef fed 4 pounds of sucrose.

In Figure 5 is shown the curves for the beef muscle fed 2 pounds of sucrose for the 4 feeding periods. The 12-day feeding period gave the lowest curve which represented the poorest color.

The meat which had not been stored showed similar values for tenderness in the shearing tests for all animals (Table 9, Appendix Table VII). The scores for quality appraisal tests by the panel of judges were also similar for all animals. Differences were slight and inconsistent which indicated that the different amounts of sugar fed and the time of feeding

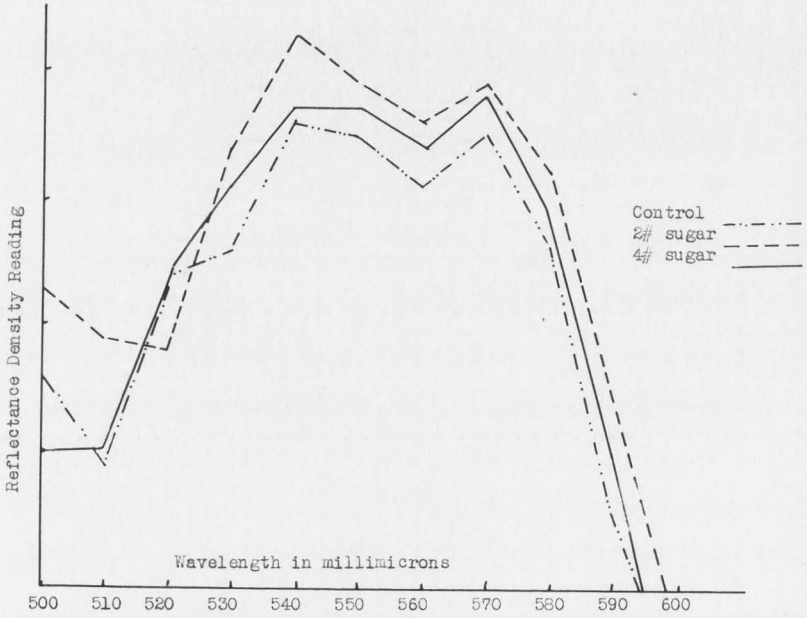

Figure 1. Effect of sugar feeding for 3 days on the reflectance curve of beef muscle.

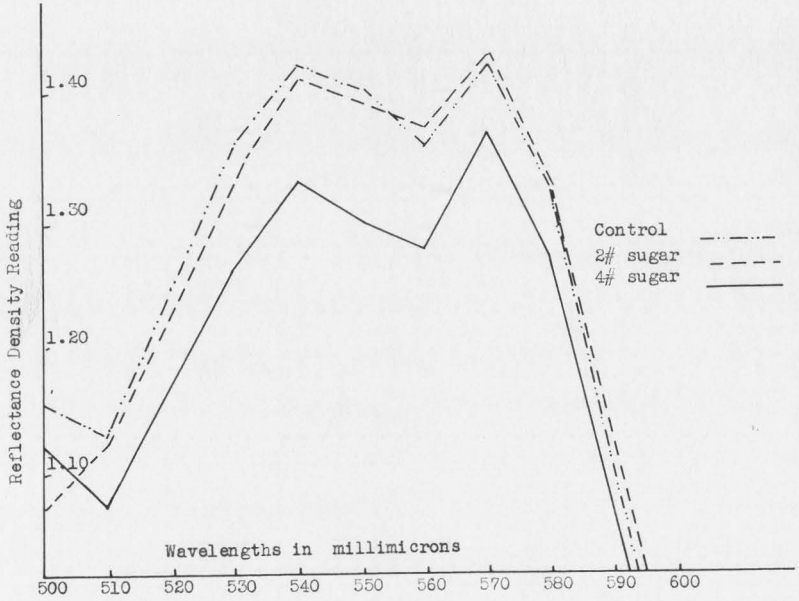

Figure 2. Effect of sugar feeding for 6 days on the reflectance curve of beef muscle.

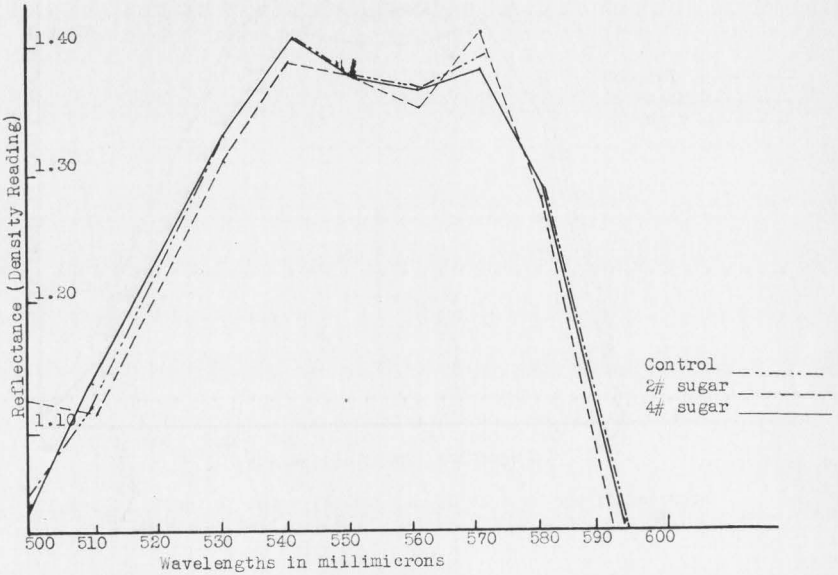

Figure 3. Effect of sugar feeding for 9 days on the reflectance curve of beef muscle.

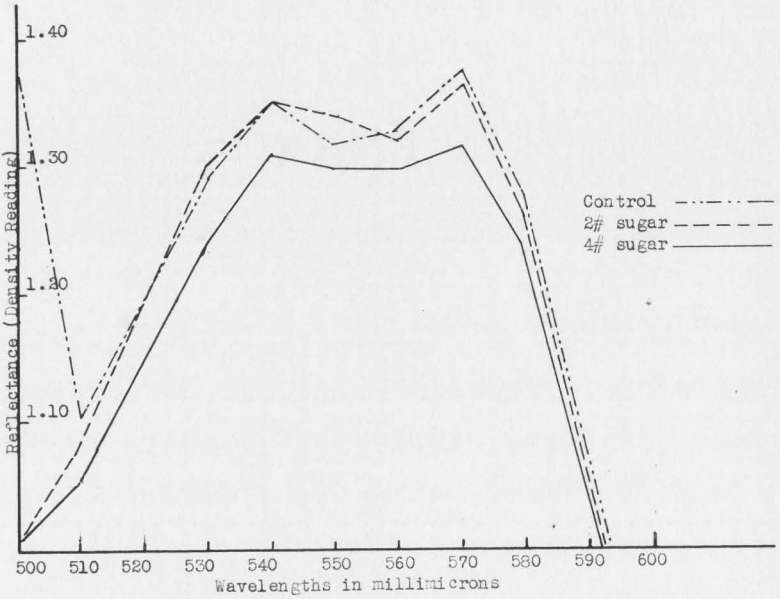

Figure 4 Effect of sugar feeding for 12 days on the reflectance curve of beef muscle.

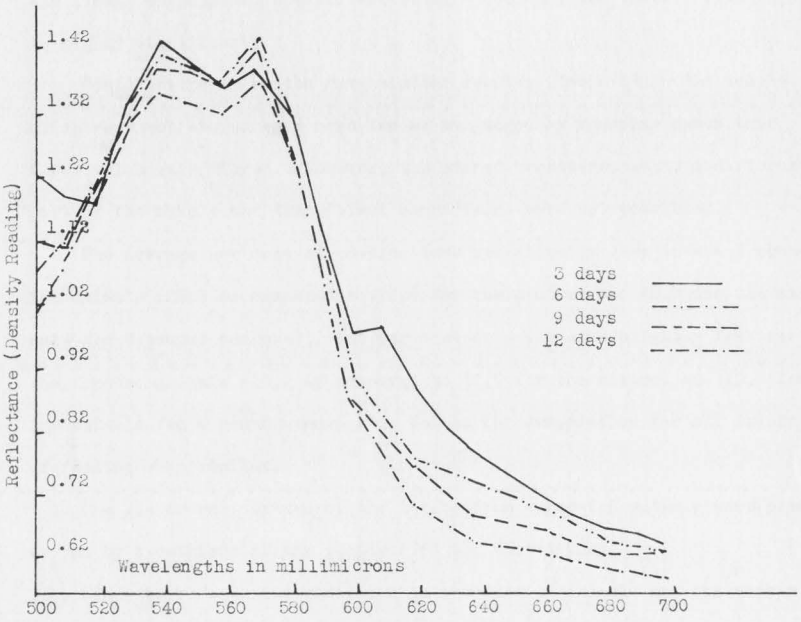

Figure 5. Effect of feeding 2# sugar for different lengths of time on reflectance curves of beef muscle.

had little effect on the quality. It should be noted that all the animals received sugar in the form of molasses, the controls received this as well as the 2 and 4 pound levels of feeding. Close agreement was noted between the scores for tenderness by the shearing machine and the panel of judges, the linear correlation coefficient being -0.965 for the tests. This figure is highly significant.

Roasts stored 3 months gave similar results (Table 10). The roasts which were not stored were more tender as judged by shearing tests than those which were stored. However, the stored roasts represent a different part of the muscle and thus direct comparisons were not possible.

The average per cent of cooking loss was slightly less in the 2 pound fed animals (28.3 as compared to 28.6 for the control and 28.8 for the animals fed 4 pounds sucrose). The per cent drip was also slightly less in the 2 pound animals (10.2 as compared to 10.5 for the control and 10.6 for the animals fed 4 pounds sucrose). Values for evaporation for all levels of feeding were similar.

The flavor and texture of the livers from sugar-fed animals were preferred by two-thirds of the people (75) who tested them.

Since there was wide variation in response of animals and the number of animals per treatment was small, further study on larger numbers of animals is needed before definite conclusions can be established as to the optimum amount of sucrose or length of feeding time.

Swine

Feeding swine varying amounts of sugar 3 and 14 days before slaughter resulted in marked increases in the percentage of carbohydrate in the liver and in the muscle. The percentage of carbohydrate in the liver in the control animals was 0.86 as compared to 1.80 for the 2 pound feeding level

Table 9. Quality appraisal tests on beef with no storage

Sugar fed	Shearing test*	Test by panel of judges***					Cooking loss		
		Tender-ness**	Tex-ture	Flavor		Juici-ness	Loss	Drip	Evap.
				Lean	Fat				
lbs.	lbs.						%	%	%
Fed Sucrose for 3 Days									
0	7.3	5.8	5.6	5.9	5.5	5.7	28.8	9.7	19.1
2	8.9	5.0	5.2	6.0	5.0	5.5	28.9	8.9	20.0
4	8.1	5.8	5.6	5.9	5.4	5.7	27.7	10.0	17.0
Fed Sucrose for 6 Days									
0	9.0	5.5	5.6	5.8	5.9	5.5	27.7	10.2	17.5
2	8.6	5.5	5.5	5.9	6.0	5.6	28.8	11.4	17.4
4	8.3	5.6	5.5	5.8	5.7	5.8	30.1	10.8	19.3
Fed Sucrose for 9 Days									
0	8.3	5.8	5.6	5.9	5.6	5.5	28.5	11.0	17.5
2	7.6	5.8	5.5	5.9	5.5	5.5	28.5	11.3	17.2
4	8.0	5.6	5.5	5.8	5.6	5.6	28.9	10.8	18.1
Fed Sucrose for 12 Days									
0	9.0	4.9	5.2	5.6	5.3	5.5	29.2	11.1	18.1
2	8.7	5.5	5.3	5.7	5.3	5.5	26.9	9.4	17.5
4	8.8	5.1	5.3	5.8	5.2	5.5	28.4	10.6	17.8
Average of 3, 6, 9, and 12 Days Feeding									
0	8.4	5.5	5.5	5.8	5.6	5.6	28.6	10.5	18.1
2	8.4	5.5	5.4	5.8	5.4	5.5	28.3	10.2	18.1
4	8.3	5.5	5.5	5.8	5.4	5.6	28.8	10.6	18.2

*Low score indicates more tender
**High score indicates more tender
***Maximum score for any factor, 7

Table 10. Quality appraisal tests and cooking losses on beef stored 3 months[a]

Sugar fed	Shearing test*	Test by panel of judges***					Cooking loss		
		Tender-ness**	Tex-ture	Flavor		Juici-ness	Loss	Drip	Evap.
				Lean	Fat				
lbs.	lbs.						%	%	%
Fed Sucrose 3 Days									
0	11.1	5.4	5.2	5.9	5.4	5.3	30.4	8.6	21.8
2	12.0	4.7	5.0	5.6	4.1	5.3	27.8	7.2	20.6
4	9.2	5.8	5.3	6.0	5.7	5.3	29.8	8.0	21.8
Fed Sucrose for 6 Days									
0	11.4	5.4	5.5	5.6	5.2	5.0	28.2	7.7	20.6
2	11.0	4.7	5.0	5.6	5.8	5.2	26.7	8.4	18.4
4	11.5	4.9	5.0	5.6	4.9	5.4	26.8	6.0	20.8
Fed Sucrose for 9 Days									
0	9.2	6.0	5.8	6.2	5.7	5.6	26.8	7.5	19.3
2	9.7	5.6	5.4	6.0	5.6	5.6	26.9	6.8	20.1
4	10.2	6.0	5.5	6.1	5.9	5.6	30.2	9.4	20.8
Fed Sucrose for 12 Days									
0	12.0	4.5	4.8	5.5	4.5	5.2	28.7	9.8	19.8
2	9.4	5.8	5.4	6.0	5.5	5.3	28.3	7.3	21.0
4	11.2	5.1	5.0	5.7	4.7	5.2	30.4	8.8	21.7
Average of 3, 6, 9, and 12 Days Feeding									
0	10.9	5.3	5.3	5.8	5.2	5.3	29.3	7.9	21.4
2	10.5	5.2	5.2	5.8	5.5	5.4	27.2	7.7	19.9
4	10.5	5.4	5.2	5.9	5.3	5.4	28.0	7.9	20.1

[a]Represent average of 2 roasts for each group

*Low score indicates more tender

**High score indicates more tender

***Maximum score for any factor, 7

Table 11a. Carbohydrate and pH of swine

Animal number	Sugar fed	Carbohydrate as dextrose		pH	
		Liver	Muscle	Muscle	Liver
	lbs.	%	%		
801	0	1.08	0.189	5.5	6.5
805	0	0.52	0.172	5.4	6.4
5	0	1.22	0.272	5.2	6.0
6	0	0.49	0.158	5.2	6.2
8	0	0.99	0.126	5.4	6.0
Avg.		0.86	0.183	5.3	6.2
804	2	1.78	0.323	5.4	6.3
807	2	1.20	0.410	5.5	6.4
1	2	2.34	0.463	5.2	5.8
2	2	1.90	0.224	5.3	6.0
3	2	1.77	0.194	5.2	5.9
Avg.		1.80	0.323	5.3	5.1
802	4	2.04	0.352	5.3	6.3
803	4	1.05	0.336	5.4	6.4
Avg.		1.54	0.344	5.4	6.4

Table 11b. Carbohydrate and pH in ham and bacon

Animal number	Sugar fed	Carbohydrate as dextrose		pH	
		Ham	Bacon	Ham	Bacon
801	0	0.394	0.300	5.8	5.8
805	0	0.308	0.247	5.8	5.7
Avg.		0.351	0.274	5.8	5.8
804	2	0.394	0.264	5.8	5.7
807	2	0.588	0.264	5.6	5.6
Avg.		0.491	0.264	5.7	5.7
802	4	0.478	0.231	5.8	5.6
803	4	0.548	0.196	5.7	5.7
Avg.		0.513	0.214	5.7	5.7

and 1.54 for the 4 pound feeding; in the muscle the percentage of carbohydrate was 0.183, 0.323, and 0.344 for the control, 2 and 4 pound fed animals (Table 11). The liver of the sugar-fed animals contained over twice the amount of sugar as the control animals and the muscle contained nearly twice as much sugar. These differences were significant for the sugar content of the muscle and highly significant for the sugar content of the liver.

The pH showed only slight changes as a result of feeding sugar to the animals.

Similar values were obtained for each lot of animals when color of the muscle was read on the reflectance attachment of the Beckman Spectrophotometer.

Shearing tests showed that the sugar-fed roasts were slightly more tender than the control (Table 12). However, these differences were not significant. Quality appraisal tests showed that the sugar-fed roasts had better flavor and texture than the control. Consumer acceptance tests of livers also showed a preference for the sugar-fed livers.

Cooking loss, drip and evaporation were similar in each lot. However, the animals in Lot 1 showed greater cooking losses than Lot 2.

In the cured hams feeding sucrose to swine increased the percentage of carbohydrate in the ham (0.351, 0.491, and 0.513 for the control, 2 and 4 pound feedings), while that of bacon decreased, 0.274 for the control, 0.264 for the 2 pound feeding and 0.214 for the 4 pound feeding. These values are higher than the percentage of carbohydrate in the muscle of the uncured pork which is logical since the curing solution has a large amount of sucrose in it.

The pH of the cured hams and bacon showed only slight change as a

Table 12. Quality appraisal tests and cooking loss on pork

Animal number	Sugar fed lbs.	Shearing	Test by panel of judges: Tenderness	Texture	Flavor: Lean	Flavor: Fat	Juiciness	Cooking loss: Total %	Cooking loss: Drip %	Cooking loss: Evap. %
801	0	16.2	4.2	4.2	5.1	6.0	4.5	27.6	6.2	21.4
805	0	14.6	4.6	4.9	5.4	5.8	4.8	32.4	11.0	21.4
5	0	8.4	6.7	6.2	6.4	5.4	5.2	30.5	7.8	22.7
6	0	7.0	6.6	6.0	6.3	6.2	5.1	20.5	5.6	14.9
8	0	5.5	6.7	5.9	6.3	6.0	5.3	30.8	8.8	22.0
Avg.		10.3	5.8	5.4	5.9	5.9	5.0	28.4	7.9	20.5
804	2	12.25	5.3	5.1	5.3	6.2	4.9	36.3	11.0	25.3
807	2	6.2	6.4	6.1	6.4	6.2	5.9	36.1	10.6	25.5
1	2	8.9	6.5	6.2	6.4	5.8	4.8	31.2	7.7	23.5
2	2	6.6	6.4	5.9	6.3	5.4	5.1	27.0	8.0	19.0
3	2	7.8	6.3	5.8	6.1	5.8	5.2	24.5	6.4	18.1
Avg.		8.3	6.2	5.8	6.1	5.9	5.2	31.0	8.7	22.3
802	4	7.0	5.9	5.4	6.2	6.2	5.4	35.1	8.3	26.8
803	4	8.5	5.8	5.4	6.0	5.2	5.2	33.3	9.4	23.8
Avg.		7.8	5.8	5.4	6.1	5.7	5.3	34.2	8.9	25.3
					Ham					
801	0	8.1	6.1	5.6	5.8	5.2	5.2	19.3	7.3	12.0
805	0	11.3	5.5	5.3	5.9	6.2	5.4	25.8	11.0	14.8
Avg.		9.7	5.3	5.5	5.8	5.7	5.3	22.6	9.2	13.4
804	2	9.2	5.9	5.5	6.1	6.4	5.7	26.7	7.4	19.3
807	2	11.8	5.9	5.7	6.0	5.6	5.6	24.8	7.5	17.3
Avg.		10.5	5.9	5.6	6.0	6.0	5.7	25.8	7.5	18.3
802	4	9.1	5.5	5.2	6.2	6.0	5.6	24.8	9.1	15.7
803	4	9.4	6.0	5.4	6.1	6.0	5.6	29.8	13.3	16.5
Avg.		9.2	5.8	5.3	6.2	6.0	5.6	27.3	11.2	16.0
					Bacon					
801	0	--	5.7	5.4	6.0	6.0	4.8	--	--	--
805	0	--	5.3	5.6	6.1	6.1	4.6	--	--	--
Avg.			5.5	5.5	6.1	6.1	4.7			
804	2	--	5.4	5.6	5.7	5.7	4.6	--	--	--
807	2	--	5.4	5.7	6.0	6.0	4.6	--	--	--
Avg.			5.4	5.6	5.4	5.8	4.6			
802	4	--	5.6	5.6	5.4	5.8	4.6	--	--	--
803	4	--	5.4	5.7	5.6	5.7	4.6	--	--	--
Avg.			5.5	5.6	5.5	5.8	4.6			

result of feeding sugar to animals (Table 11).

In quality tests the hams of the sugar-fed animals were slightly superior to the control animals (Table 12). Cooking loss, drip, and evaporation in hams were slightly higher in the sugar-fed animals.

Since there was a small number of experimental animals, these results should be considered tentative in nature and provide a basis for further studies.

SUMMARY

Beef were divided into three series: Series I, 5 animals were fed 0, 2, 4, 8, or 12 pounds of sucrose 6 hours before slaughter; Series II, the animals were divided into 6 lots with 5 animals in each lot. One lot of steers and 1 lot of heifers were control animals. Two lots of steers and 2 lots of heifers were given 6 and 12 pounds of sucrose per animal 30 hours before slaughter; and Series III, 60 animals were divided into 3 lots. One lot was control animals. Two lots were given 2 and 4 pounds of sucrose per animal per day for 3, 6, 9, and 12 days.

Two lots of pigs were used. They were grouped as control, 2 and 4 pound feeding groups. The animals in Lot 1 were fed 14 days and in Lot 2, 3 days prior to slaughter.

In Series I, feeding beef varying amounts of sugar 6 hours prior to slaughter resulted in only a slight increase in the percentage of carbohydrate in the muscle, but did produce a slightly higher percentage of carbohydrate in the liver.

Feeding of sucrose 30 hours before slaughter, in Series II, did not significantly increase the percentage of carbohydrate found in the beef muscle. The percentage of carbohydrate in the liver was increased by one-tenth to one-third over the control animals by feeding sucrose. These differences did not approach significance. The average per cent of carbohydrate in the good livers was consistently higher than in the fluke livers.

In Series III, the 3 and 6 day feeding periods appeared to result in a slightly higher per cent of carbohydrate in the muscle than the 9 and 12 day feeding periods.

The livers of the steers fed 2 pounds of sucrose showed highest increases in the per cent of carbohydrate. All values for percentage of carbohydrate in the liver for the 3-day feeding period were slightly higher than for the other periods. Statistical analyses of the differences of the percentage of carbohydrate in the muscle and liver were highly significant for length of time of feeding and amount of sugar fed times length of time.

The Munsell color readings on the beef in Series I and II on the rib-eye muscle and fat showed little variation. Similar values were also obtained for each lot of animals when the color of the muscle was read on the reflectance attachment of the Beckman spectrophotometer. No level of feeding in Series III resulted in a consistently higher or lower curve for color as compared to the control. The best color was shown by the curves for the 2 pounds of sucrose-fed beef which were higher in all cases except one. The 12-day feeding period gave the lowest curve which represented the poorest color.

The pH of both the muscle and liver in all 3 series showed only a slight change as a result of feeding varying amounts of sugar to the animals for different periods of time.

Similar values for tenderness were obtained in the shearing tests for all animals in all 3 series. In some instances the meat from the controls was slightly more tender than the sucrose-fed meat. Roasts from steers were slightly more tender than those from heifers. Scores for all lots of animals for quality appraisal tests by the panel of judges were similar. Cooking loss was slightly less in the 2 pound fed animals in Series III. The percentage of drip was also slightly less in the 2 pound animals. Values for evaporation on all levels were similar.

Consumer acceptance tests of beef and pork livers showed that from

two-thirds to three-fourths of the people preferred the livers from the sucrose-fed animals.

The feeding of sucrose to swine 3 to 14 days before slaughter resulted in marked increases in the percentage of carbohydrate in the muscle and in the liver of fresh pork, slight increases in cured hams and slight decreases in cured bacon. The liver of the sugar-fed animals contained over twice the amount of sugar as the control animals and the muscle contained nearly twice as much. These differences were significant for the sugar content of the muscle and highly significant for the sugar content of the liver.

The pH of the fresh muscle, cured hams and bacon showed only slight changes as a result of feeding sugar to swine.

Similar values for color were obtained for each lot of pigs when the muscle was read on the reflectance attachment of the Beckman spectrophotometer.

Shearing tests showed that the sugar-fed pork muscle was slightly more tender than the control. However, these differences were not significant. Quality appraisal tests showed that the sugar-fed roasts had slightly better flavor and texture than the control animals. Cooking loss, drip and evaporation were similar for the 2 lots of roasts.

Shearing tests showed that tenderness values for the ham were similar. Quality appraisal on the ham and bacon were also similar.

Since there was a wide variation in response of animals and the number of animals per treatment was small, further study on larger numbers of animals is needed before definite conclusions can be established as to the optimum amount of sucrose or length of feeding time.

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APPENDIX

Appendix Table I. Physical characteristics of beef animals, Series I and II

Animal number	Wt. of sugar	Live weight	Dressing yield	U.S. grade	Munsell color: Exterior carcass fat	Munsell color: Lean ribeye	Liver weights
	lbs.	lbs.	%				lbs.
SERIES I							
8299	0	905	55.6	utility	4	5	--
8296	2	795	54.9	utility	4	5	--
8297	4	820	52.3	utility	4	4	--
8298	8	775	52.8	utility	5	4	--
8295	12	835	52.3	utility	3	4	--
SERIES II							
Steers							
180	0	920	58.7	choice	2	3	12.0 N*
181	0	985	62.2	choice	2	3	13.6 A*
182	0	975	62.2	choice	2	3	11.1 N
183	0	900	58.3	choice	3	4	13.1 A
184	0	945	59.4	choice	2	3	11.3 N
Avg.		945	60.2		2	3	12.2
Heifers							
189	0	760	59.2	good	2	4	11.2 N
191	0	810	56.3	good	2	3	10.0 N
192	0	860	59.6	choice	2	3	14.0 A
193	0	780	60.6	choice	3	3	13.2 N
893	0	815	58.4	choice	3	4	11.5 A
Avg.		805	58.8		2	3	12.0
Steers							
177	6	960	61.1	choice	2	3	16.4 N
178	6	1065	61.8	choice	2	4	15.8 A
179	6	1000	60.2	choice	3	2	14.8 A
185	6	1040	61.6	choice	2	3	15.5 N
186	6	1175	63.5	choice	2	4	16.4 N
Avg.		1084	61.6		2	3	15.8
Heifers							
174	6	875	58.6	good	3	4	10.1 N
894	6	840	67.4	choice	2	3	11.4 N
898	6	920	55.2	good	3	4	13.1 A
899	6	760	58.6	choice	2	3	11.0 N
900	6	830	54.3	good	2	4	11.1 N
Avg.		845	58.8		2	4	11.3

A = Abscessed
N = Normal

Appendix Table I (continued).

Animal number	Wt. of sugar	Live weight	Dressing yield	U.S. grade	Munsell color: Exterior carcass fat	Munsell color: Lean ribeye	Liver weights
	lbs.	lbs.	%				lbs.
Steers							
176	12	1060	56.7	good	4	4	13.1 N
188	12	950	55.6	choice	2	3	16.8 A
196	12	950	57.7	choice	2	4	17.8 N
895	12	1040	56.4	choice	2	4	14.1 N
896	12	1100	58.9	choice	2	3	16.1 A
Avg.		1020	57.1		2	4	16.4
Heifers							
173	12	835	54.0	good	3	4	12.4 A
187	12	795	57.0	good	2	4	13.0 N
194	12	880	49.3	commercial	4	4	11.1 N
195	12	860	54.0	good	3	4	13.5 A
505	12	910	50.1	good	2	3	11.4 N
Avg.		856	52.9		3	4	12.3

Appendix Table II. Physical characteristics of beef animals, Series III

Animal number	Days fed	Live weight lbs.	Dressing yield %	U. S. grade	Liver weights lbs.
			Control		
50	0	1195	61.6	choice	13.0 N
51	0	1410	58.7	choice	11.3 A
56	0	1195	58.2	choice	12.8 A
68	0	1020	59.7	choice	14.0 A
69	0	1015	60.0	choice	16.9 A
Avg.		1167	59.6		13.6
64	0	1105	57.4	choice	18.0 A
90	0	1160	60.5	choice	16.3 A
92	0	1215	60.3	choice	17.4 A
93	0	1210	59.1	choice	12.4 N
98	0	1120	57.9	choice	12.0 N
Avg.		1162	59.0		15.2
6	0	1210	59.9	choice	13.5 A
7	0	1170	57.4	choice	12.5 N
8	0	1190	59.0	choice	13.3 N
9	0	1065	58.7	choice	12.6 N
10	0	1260	60.6	choice	14.1 N
Avg.		1179	59.1		13.2
21	0	1155	60.8	prime	15.3 N
22	0	1145	59.9	choice	12.3 N
23	0	1155	60.6	choice	12.5 N
24	0	1065	59.6	choice	12.0 N
25	0	1285	59.3	choice	16.8 N
Avg.		1161	60.0		13.8
		2 pounds Sugar per Steer Daily			
76	3	1055	59.4	choice	17.7 A
78	3	1355	59.6	choice	17.4 A
79	3	1135	60.0	choice	15.3 N
80	3	1290	60.5	choice	14.4 N
81	3	1195	62.0	choice	15.3 N
Avg.		1206	60.3		16.0
72	6	1230	56.8	choice	15.6 N
74	6	1285	57.7	choice	16.3 N
75	6	1185	57.9	choice	15.3 A
88	6	1085	59.4	choice	14.1 N
91	6	1320	60.3	choice	16.8 N
Avg.		1221	58.4		15.6

Appendix Table II (continued).

Animal number	Days fed	Live weight	Dressing yield	U. S. grade	Liver weights
		lbs.	%		lbs.
11	9	1365	58.6	choice	16.0 A
12	9	1150	58.5	choice	15.8 A
13	9	1290	60.3	choice	14.1 A
14	9	1295	60.5	choice	14.8 N
15	9	1010	58.8	choice	12.3 A
Avg.		1222	59.3		14.6
16	12	1210	62.4	choice	14.8 N
17	12	1125	59.6	choice	14.8 N
18	12	1175	58.0	choice	14.9 N
19	12	1125	57.6	choice	14.8 N
20	12	1275	60.8	choice	16.6 A
Avg.		1182	59.7		15.2
		4 Pounds Sugar per Steer Daily			
65	3	1145	61.0	choice	15.0 N
66	3	1130	60.4	choice	14.5 N
67	3	1040	63.8	choice	14.4 N
82	3	1405	59.7	choice	18.0 N
83	3	1195	61.6	choice	14.8 A
Avg.		1183	61.3		15.3
73	6	1265	52.9	choice	15.3 N
86	6	1105	56.8	choice	14.1 N
89	6	1090	--	choice	17.3 N
96	6	1255	54.6	choice	17.2 A
97	6	1120	57.6	choice	14.4 N
Avg.		1167	55.5		15.7
1	9	1275	59.5	choice	17.3 A
2	9	1210	60.0	prime	17.3 A
3	9	1195	61.6	choice	14.3 N
4	9	1355	61.3	choice	16.3 N
5	9	1060	62.7	choice	15.3 A
Avg.		1239	61.0		16.1
26	12	1155	58.5	choice	14.9 N
27	12	1265	55.7	choice	15.4 N
28	12	1265	59.3	choice	14.1 N
29	12	1130	58.8	choice	15.6 N
30	12	1140	58.7	choice	13.8 N
Avg.		1191	58.2		14.8

Appendix Table III. Physical characteristics of swine

Animal number	Wt. of sugar	Time of feeding	Live weight	Dressing yield	Sex	Liver weights
	lbs.	days		%		lbs.
			Control			
801	0	14	220	78.6	M	3.2
805	0	14	240	80.8	M	3.1
5	0	3	193	76.2	M	3.0
6	0	3	176	70.0	M	2.9
8	0	3	210	73.2	M	3.0
Avg.				75.8		3.2
804	2	14	230	79.5	F	3.4
807	2	14	240	80.4	M	3.4
1	2	3	234	82.0	M	3.6
2	2	3	223	81.1	M	3.4
3	2	3	197	80.1	F	3.4
Avg.				80.4		3.4
802	4	14	240	83.3	F	3.9
803	4	14	239	78.2	M	3.6
Avg.				80.8		3.8

Appendix Table IV. Percentage of carbohydrate and pH in beef muscle and liver, Series II

Animal number	Carbohydrate calculated as dextrose: Muscle %	All livers %	Good livers %	Fluke livers %	pH Muscle	pH Liver
Control - no sucrose						
Steers						
180	0.241	1.43	1.43	--	5.7	5.5
181	0.160	1.62	--	1.62	6.0	5.4
182	0.169	1.97	1.97	--	5.9	5.3
183	0.186	1.30	--	1.30	6.0	5.4
184	0.196	2.00	2.00	--	5.7	5.4
Avg.	0.190	1.66	1.80	1.46	5.9	5.4
Heifers						
189	0.214	1.53	1.53	--	6.0	5.4
191	0.186	1.43	1.43	--	5.9	5.4
192	0.160	1.17	--	1.17	6.1	5.4
193	0.206	1.84	1.84	--	5.9	5.4
893	0.178	1.02	--	1.02	6.1	5.4
Avg.	0.189	1.40	1.60	1.10	6.0	5.4
Fed 6# sugar by stomach tube						
Steers						
177	0.178	1.64	1.64	--	6.1	5.3
178	0.110	1.02	--	1.02	6.0	5.5
179	0.206	2.07	--	2.07	6.0	5.3
185	0.206	2.67	2.67	--	5.8	5.4
186	0.143	2.18	2.18	--	5.7	5.3
Avg.	0.169	1.92	2.16	1.54	5.9	5.4
Heifers						
174	0.160	1.86	1.86	--	5.9	5.2
894	0.110	1.86	1.86	--	5.8	5.4
898	0.160	0.95	--	0.95	6.2	5.5
899	0.258	2.51	2.51	--	5.8	5.4
900	0.135	2.07	2.07	--	5.8	5.3
Avg.	0.165	1.85	2.07	0.95	5.9	5.4
Fed 12# sugar by stomach tube						
Steers						
176	0.160	2.30	2.30	--	6.0	5.4
188	0.223	1.86	--	1.86	6.0	5.3
196	0.178	2.00	2.00	--	6.0	5.4
895	0.232	2.24	2.24	--	5.8	5.4
896	0.232	1.78	--	1.78	6.1	5.4
Avg.	0.205	2.04	2.18	1.82	6.0	5.4

Appendix Table IV (continued).

Animal number	Carbohydrate calculated as dextrose: Muscle	All livers	Good livers	Fluke livers	pH Muscle	pH Liver
	%	%	%	%		
Fed 12# sugar by stomach tube						
Heifers						
173	0.120	1.58	--	1.58	6.1	5.3
187	0.232	1.43	1.43	--	6.0	5.3
194	0.101	1.34	1.34	--	5.9	5.3
195	0.152	1.24	--	1.24	6.0	5.4
505	0.143	2.18	2.18	--	5.7	5.2
Avg.	0.150	1.55	1.65	1.41	5.9	5.3

Appendix Table V. Percentage of carbohydrate, dry solids, fat, and pH in muscle and liver of beef steers

Animal no.	Sucrose fed	Liver: Sugar moist basis	Liver: Dry solids	Liver: Fats	Liver: pH	Muscle: Sugar moist basis	Muscle: Dry solids	Muscle: Fats	Muscle: pH
	lbs.	%	%	%	%	%	%	%	%
				Fed Sucrose for 3 Days					
50	0	2.60	29.0	--	5.7	0.170	30.7	8.99	5.4
51	0	2.22	--	--	5.9	0.147	25.2	2.71	5.4
56	0	2.98	28.6	2.26	5.7	0.205	29.1	5.39	5.3
68	0	2.64	--	--	5.9	0.182	26.1	3.89	5.3
69	0	2.38	--	--	5.8	0.199	28.8	5.54	5.4
Avg.		2.56	28.8	2.26	5.8	0.181	28.0	5.30	5.4
76	2	2.88	--	--	5.8	0.160	27.5	4.69	5.4
78	2	2.61	--	--	5.9	0.204	30.7	8.25	5.4
79	2	2.72	28.6	3.69	5.9	0.245	28.3	5.12	5.3
80	2	2.77	31.1	3.82	5.8	0.125	27.7	6.47	5.4
81	2	2.80	29.1	3.62	5.7	0.245	27.6	--	5.3
Avg.		2.76	29.6	3.71	5.8	0.196	28.5	6.13	5.3
65	4	2.45	30.6	2.84	5.8	0.178	27.8	5.34	5.5
66	4	2.93	31.0	--	5.6	0.134	28.7	6.14	5.4
67	4	2.61	28.3	--	5.8	0.214	27.2	--	5.3
82	4	3.71	30.6	3.09	5.8	0.188	29.4	7.38	5.3
83	4	2.02	--	--	5.8	0.268	29.7	7.44	5.3
Avg.		2.94	30.1	2.96	5.8	0.196	28.6	6.58	5.4
				Fed Sucrose for 6 Days					
64	0	1.36	37.7	2.67	5.9	0.166	29.4	6.68	5.5
90	0	2.27	30.9	2.20	5.7	0.203	31.3	8.34	5.4
92	0	1.96	28.1	0.98	5.8	0.178	28.8	5.02	5.5
93	0	1.73	27.7	3.61	5.9	0.216	28.8	7.27	5.4
98	0	1.97	28.4	2.32	5.8	0.203	28.5	4.05	5.4
Avg.		1.86	28.6	2.36	5.8	0.193	29.4	6.27	5.4
72	2	2.13	28.2	3.70	5.8	0.237	30.3	7.47	5.4
74	2	2.12	29.8	3.15	5.9	0.245	29.8	6.33	5.4
75	2	1.44	28.5	1.33	5.8	0.198	28.9	6.44	5.4
88	2	2.62	33.0	5.76	5.7	0.207	30.1	5.69	5.4
91	2	3.55	30.9	1.14	5.8	0.178	29.1	5.79	5.4
Avg.		2.37	30.1	3.02	5.8	0.213	29.6	6.34	5.4
73	4	2.37	29.3	1.56	5.9	0.220	29.2	6.94	5.4
86	4	1.95	27.7	2.22	5.8	0.203	30.9	8.79	5.5
89	4	2.33	30.3	1.90	5.8	0.192	30.7	8.65	5.4
96	4	1.93	28.4	2.29	5.8	0.228	29.6	6.44	5.4
97	4	2.42	28.7	1.00	5.9	0.207	31.4	9.39	5.4
Avg.		2.20	28.9	1.79	5.8	0.210	30.4	8.04	5.4

Appendix Table V (continued).

Animal no.	Sucrose fed	Liver: Sugar moist basis	Liver: Dry solids	Liver: Fats	Liver: pH	Muscle: Sugar moist basis	Muscle: Dry solids	Muscle: Fats	Muscle: pH
	lbs.	%	%	%	%	%	%	%	%
				Fed Sucrose for 9 Days					
6	0	2.20	27.6	2.55	5.9	0.134	29.4	7.09	5.5
7	0	2.50	28.8	3.62	5.8	0.177	29.1	6.78	5.5
8	0	1.63	29.6	6.36	5.8	0.125	30.6	8.28	5.4
9	0	1.67	28.5	6.14	6.0	0.163	28.2	5.62	5.5
10	0	2.50	30.5	5.85	5.9	0.134	28.4	6.82	5.4
Avg.		2.10	29.0	4.90	5.9	0.147	29.2	6.92	5.5
11	2	2.64	30.8	3.29	5.8	0.114	28.9	6.27	5.4
12	2	2.72	29.0	1.97	6.0	0.146	29.5	6.26	5.4
13	2	2.61	31.1	2.13	5.9	0.114	28.1	5.20	5.5
14	2	1.59	28.6	1.29	6.0	0.206	27.7	4.93	5.4
15	2	1.95	29.7	2.05	6.0	0.136	29.6	7.4	5.4
Avg.		2.30	29.8	2.15	5.9	0.143	28.8	6.01	5.4
1	4	1.69	28.3	2.39	6.1	0.146	28.4	5.45	5.4
2	4	2.56	28.0	2.78	5.9	0.082	30.5	8.56	5.5
3	4	2.52	28.7	3.50	5.9	0.150	29.9	6.34	5.4
4	4	1.80	30.0	6.01	5.9	0.224	32.3	9.83	5.4
5	4	1.70	28.2	6.80	5.9	0.112	31.3	7.97	5.3
Avg.		2.06	28.6	4.30	5.9	0.143	30.3	7.63	5.4
				Fed Sucrose for 12 Days					
21	0	3.02	31.5	6.26	5.8	0.155	32.7	10.68	5.4
22	0	1.57	32.5	4.78	5.9	0.142	27.8	4.64	5.5
23	0	2.67	32.1	8.89	5.8	0.208	29.3	6.02	5.4
24	0	2.13	31.2	5.90	5.8	0.171	29.14	--	5.5
25	0	2.43	28.1	3.68	5.9	0.183	30.2	7.94	5.4
Avg.		2.36	31.1	5.90	5.8	0.172	29.8	7.32	5.4
16	2	2.59	29.8	3.77	5.9	0.179	30.3	8.52	5.5
17	2	2.56	31.9	6.17	5.8	0.179	27.8	--	5.5
18	2	2.34	29.5	1.90	5.9	0.232	28.9	--	5.5
19	2	1.84	32.5	6.20	6.8	0.179	28.4	5.12	5.4
20	2	2.89	29.8	3.29	5.9	0.163	28.3	5.43	5.4
Avg.		2.44	30.7	4.27	5.9	0.186	28.8	8.58	5.5
26	4	2.97	31.1	4.27	5.9	0.179	28.1	5.16	5.5
27	4	1.86	30.7	5.56	5.8	0.204	26.8	3.84	5.4
28	4	2.48	29.5	3.91	5.9	0.179	34.1	12.09	5.4
29	4	2.58	29.8	4.75	5.9	0.188	28.3	4.95	5.5
30	4	1.42	26.7	3.06	6.1	0.194	28.0	4.98	5.4
Avg.		2.26	26.6	4.31	5.9	0.189	29.1	6.20	5.4

Appendix Table VI. Quality appraisal tests and cooking loss on beef, Series II

Animal number	Sugar fed	Shearing*	Test panel by judges: Tenderness**	Texture	Flavor: Lean	Flavor: Fat	Juiciness	Cooking loss: Loss	Cooking loss: Drip	Cooking loss: Evap.
	lbs.	lbs.						%	%	%
Steers										
180	0	10.7	5.9	5.8	6.1	6.2	5.5	25.8	5.1	20.7
181	0	8.9	6.0	5.5	6.1	5.6	5.8	23.9	8.4	15.5
182	0	8.5	5.8	5.3	6.1	5.5	5.5	26.1	7.5	18.6
183	0	7.4	6.2	5.8	6.1	5.6	5.5	24.1	5.8	18.3
184	0	8.3	6.3	5.8	6.2	5.6	5.6	26.9	8.9	18.0
Avg.		8.8	6.0	5.6	6.1	5.7	5.6	25.4	7.1	18.3
Heifers										
189	0	8.3	5.7	5.3	5.9	5.2	5.1	33.2	12.0	21.2
191	0	13.0	4.9	5.4	5.6	5.4	5.0	25.6	6.4	19.2
192	0	7.6	6.2	5.7	5.8	5.8	5.7	29.7	10.6	19.1
193	0	12.3	5.2	5.4	5.6	5.5	5.0	26.7	6.0	20.7
893	0	13.4	4.9	5.1	5.6	5.2	5.6	21.9	4.4	17.5
Avg.		10.9	5.4	5.4	5.7	5.4	5.3	27.4	7.9	19.5
Steers										
177	6	14.8	4.4	4.9	5.3	5.8	4.9	15.3	8.9	6.4
178	6	9.8	5.1	5.2	5.5	5.6	5.3	26.0	9.4	16.6
179	6	8.8	5.9	5.8	6.2	5.2	5.6	26.8	6.7	20.1
185	6	12.4	4.6	5.0	5.4	5.6	5.4	29.1	9.4	19.7
186	6	7.8	5.8	5.5	6.0	5.8	5.8	31.1	11.7	19.4
Avg.		10.7	5.2	5.3	5.7	5.6	5.4	25.6	9.3	16.4
Heifers										
174	6	12.2	4.9	5.1	5.6	5.8	5.3	32.8	11.3	21.5
894	6	14.3	5.9	5.2	5.7	5.0	5.3	28.3	7.7	20.6
898	6	13.5	4.4	5.1	5.3	5.2	4.6	31.0	10.8	20.2
899	6	7.3	6.1	5.9	6.1	6.0	5.5	24.6	7.8	16.8
900	6	7.4	5.8	5.7	5.9	5.8	5.6	27.4	9.7	17.7
Avg.		10.9	5.2	5.4	5.7	5.6	5.3	28.8	9.5	19.3
Steers										
176	12	7.1	6.4	5.8	6.1	5.2	5.7	25.6	4.9	20.7
188	12	13.3	5.6	5.6	5.9	5.2	5.3	25.7	6.0	19.7
198	12	9.4	5.9	5.8	6.0	6.0	5.4	23.5	6.1	17.4
895	12	9.9	5.8	5.3	5.9	5.4	5.4	19.4	10.7	8.7
896	12	8.8	5.9	5.5	5.9	5.4	5.3	28.5	9.7	18.8
Avg.	12	9.7	5.9	5.6	6.0	5.4	5.4	24.5	7.5	17.0
Heifers										
173	12	13.4	3.5	4.5	4.9	5.0	5.0	23.8	8.3	15.5
187	12	9.1	5.8	5.7	5.8	5.6	5.7	26.1	8.3	17.8
194	12	7.6	5.7	5.6	5.9	5.6	5.4	16.6	6.7	9.9
195	12	12.2	5.1	5.2	5.5	5.5	5.2	32.3	8.0	24.3
505	12	13.3	5.2	5.8	5.7	5.2	4.8	27.9	10.1	17.7
Avg.		11.1	5.1	5.4	5.6	5.4	5.2	25.3	8.3	17.0

*Low score indicates meat is more tender

**High score indictes meat is more tender

Appendix Table VII. Quality appraisal tests and cooking loss on beef, Series III

Animal number	Sugar fed	Shearing*	Test panel by judges: Tenderness**	Texture	Flavor: Lean	Flavor: Fat	Juiciness	Cooking loss: Loss	Cooking loss: Drip	Cooking loss: Evap.
	lbs.	lbs.						%	%	%
				3 Day - Control						
50	0	6.3	6.2	5.8	6.0	5.2	5.9	30.4	11.5	18.9
51	0	8.5	5.2	5.3	5.8	6.0	5.6	31.7	12.0	19.7
56	0	6.3	5.9	5.7	6.2	6.2	5.9	24.6	7.8	16.8
68	0	8.3	5.6	5.4	5.4	5.0	5.5	30.3	8.4	21.9
69	0	6.9	6.1	5.9	6.1	5.0	5.6	27.2	9.0	18.2
Avg.		7.3	5.8	5.6	5.9	5.5	5.7	28.8	9.7	19.1
76	2	10.0	4.3	4.9	5.2	4.5	5.2	30.6	9.5	21.1
78	2	6.8	4.5	4.6	5.4	5.0	5.8	29.7	10.2	19.5
79	2	11.1	4.3	5.1	5.7	4.7	5.2	30.0	9.5	20.5
80	2	6.4	5.9	5.7	6.0	5.8	5.9	27.8	8.1	19.7
81	2	10.0	5.8	5.6	5.6	5.2	5.3	26.4	7.3	19.1
Avg.		8.9	5.0	5.2	5.6	5.0	5.5	28.9	8.9	20.0
65	4	6.7	5.8	5.4	5.8	5.2	5.9	26.0	9.0	17.0
66	4	7.2	6.6	6.1	5.8	5.5	5.1	26.3	7.2	19.1
67	4	7.3	5.7	5.5	6.3	5.2	5.8	29.4	14.6	14.8
82	4	9.6	5.1	5.2	5.7	5.0	5.8	30.4	10.8	19.6
83	4	9.6	5.7	5.8	5.8	6.0	5.6	26.4	8.4	18.0
Avg.		8.1	5.8	5.6	5.9	5.4	5.7	27.7	10.0	17.7
				6 Day Level						
64	0	10.4	4.9	5.3	5.8	5.5	5.6	24.2	8.0	16.2
90	0	6.9	6.0	5.9	5.9	5.5	5.6	27.1	10.1	17.0
92	0	11.4	5.3	5.6	5.7	6.2	5.3	28.6	11.0	17.6
93	0	8.1	5.2	5.3	5.9	5.8	5.7	31.2	12.8	18.4
98	0	8.2	5.8	5.6	5.7	6.5	5.4	27.5	9.2	18.3
Avg.		9.0	5.5	5.5	5.8	5.9	5.5	27.7	10.2	17.5
72	2	9.4	5.5	5.4	6.0	6.5	5.8	30.7	12.5	18.2
74	2	10.2	5.7	5.8	6.0	5.5	5.8	27.6	11.5	16.1
75	2	7.1	5.3	5.5	5.8	6.0	5.9	31.2	11.9	19.3
88	2	9.8	4.9	5.4	5.7	5.8	5.1	26.2	10.0	16.2
91	2	6.6	6.0	5.5	5.9	6.3	5.8	28.4	11.0	17.4
Avg.		8.6	5.5	5.5	5.9	6.0	5.6	28.8	11.4	17.4
73	4	11.0	5.1	5.4	6.0	5.3	5.8	29.5	11.6	17.9
86	4	9.4	4.6	5.1	5.4	5.5	5.7	30.4	11.1	19.3
89	4	7.5	6.5	5.8	6.0	6.0	6.0	30.8	11.5	19.3
96	4	6.5	6.1	5.6	5.9	5.3	5.5	30.9	10.8	20.1
97	4	7.1	5.6	5.4	5.9	6.3	5.8	28.9	8.8	20.1
Avg.		8.3	5.6	5.5	5.8	5.7	5.8	30.1	10.8	19.3

Appendix Table VII (continued).

Animal number	Sugar fed	Test panel by judges: Shearing*	Tenderness**	Texture	Flavor: Lean	Flavor: Fat	Juiciness	Cooking loss: Loss	Cooking loss: Drip	Cooking loss: Evap.
	lbs.	lbs.						%	%	%
				9 Day Level						
6	0	7.1	5.9	5.5	5.8	6.0	5.5	28.5	12.5	16.0
7	0	8.0	5.7	5.8	6.3	5.5	5.5	25.5	9.7	15.8
8	0	10.5	5.1	5.3	5.4	5.3	5.3	31.6	13.2	18.4
9	0	7.5	6.5	5.9	5.9	5.3	5.8	27.6	10.6	17.0
10	0	8.5	5.5	5.5	6.0	6.0	5.5	29.3	8.9	20.4
Avg.		8.3	5.8	5.6	5.9	5.6	5.5	28.5	11.0	17.5
11	2	7.4	6.2	5.8	5.8	5.0	5.4	26.9	7.8	19.1
12	2	7.8	5.6	5.3	6.0	5.3	6.0	25.9	10.3	15.6
13	2	7.7	5.9	5.5	5.8	5.8	5.0	30.4	11.1	19.3
14	2	7.1	5.7	5.7	5.7	6.0	5.3	31.9	16.2	15.7
15	2	8.0	5.8	5.6	6.0	5.3	5.8	27.4	11.1	16.3
Avg.		7.6	5.8	5.5	5.9	5.5	5.5	28.5	11.3	17.2
1	4	5.9	6.4	6.0	5.9	5.3	5.6	30.0	10.4	19.6
2	4	9.5	4.3	5.2	5.7	5.3	5.5	31.6	11.7	19.9
3	4	8.8	5.2	5.3	5.4	5.3	5.4	28.0	11.2	16.8
4	4	7.7	6.0	5.5	5.8	6.3	5.6	29.1	10.4	18.7
5	4	8.0	6.0	5.6	6.0	5.8	5.8	25.7	10.2	15.5
Avg.		8.0	5.6	5.5	5.8	5.6	5.6	28.9	10.8	18.1
				12 Day Level						
21	0	10.8	4.1	4.9	5.5	5.5	5.5	28.9	12.6	16.3
22	0	8.6	5.2	5.1	5.8	5.8	5.3	29.9	11.4	18.5
23	0	9.1	4.7	5.1	5.2	5.0	5.4	27.9	10.8	17.1
24	0	10.2	4.8	5.0	5.6	4.8	5.4	29.1	9.1	20.0
25	0	6.5	5.5	5.6	6.0	5.5	6.0	30.2	11.7	18.5
Avg.		9.0	4.9	5.2	5.6	5.3	5.5	29.2	11.1	18.1
16	2	8.8	4.7	4.7	5.6	5.5	5.7	27.7	10.0	17.7
17	2	8.3	5.5	5.3	5.8	5.5	5.1	30.9	10.2	20.7
18	2	9.0	5.6	5.1	5.8	5.0	5.5	26.2	8.0	18.2
19	2	11.3	5.5	5.5	5.8	5.3	5.5	24.7	9.5	15.2
20	2	6.0	6.2	5.7	6.1	5.0	5.6	24.8	9.2	15.6
Avg.		8.7	5.5	5.3	5.7	5.3	5.5	26.9	9.4	17.5
26	4	10.9	4.5	5.0	5.9	5.0	5.3	29.5	9.8	19.7
27	4	7.1	5.8	5.7	5.9	6.0	5.3	28.2	9.5	18.7
28	4	6.7	5.6	5.3	6.1	5.3	5.6	29.9	13.0	16.9
29	4	9.1	5.7	5.3	5.9	4.8	4.6	25.5	9.6	15.9
30	4	10.1	4.1	4.9	5.3	4.8	5.5	29.1	11.3	17.8
Avg.		8.8	5.1	5.3	5.8	5.2	5.5	28.4	10.6	17.8

Appendix Sheet 1

MEAT SCORING RECORD

Name_____

Date_____

Roast No.

Pair	A			B			C		
Sample No.									
Tenderness									
7 Very tender									
6 Tender									
5 Moderately tender									
4 Slightly tough									
3 Tough									
2 Very tough									
1 Extremely tough									
Texture									
7 Very fine									
6 Fine									
5 Moderately fine									
4 Slightly coarse									
3 Coarse									
2 Very coarse									
1 Extremely coarse									
Flavor of Lean									
7 Very desirable									
6 Desirable									
5 Moderately desirable									
4 Slightly desirable									
3 Neutral									
2 Slightly undesirable									
1 Undesirable									
Flavor of Fat									
7 Very desirable									
6 Desirable									
5 Moderately desirable									
4 Slightly desirable									
3 Neutral									
2 Slightly undesirable									
1 Undesirable									
Juiciness									
7 Very juicy									
6 Juicy									
5 Moderately juicy									
4 Slightly dry									
3 Dry									
2 Very dry									
1 Extremely dry									

Appendix Sheet 2

LIVER SCORING RECORD

Name_____

Date_____

Sample No.	Judge 1			Judge 2			Judge 3		
Tenderness									
5 Very tender									
4 Tender									
3 Moderate									
2 Tough									
1 Very tough									
Flavor of Liver									
5 Very desirable									
4 Desirable									
3 Slightly desirable									
2 Slightly undesirable									
1 Undesirable									

Cook the three samples of liver the same. Do not use flour. Either broil or fry in a small amount of fat. Mark samples with colored toothpicks or cut in different shapes so that you can keep each separate when you judge them together. Decide which sample you like best, which one second best, and which one least. Then mark as shown in the following example rating the best as 5 or 4, or whatever number you think it should be.

Sample No.	Judge 1			Judge 2			Judge 3		
Tenderness									
5 Very tender									
4 Tender									
3 Moderate									
2 Tough									
1 Very tough									
Flavor of Liver									
5 Very desirable									
4 Desirable									
3 Slightly desirable									
2 Slightly undesirable									
1 Undesirable									