A study of the effect of feeds on the cooking quality of lamb
by Judith Jean Belden

A THESIS Submitted to the Graduate Committee in partial fulfillment of the requirements for the degree of Master of Science in Home Economies at Montana State College
Montana State University
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Abstract:
1. The lambs used in ths study were Rambouillet wether and ewe lambs, approximately eight months old.

2. These lambs were fed by the Animal Husbandry Dept. on three different lots of feed:- barley and alfalfa hay; wheat and alfalfa hay; and barleys wet beet pulp, and alfalfa hay.

3. Complete records of the general observations made before roasting and after-roasting were kept to use in comparing the lamb from the three feeding lots.

4. All legs of lamb were roasted according to the standard method by searing for 30 minutes in an oven at 480° F. then reducing the oven temperature rapidly to 300° F. and cooking without water in an uncovered pan until the desired internal temperature of 182° F. - 183° F. or 83° C. was reached.

5. Thermocouples were used in this study to follow the internal temperature of the lamb during the roasting. The hot-end junctions of two thermocouples were inserted in each roast in manners as nearly alike as possible.

6. The wheat-fed lamb required the shortest cooking period and roasted at the average rate of 32.6 minutes per pound.

The barley-fed lamb required a longer period with an average roasting rate of 37.3 minutes per pound. When wet beet pulp was added to the barley and alfalfa feed, the lamb required the longest cooking"period, roasting at an average rate of 39.8 minutes per pound.

7. Each leg of lamb was scored by a committee of ten Judges who used the meat grading chart as prepared by the nation- al meat committee.

8. According to the average judgments, the barley-fed lamb produced a lean meat that was slightly more intense in flavor but more desirable than that produced by the wheat or barley and pulp-fed lamb.

9. The barley and pulp-fed lamb produced the juiciest cooked meat. The wheat-fed lamb gave the driest cooked meat.

10. From the tests for tenderness determined both from the judgments and from the shearing strength, the barley-fed lamb seemed to be more tender than the wheat-fed lamb.

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A STUDY OF THE EFFECT OF FEEDS ON THE COOKING QUALITY OF LAMB

INTRODUCTION

It is commonly recognized that meats may vary greatly in their quality and palatability. That a number of factors, such as breed, sex, age, and feed are responsible for these variations has been demonstrated by the experiences of meat producers as well as by investigations being carried on by the Institute of Animal Nutrition in England and by state experiment stations in cooperation with the United States Department of Agriculture.

In these considerations of meat quality, special emphasis has been placed on the study of beef and pork, due to their popularity and more general use. However, in the last few years, lamb has been steadily advancing in its place of importance among the meats and now appears regularly on the market, so that it is beginning to receive more attention with respect to its variation in quality. Since lamb has a rather unusual flavor, it seems to require more investigation than other meats in order to obtain a product that might be more popular with the consumer.

Montana, being a sheep-raising state, has become especially interested in the production of lamb of good quality and finish. The fact that several kinds of feeds are available within the state for this purpose, has drawn the attention of the producers and the investigators to a consideration of the comparative

effects of these feeds upon the quality of the lamb produced. The grains, barley, oats, and wheat have each been fed in combination with alfalfa hay. To some of these rations, beet pulp has also been added, and in some instances, wheat screenings have been substituted for the grains.

At first, the results of these feeding tests were judged by the degree of finish of the lamb before slaughtering and the condition of the carcass. Later, it seemed advisable to carry the comparisons farther by including the judgments of the respective cooking quality and palatability of each kind of lamb as produced by different rations.

In connection with the latter plan, this study has been carried on through the cooperation of the departments of Animal Husbandry and Home Economics of the Montana Experiment Station to determine the effect of three feed combinations;- (1) barley and alfalfa hay, (2) wheat and alfalfa hay, and (3) barley, alfalfa hay, and beet pulp,- upon the cooking quality and palatability of lamb.

HISTORY

Practically all of the meat investigations have been carried on since the year 1900. During this period, several trends in the study of meats have appeared. At first, investigation ended with the slaughter of the animal and the grading of the carcass. Later, there was developed an interest in methods that would improve the quality and market value of the meat. Then certain workers began to pay attention to the experimental cooking of meats, most of the early data being reported by Grindley, Sprague and co-workers (16) at the University of Illinois. This formed a basis for developing standard methods of roasting.

When it was recognized that certain factors, which might affect the quality of meat, had not been observed, the workers began to realize a definite need for additional information along this line. It was therefore due to this need, that in 1924 the National Live Stock and Meat Board promoted the national project, "Cooperative Meat Investigations", which has included studies to show how the quality and palatability of meats are affected by such factors as age, breed, sex and feed. As a result of experimental work and observations that have been carried out, interesting conclusions have been reached on the factors considered.

There have been eight years of work done on a general nation-wide project relative to the factors influencing the palatability of beef. Five years of this project (1925-1930)

were devoted to the study of the "Influence of Age on the Quality and Palatability of Beef". Nelson, Lowe and Helser at Iowa State College (17) concluded that roasts from two year old and yearling steers were more palatable than roasts from calves.(20) Another project concerned with the age of the animal was carried on at Purdue University (24) which investigated the relation between maturity and the quality of meat in swine. They found that young pigs were soft in fat, the fat hardening during the growth and fattening processes of the pigs.

Seven state experiment stations have been investigating the influence of sex in cattle on the quality and palatability of the beef produced. This part of the project was started in Nov. 1930. Steers and heifers directly comparable for age, breeding, previous feeding, and management, produced beef which showed no consistent difference in palatability (10). The greatest difference appeared to be in the individual and not in the sex. The problem of sex as related to meat produced by sheep was reported in the completed ram and wether meat project handled by four stations over a period of five years which showed no difference in the tenderness and palatability of meat from the two sexes, and in no case did the meat from the ram lambs possess a disagreeable or bucky flavor (18).

Numerous studies have been made regarding the influence of breeding on the quality and palatability of beef produced,

but so far the results have been so variable that no definite conclusions can be reached. However, at a meeting of the representatives of institutions engaged in the Cooperative Meat Investigations held at Chicago in 1932, data were collected from lamb meat projects on the influence of breeding on lamb meat. The lambs used in this study were produced at the Ohio experiment station (18). Corriedale rams were crossed on native West Virginia ewes of Hampshire type, the first of these Corriedale crosses indicated that their quality of meat is very similar to that produced in previous years by the use of Hampshire and Shropshire rams. Their meat graded moderately for both intensity and desirability. In Mississippi (18), tests on native, Southdown native, and high grade Southdown lambs showed no significant difference in the palatability of meat from these three lots.

Feeds have become an important factor not only in the study of their effect on the quality of the meat, but also their effect on the palatability of the meat. Considerable work has already been done in this connection, but there still remains much to be learned. The Illinois station (5) reported that barley-fed animals attained a better finish than corn-fed animals. They found no difference in firmness of the fat, but the lean was better on the barley-fed. Then Linfield at the Montana station (13) reported two trials in which wheat was

slightly superior to barley for fattening lambs. At the Utah station (14) they noted that ground barley was noticeably less palatable than whole barley.

In experimenting with wheat for fattening lambs, the station at the University of Nebraska (27) stated that the cooking tests and palatability studies of roasted legs of lamb showed no significant difference in corn-fed and wheat-fed lambs. In 1927 the Montana station (26) carried out an experiment with lambs fed wheat screenings containing 28.1% wheat, 16.1% fanweed, 20% hare's ear mustard and lesser amounts of other weed seeds. The lambs developed a wild seed flavor in meat after 60 days on feed. Feeding on screenings for 68 days and then on wheat for 60 days almost eliminated the objectionable flavor. In lambs fed wheat 82 days after 128 days on screenings the flavor was reduced to an almost negligible point. The meat produced when wheat was used for fattening had when roasted a rather desirable aroma and flavor, but was slightly tough and of loose fibrous texture.

Other feed investigations have included the one reported by the Kansas station (21) on the influence of feed of grass-fed cattle on the cooking qualities of meat. Cattle fed on blue-stem grass hay alone produced a more desirable meat than others fed with blue-stem grass hay and corn. The Nebraska station (23) reported on three lots of lamb; Lot I, full-fed shelled corn and alfalfa hay for 140 days; Lot II, full-fed the same

ration for 84 days, then a maintenance ration; Lot III, maintenance ration of alfalfa hay for 56 days, then corn and alfalfa for 84 days. Lot I roasts had a more choice aroma, while the flavor of the fat and the lean was less marked and more desirable. Purdue University (18) fed Rambouilett range lambs on a ration of only clover hay and corn silage and reported that the meat was very undesirable in aroma and flavor.

There was no significant difference in the palatability of lambs fed oats and barley as found by the Montana station (18), nor did the addition of wet beet pulp to these feeds seem to alter these results. Wyoming (19) stated that corn silage and wet beet pulp each when added to a ration of barley and alfalfa improved the palatability, and wet beet pulp added to a ration of barley alone increased the rate of gain and improved the quality of lamb.

All methods of cooking meat have been investigated, but roasting has received the most attention. Standard cooking methods have been developed for beef, veal, pork and lamb. Previous work on standard methods of preparation began at the Illinois station in 1900 (1). Experiments showed the advantages of roasting beef ribs in an open pan without water. However, Nelson and Morgan (15) found no difference in the speed of roasting and the shrinkage of meat with covered and open pans.

The study of the effect of temperature and time of cooking

on the quality and palatability of meat by the Missouri experiment station (22) concluded that the oven temperature did not have a decided effect on the palatability of the meat. The higher oven temperature did increase the total cooking losses, but decreased the cooking time per pound. Cline and Godfrey (6) roasted beef at various temperatures finding that roasting at a constant temperature of 230° - 325° F. gave a product judged more palatable and at 425° - 500° F. less palatable. Alexander (2) (3) experimented with the shrinkage of roast beef in relation to the fat content and cooking temperature and stated that the shrinkage of meat during cooking affects its appearance, palatability, nutritive value, and quantity.

In the National project the United States Department of Agriculture has been responsible for developing standard methods of cooking lamb. The methods worked out by Alexander and Yeatman in the Bureau of Home Economics are now in use. The 1930 report of this Bureau showed that there has been research done on the cooking of legs of lamb for the purpose of determining comparative effects of slow and rapid roasting. So far there appears to be no definite relation between roasting temperature, tenderness and flavor. However, there is a close relation between cooking loss, or shrinkage and oven temperature (25).

In a 1932 report on an experiment to determine the effect of initial searing in roasting beef, pork and lamb, roasts of lamb cooked at a constant, low temperature without preliminary

searing had a dull or very pale external fat, while those seared were more attractive. Searing decreased the number of minutes per pound but caused greater cooking losses. There was, however, no difference in palatability between the seared and unseared roasts (18).

Along with the development of cooking methods has come a recognition of the fact that meats may exhibit a variety of cooking qualities, that is, they do not always yield similar products under the influence of certain conditions of cookery. While the aroma, flavor and texture produced in the cooked meats appear to have been largely predetermined by the feeds used, very little has been done to show the cause of some meats remaining tough while others are tender; some being dry while others are juicy; and some cooking quickly while others cook slowly. This latter question has been considered in a few studies. Recently the United States Department of Agriculture (1) has found that ripened lamb cooks more quickly than strictly fresh lamb, and the University of California in 1927 (1) reported that the rate of heat penetration of roasts was increased by external fat but retarded by internal fat.

Since so little information is available regarding the effect of feeds on the cooking quality of meat, it has seemed desirable to carry on some further investigations along this line. For this particular study lamb has been used, with the

purpose of showing the effect of three feed combinations,- (1) barley and alfalfa hay, (2) wheat and alfalfa hay, (3) barley, alfalfa hay and beet pulp,- upon its cooking quality.

EXPERIMENTAL PROCEDURE

In this study of lamb, the samples were secured from three feeding lots of range lambs maintained by the Animal Husbandry Department. These consisted of Rambouillet wether and ewe lambs, about eight months of age.

The lambs were grouped into three lots, I, II, and III, according to the kind of feed that had been used. Five lambs were taken from Lot I, which had been finished on barley and alfalfa hay at Huntley; four from Lot II, fed on wheat and alfalfa hay at Fort Ellis; and five from Lot III, fed on barley, wet beet pulp, and alfalfa hay at Huntley. The average live weight, dressed weight, and weight the day the lambs were brought in to the experiment station, are given for each feeding lot.

	Av. live wt. Jan. 3	Av. dressed wt. Jan. 3	Av. wt. Jan. 6
Lot I	96.0 lbs.	47.4 lbs.	44.8 lbs.
Lot II	99.0 "	48.0 "	47.2 "
Lot III	95.4 "	47.2 "	45.2 "

A good quality alfalfa, first and second cuttings, were fed with Trebi barley, soft wheat, and beet pulp trucked from the Great Western Sugar Company, Billings, Montana. These feeds were analyzed by the chemistry department, and their chemical composition is presented here.

Chemical Composition of Feeds Used in Fattening Lambs.

	Water	Ash	N	Crude protein (Nx6.25)	Carbohydrates Crude fiber	Carbohydrates N. F. extract	Ether extract
Lot I							
Barley	11.91	3.11	1.98	12.375	8.88	62.455	1.27
Alfalfa hay	8.77	4.47	3.18	19.875	24.40	39.695	2.79
Lot II							
Wheat	10.49	1.77	1.38	8.625	2.77	74.125	2.22
Alfalfa hay	10.67	6.70	1.67	10.438	42.43	28.002	1.76
Lot III							
Barley	11.91	3.11	1.98	12.375	8.88	62.455	1.27
Wet beet pulp	88.80	3.11	1.96	12.250	33.54	49.64	1.46
" " "	90.88	3.26	2.00	12.500	32.90	49.50	1.84
Alfalfa hay	8.77	4.47	3.18	19.875	24.40	39.695	2.79

The cut of meat adopted for the roasting tests was the leg of lamb, as recommended by the national meat committee. Both the right and left legs from each of these carcasses were used.

When the legs of lamb were delivered to the experimental cooking laboratory, each sample was labeled by means of a numbered aluminum band, which remained on the leg during the entire period of testing. These labeled samples were then loosely wrapped in cloth and placed on racks in an electric

refrigerator so that a circulation of air was assured. They were allowed to remain in this storage for a period of two to five days before the roasting work was begun. This made the total aging period vary from six to nine days.

At the end of this aging period, the roasts were prepared for the oven. Each leg was cleaned with a damp cloth, and the fell removed with a sharp knife. The fell is a thin, papery, outer covering on the lamb carcass. At the present time it is believed that the flavor of the lamb roast is not affected by the fell. However, it is sometimes advised to remove the fell previous to cooking, (4) and as this seems to be the practice of many housewives, it was removed from the samples used in this experimental work.

General observations recorded for each sample previous to roasting, included qualitative and quantitative grading of the color, texture and amount of fat, as well as the color, firmness and texture of the lean.

Since it seemed desirable to determine the effect of roasting on the total loss in weight of the roast, the weight of each leg, as prepared for the oven, was recorded. As it was interesting to note whether there was any relation between the weight and volume of the legs of lamb, volumes for the individual uncooked samples were also taken and recorded.

As two thermocouples were to be inserted in each roast, two small openings were made in each sample by means of a

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stiletto. One hole was made in a definite position in the larger and thicker muscle of the sample, while the other was made about two inches from the first in a thinner portion. Thermocouples in each roast were inserted in these same general positions, for if the thermocouple point should be placed in a different portion, the structure of the muscle might cause a variation in the rate of heat penetration.

The roasts were placed in light weight oval aluminum roasters of the same style and size. They measured 13 x 7½ x 3½ inches.

While the samples of lamb were being prepared for cooking the oven was preheated to 480° F. The range available for this work was an electric Hotpoint range and the well insulated oven was equipped with an automatic heat control, which was tested and adjusted previous to the roasting work by checking with an accurate oven thermometer. Since the oven, which measures 14 x 18 x 18 inches, held two of the aluminum roasters used in this study, two legs, representing samples from different lots were always baked at the same time.

When the oven reached 480° F. four thermocouples were pulled through the steam vent opening in the back of the oven. To do this it was necessary to remove the adjustable vent cap. The thermocouple wires were inserted through a cork in the vent. The hot junctions of two of the thermo-

couples were inserted in each roast in the holes previously prepared. At this time data were recorded indicating the thermocouple number, the roast number, the placement of each point in the sample and the initial internal temperature of the roast. To insure good insulation of the end of the thermocouple, bread dough was securely pressed around each one at the point of insertion into the meat.

The thermocouples were used in this study to follow the internal temperature of the samples during the roasting process. The equipment consisted of four No. 22 B & S gauge Hoskins thermocouples, six feet long, and covered with asbestos. These were attached to twenty-foot lead wires that were connected to a four-point selective switch which in turn was connected with a Hoskins, high resistance type, T.A. pyrometer 550° F., equipped with an automatic cold end compensation. This switch, together with the cold end compensation facilitated the ease and accuracy of taking the temperature readings.

A standard method for roasting lamb, the one recommended by Alexander (4) (8) of the Bureau of Home Economics, was followed. The roasts were seared for 30 minutes at 480° F. At this time the oven temperature was reduced to 300° F. and the cooking was continued at this temperature, without water and without a cover, until the internal temperature had reached 182° - 183° F. or 83° C. Thermocouple readings were taken on the pyrometer every five minutes. The internal temperature

required by these roasts for a given stage of "doneness" was obtained from a summary of the developments in the science of cooking, as reported by Halliday and Noble (8). These workers recommend an internal temperature of 83° C. for a well done lamb roast.

When the roasts were done, they were at once removed from the oven. In order to calculate and distribute the losses in weight of the lamb roasts during the cooking process, weights were taken of the roaster containing the roast and drippings. The roast was then removed and the pan with the drippings was again weighed. As the weights of all roasters had previously been taken, they were deducted from the above, and the individual weights of the cooked roast and its drippings were recorded. To obtain approximately the relative proportion of fat to meat extract present in these drippings, they were poured into a beaker and allowed to cool. The fat which solidified on the top was removed, weighed and measured for volume.

Since it is recognized that the quality of meat cannot be determined without the judgment and reaction of the ultimate consumer, the palatability of these roasts was scored by a committee of interested and well qualified people. This group consisted of five men and five women, all accustomed to the routine of placing judgments on many and varied food materials. Each judge was given a number which he kept throughout the testing period. Number one was always given the first

slice from the thicker part of each roast, after a generous cutting of the outer crust had been removed. Number two received the second slice, and so on. As this serving plan was carried on in this numerical order every judge received a comparable sample from each of the roasts.

The meat grading chart prepared for the cooperative meat investigations carried on by the national meat committee was used in this study. The factors of palatability considered were,- aroma, texture, flavor of fat, flavor of lean, tenderness, quality of juice and quantity of juice. Each factor was described by the use of qualifying terms, which were arranged in a numerical sequence. A copy of this grading chart follows and may be referred to at this time. All grading was done individually, each judge checking the term which he thought best described the sample.

It is frequently noted that a quality tested mechanically shows a higher degree of accuracy than one judged according to a personal reaction. With this in mind, samples from each roast were tested for tenderness by means of an apparatus arranged for determining the shearing strength, mechanically. Five to six samples of meat were removed from the same muscle of each leg by means of a number 8 cork borer. As there is no standard machine yet devised for testing the tenderness of meat, it was necessary to use an arrangement available in the laboratory. A small spring balance was fastened to the handle

MEAT COOKING RECORD
Grading Chart for Cooked Meat

Date_____

Sample No._____

Judge_____

Factor	Phase	7	6	5	4	3	2	1
Aroma	Intensity	Very Pronounced	Pronounced	Moderately pronounced	Slightly pronounced	Perceptible	Slightly perceptible	Imper-ceptible
	Desir-ability	Very desirable	Desirable	Moderately desirable	Slightly desirable	Neutral	Slightly undesirable	Undesir-able
Texture	Intensity	Very fine	Fine	Moderately fine	Slightly coarse	Coarse	Very Coarse	Extremely coarse
Flavor of fat	Intensity	Very pronounced	Pronounced	Moderately pronounced	Slightly pronounced	Perceptible	Slightly perceptible	Imper-ceptible
	Desir-ability	Very desirable	Desirable	Moderately desirable	Slightly desirable	Neutral	Slightly undesirable	Undesir-able
Flavor of lean	Intensity	Very pronounced	Pronounced	Moderately pronounced	Slightly pronounced	Perceptible	Slightly perceptible	Imper-ceptible
	Desir-ability	Very desirable	Desirable	Moderately desirable	Slightly desirable	Neutral	Slightly undesirable	Undesir-able
Tender-ness	Intensity	Very tender	Tender	Moderately tender	Slightly tough	Tough	Very tough	Extremely tough
Quality of juice	Richness	Very rich	Rich	Moderately rich	Slightly rich	Perceptible	Slightly perceptible	Imper-ceptible
Quantity of juice	Amount	Very large	Large	Moderately large	Slightly large	Small	Very small	Neg-ligible

Color of Lean

1. Light red
2. Dark pink
3. Light pink
4. Pinkish brown
5. Light brown
6. Dark brown

Color of Fat

1. White
2. Creamy white
3. Grayish cream
4. Yellowish brown
5. Yellow
6. Amber

Remarks:-

of a microtome which was set in a definite horizontal position. A steady downward pull was exerted on the scale until the blade of the microtome had passed the downward cutting position. This position was again noted so that each stroke had the same starting and stopping places. The amount of pull exerted on the spring balance in turning the microtome without any meat sample present, was recorded and considered as the initial force required to move the machine. In testing the shearing strength of the meat a cylindrical piece of meat, removed by the cork borer and measuring from two to three inches in length, was firmly placed in the jaws of the microtome. As it seemed necessary to balance the other end of the sample it was inserted into a test tube which held it rather firmly. This test tube was held horizontally during the shearing process. A pull was then exerted on the spring balance and the scale registered the amount of force required to cut through each sample of meat. The blade of the microtome was uniformly sharpened between the testing of samples from the different roasts.

Final observations on the color, juiciness and the texture of the roasted lamb, based on its appearance when carved were recorded.

RESULTS

Following the methods that have been outlined, the study of the effect of the feeds,- barley and alfalfa, wheat and alfalfa, and barley, beet pulp, and alfalfa,- on the cooking quality and palatability of lamb was conducted during the winter of 1933. At this time data were recorded to be used in the comparison of the legs of lamb from the different lots of feed.

General observations were made on the fat and the lean of each leg of lamb before roasting. The color, quality and amount of the fat were considered, and the color, texture, and firmness of the lean. These observations are recorded in tables I and II.

Although there are no outstanding differences to be found in the raw lamb from the three lots, the texture of the lean of the lamb fed on wheat and alfalfa appears to be coarse, while the lean of the lamb on the other feeds are of varying degrees of fineness and stringiness. This coarseness does not show up so decidedly in the cooked meat. The juiciness of the lean of the wheat and alfalfa-fed lamb was consistently less than the others. These general observations made on the legs of lamb after roasting are found in table III.

There are two kinds of losses in roasting, (1) due to the evaporation of moisture and other volatile material, and (2) loss of drippings. These losses are related to the factor

TABLE I. GENERAL OBSERVATIONS MADE ON FAT OF LEGS OF LAMB BEFORE ROASTING.

No. of roast	Kind of feed	Color of fat	Quality of fat	Amount of fat
61	Barley-alfalfa	pinkish-white	sl. greasy	moderate
62	" "	" "	mod. "	"
63	" "	" "	" "	"
64	" "	" -cream	sl. "	"
65	" "	" "	mod. "	scant
66	" "	" "	sl. "	moderate
67	" "	cream-white	not "	"
68	" "	pinkish-cream	mod. "	"
69	" "	" "	sl. "	"
70	" "	" "	" "	"
71	Wheat-alfalfa	" "	very "	large
72	" "	" "	" "	moderate
73	" "	" "	" "	"
74	" "	" "	" "	large
75	" "	" "	mod. "	moderate
76	" "	" -white	sl. "	"
77	" "	" "	" "	"
78	" "	" "	mod. "	"
51	Barley-pulp-alf.	" -cream	sl. "	"
52	" "	" "	" "	"
53	" "	" -white	" "	"
54	" "	" "	mod. "	scant
55	" "	" "	not "	large
56	" "	" "	mod. "	moderate
57	" "	" "	" "	"
58	" "	" "	sl. "	"
59	" "	" -cream	very "	"
60	" "	" -white	sl. "	"

TABLE II. GENERAL OBSERVATIONS MADE ON LEAN OF LEGS OF LAMB BEFORE ROASTING.

No. of roast	Kind of feed	Color of lean	Texture of lean	Firmness of lean
61	Barley-alfalfa	dark red	sl. fine	lacking
62	" "	" "	" "	moderate
63	" "	" "	very "	lacking
64	" "	" "	sl.stringy	pronounced
65	" "	bluish red	mod. fine	moderate
66	" "	dull red	stringy	pronounced
67	" "	bright red	"	slight
68	" "	dark red	"	"
69	" "	" "	sl.stringy	pronounced
70	" "	dull "	" "	moderate
71	Wheat-alfalfa	bright red	coarse	pronounced
72	" "	" "	"	slight
73	" "	" "	"	"
74	" "	" "	"	"
75	" "	" "	"	"
76	" "	dark red	sl. fine	moderate
77	" "	" "	" coarse	"
78	" "	" "	" "	"
51	Barley-pulp-alf.	" "	" stringy	pronounced
52	" "	" "	mod.fine	moderate
53	" "	" "	coarse	"
54	" "	" "	sl.stringy	slight
55	" "	dull "	mod. fine	pronounced
56	" "	" "	fine	"
57	" "	" "	sl.stringy	moderate
58	" "	" "	" "	pronounced
59	" "	" "	mod. fine	moderate
60	" "	dark "	sl. fine	"

TABLE III. GENERAL OBSERVATIONS MADE ON LEGS OF LAMB AFTER ROASTING.

No. of roast	Kind of feed	Color of lean	Texture of lean	Juiciness of lean	Average shearing strength in lbs.
61	Barley-alfalfa	lt. brown	sl. coarse	slight	1.05
62	" "	pinkish brown	" "	abundant	1.55
63	" "	lt. brown	" fine	slight	1.54
64	" "	" "	mod. "	moderate	1.80
65	" "	" "	" "	"	2.35
66	" "	" "	" "	slight	1.29
67	" "	" "	sl. "	sl. dry	1.13
68	" "	" "	" coarse	" "	2.13
69	" "	" "	very "	moderate	1.50
70	" "	" "	sl. "	sl. dry	1.46
71	Wheat-alfalfa	" "	mod. fine	slight	1.85
72	" "	" "	sl. coarse	"	1.93
73	" "	" "	mod. fine	"	2.50
74	" "	pinkish brown	" "	"	1.63
75	" "	lt. brown	sl. coarse	"	2.05
76	" "	" "	" "	very dry	1.05
77	" "	pinkish brown	coarse	" "	1.66
78	" "	" "	mod. fine	moderate	1.33
51	Barley-pulp-alf.	lt. brown	sl. fine	slight	1.20
52	" "	pinkish brown	" "	abundant	1.70
53	" "	" "	" "	sl. dry	1.90
54	" "	" "	" coarse	moderate	1.79
55	" "	lt. brown	mod. fine	mod. dry	1.75
56	" "	" "	very "	abundant	1.90
57	" "	" "	sl. "	slight	1.38
58	" "	" "	" "	sl. dry	1.29
59	" "	pinkish brown	" coarse	moderate	1.83
60	" "	" "	" "	slight	1.66

of juiciness, which in turn determines to a large extent the quality and the palatability of the meat (12). Table IV gives the cooking losses during the roasting of legs of lamb as expressed in weight. The same data are presented in table V in percentages.

For a comparison of the losses in weight of each leg of lamb during roasting, the weights were taken before roasting and after roasting. These are recorded in table VI. It will be noted in the total losses listed that the individual variations within a single lot are so great that it prevents a comparison of the three lots.

The temperatures of the roasts at ten minute intervals were averaged and recorded as the average time-temperature data during the roasting of legs of lamb from each feeding lot, table VII. Lot III averaged the longest total cooking period of 280 minutes, while Lot II required the shortest total cooking period of 230 minutes. Lot I occupied an intermediate position.

The composites of the time-temperature relationships during the roasting of the lamb from the three feeding lots (figure 1) show that there was a lag in the roasting of the barley, pulp and alfalfa-fed lamb, and the average cooking time was longer. The composite curves of barley and alfalfa fed lamb are more nearly alike, the differences in the time

TABLE IV. COOKING LOSSES DURING THE ROASTING OF LEGS OF LAMB EXPRESSED IN WEIGHT.

No. of roast	Kind of feed	Wt. before roasting gms.	Loss by evap. gms.	Loss by drippings gms.	Fat in drippings gms.	Liquid in drippings gms.	Total loss gms.
61	Barley-alfalfa	2360	261.1	297.0	95.5	201.5	558.1
62	" "	2357	181.1	209.4	61.9	147.5	390.5
63	" "	1863	259.2	205.4	89.2	116.2	464.6
64	" "	1866	204.0	208.1	78.6	129.5	412.1
65	" "	2182	258.3	301.6	113.4	188.2	559.9
66	" "	2270	305.2	345.8	128.8	217.0	651.0
67	" "	2328	270.2	355.1	76.9	278.2	625.3
68	" "	2347	295.4	320.4	89.7	230.7	615.8
69	" "	2019	276.5	236.4	123.3	113.1	512.9
70	" "	1919	250.5	276.8	107.1	169.7	527.3
71	Wheat-alfalfa	2369	215.3	354.9	103.3	251.6	570.2
72	" "	2334	357.3	249.9	103.6	146.3	607.2
73	" "	2376	254.1	352.4	73.3	279.1	606.5
74	" "	2386	228.8	362.9	84.3	278.6	591.7
75	" "	2265	16.6	359.7	101.8	257.9	376.3
76	" "	2385	263.9	348.8	129.8	219.0	612.7
77	" "	2238	262.1	294.9	147.6	147.3	557.0
78	" "	2264	202.6	305.4	108.8	196.6	508.0
51	Barley-pulp-alf.	2080	235.1	274.1	100.5	173.6	509.2
52	" "	2087	208.6	251.0	110.5	42.3	459.6
53	" "	2289	270.8	393.5	79.5	31.4	664.3
54	" "	2257	259.0	264.9	96.1	168.8	523.9
55	" "	2131	356.3	290.0	110.3	179.7	646.3
56	" "	2107	228.8	249.9	86.9	163.0	478.7
57	" "	2204	297.1	300.7	86.0	214.7	597.8
58	" "	2258	311.6	286.8	94.8	192.0	598.4
59	" "	2275	175.1	216.2	78.3	137.9	391.3
60	" "	2257	200.0	340.4	77.4	263.0	540.4

TABLE V. COOKING LOSSES DURING THE ROASTING OF LEGS OF LAMB EXPRESSED IN PERCENTAGE.

No. of roast	Kind of feed	Wt. before roasting gms.	% loss by evap.	% loss by drippings	% fat in drippings	% liquid in drippings	% total loss
61	Barley-alfalfa	2360	11.00	12.50	32.10	67.80	23.60
62	" "	2357	7.68	8.88	29.50	70.40	16.50
63	" "	1863	13.91	11.02	43.40	56.50	24.93
64	" "	1866	10.93	11.15	37.70	62.20	22.08
65	" "	2182	11.83	13.82	37.50	62.40	25.66
66	" "	2270	13.44	15.23	37.20	62.70	28.67
67	" "	2328	11.60	15.25	21.60	78.30	26.85
68	" "	2347	12.58	13.65	27.99	72.00	26.24
69	" "	2019	13.69	11.70	52.10	47.80	25.40
70	" "	1919	13.05	14.40	38.60	61.30	27.47
71	Wheat-alfalfa	2369	9.08	14.97	29.10	70.89	24.06
72	" "	2334	15.30	10.70	41.40	58.50	26.01
73	" "	2376	10.69	14.83	20.80	79.19	25.52
74	" "	2386	9.58	15.20	23.22	76.77	24.79
75	" "	2265	.73	15.88	28.30	71.69	16.61
76	" "	2385	11.06	14.62	37.21	62.78	25.68
77	" "	2238	11.71	13.17	50.05	49.94	24.88
78	" "	2264	8.94	13.48	35.62	64.37	22.43
51	Barley-pulp-alf.	2080	11.30	13.17	36.60	63.30	24.48
52	" "	2087	9.99	12.02	44.02	55.98	22.01
53	" "	2289	11.83	17.19	20.20	79.70	29.02
54	" "	2257	11.47	11.73	36.27	63.72	23.20
55	" "	2131	16.72	13.60	38.00	61.90	30.32
56	" "	2107	10.85	11.86	34.77	65.22	22.71
57	" "	2204	13.47	13.64	28.59	71.40	27.12
58	" "	2258	13.79	12.70	33.05	66.94	26.49
59	" "	2275	7.69	9.50	36.21	63.78	17.20
60	" "	2257	8.86	15.08	22.73	77.26	23.94

TABLE VI. THE LOSS IN WEIGHT OF EACH LEG OF LAMB DURING ROASTING.

No. of roast	Kind of feed	Vol. before roasting c.c.	Wt. before roasting gms.	Wt. after roasting gms.	Total loss gms.
61	Barley-alfalfa	2060	2360	1801.9	558.1
62	" "	2140	2357	1966.5	390.5
63	" "	1670	1863	1398.5	464.6
64	" "	1620	1866	1453.9	412.1
65	" "	1970	2182	1621.1	559.9
66	" "	2070	2270	1619.0	651.0
67	" "	2175	2328	1702.7	625.3
68	" "	2120	2347	1730.9	615.8
69	" "	1750	2019	1506.1	512.9
70	" "	1760	1919	1391.7	527.3
71	Wheat-alfalfa	2180	2369	1799.2	570.2
72	" "	2110	2334	1726.9	607.2
73	" "	2140	2376	1769.5	606.5
74	" "	2030	2386	1794.7	591.7
75	" "	2170	2265	1888.7	376.3
76	" "	2110	2385	1772.3	612.7
77	" "	2010	2238	1681.0	557.0
78	" "	2020	2264	1756.2	508.0
51	Barley-pulp-alf.	1870	2080	1570.8	509.2
52	" "	1890	2087	1836.0	251.0
53	" "	1990	2289	1624.2	664.3
54	" "	2080	2257	1733.5	523.9
55	" "	2000	2131	1484.6	646.3
56	" "	1870	2107	1628.3	478.7
57	" "	1980	2204	1606.4	597.8
58	" "	2050	2258	1659.8	598.4
59	" "	2060	2275	1883.7	391.3
60	" "	1940	2257	1716.6	540.4

TABLE VII. THE AVERAGE TIME-TEMPERATURE DATA DURING ROASTING OF LEGS OF LAMB FROM EACH FEEDING LOT.

Time in minutes	Lot I Barley-alfalfa Av. temperature °F.		Lot II Wheat-alfalfa Av. temperature °F.		Lot III Barley-pulp-alf. Av. temperature °F.	
0	47	± 2.30	47	± 0.00	60	± 0.00
10	54	± 2.02	63	± 8.17	62	± 1.63
20	64	± 8.22	67	± 5.76	60	± 8.09
30	67	± 8.22	71	± 4.36	64	± 6.84
40	73	± 6.38	76	± 6.12	69	± 7.17
50	85	± 5.41	86	± 7.50	77	± 8.15
60	99	± 4.33	98	± 5.98	86	± 11.46
70	114	± 3.46	110	± 5.00	98	± 11.27
80	128	± 5.36	122	± 3.89	112	± 7.58
90	141	± 6.22	127	± 7.10	125	± 5.95
100	151	± 6.20	144	± 3.45	136	± 4.00
110	158	± 6.91	152	± 3.22	145	± 3.61
120	163	± 6.41	158	± 3.44	152	± 3.29
130	167	± 6.14	162	± 3.45	158	± 3.55
140	170	± 6.17	166	± 3.19	162	± 4.21
150	173	± 5.75	170	± 4.36	166	± 4.16
160	175	± 6.48	172	± 3.41	169	± 4.49
170	176	± 6.20	174	± 2.69	172	± 5.02
180	176	± 4.93	176	± 1.12	172	± 4.25
190	176	± 4.40	178	± 2.57	174	± 4.21
200	176	± 3.07	180	± 1.84	177	± 4.83
210	177	± 3.44	182	± 1.22	177	± 4.37
220	177	± 0.57	182	± 1.29	178	± 4.23
230	179	± 0.00	183	± 0.00	177	± 2.83
240	180	± 0.57			178	± 3.44
250	183	± 0.57			177	± 2.24
260					179	± 3.35
270					180	± 3.42
280					180	± 3.00

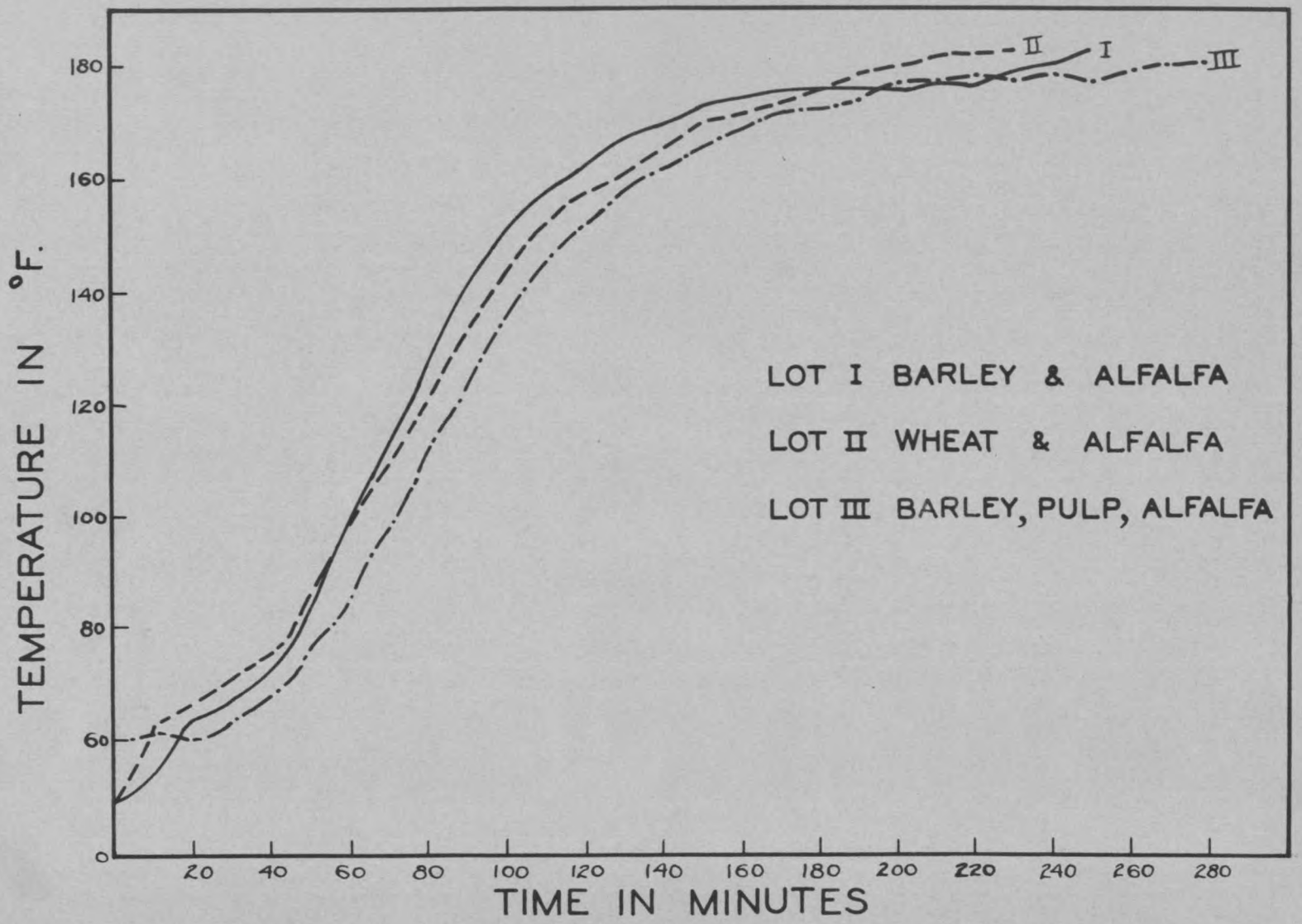

Fig. 1. Composite curves showing time-temperature relationships during the roasting of lamb from three feeding lots.

of roasting were not enough to be significant.

The average scores of the roasted legs of lamb from each feeding lot, which are based on the individual opinion of ten judges, table VIII, indicate some interesting trends. Although a fractional difference in the judgments is not significant there are a few indications that should be pointed out. The flavor of the fat in the barley-fed lamb tends to be more intense and less desirable, while the lean is slightly more intense in flavor but also slightly more desirable. The texture of the wheat-fed lamb was judged the coarsest, which corresponds with the general observation made before roasting. Beet pulp added to barley and alfalfa gave slightly more juice in the cooked meat. Barley produced a more tender lamb than wheat.

Since there were so many judgments recorded in the scoring of each roast, it seems advisable to treat them by the distribution plan as well as by the method of averages. In figures 2, 3, 4, 5 and 6 are shown graphs, based on the distribution of the scores for each quality of meat that was judged, and for each lot of lamb. The abscissa or horizontal base line in the graph represents the degree of judgment. The ordinate or vertical line represents the number of judgments. In figure 2, it will be seen that the intensity of aroma from barley-fed lamb, Lots I and III, is more pronounced

TABLE VIII. THE AVERAGE SCORING OF ROASTED LEGS OF LAMB FROM EACH FEEDING LOT BASED ON THE INDIVIDUAL OPINION OF TEN JUDGES.

Factors judged	Lot I Barley-alfalfa Average judgment	Lot II Wheat-alfalfa Average judgment	Lot III Barley-pulp-alfalfa Average judgment
Aroma - intensity	4.32 ± .86	4.11 ± .89	4.53 ± .96
Aroma - desirability	5.05 ± .75	5.03 ± .83	5.03 ± .85
Texture	5.14 ± .63	4.58 ± .66	5.01 ± .68
Flavor fat - intensity	4.90 ± .73	4.73 ± .82	4.78 ± .83
Flavor fat - desirability	4.47 ±1.06	4.57 ±1.03	4.69 ±1.02
Flavor lean - intensity	4.81 ± .53	4.39 ± .98	4.81 ± .67
Flavor lean- desirability	5.50 ± .90	5.24 ± .89	5.52 ± .88
Tenderness	6.00 ± .66	5.61 ± .74	5.69 ± .72
Juice - richness	4.69 ± .70	4.78 ± .86	4.60 ± .71
Juice - amount	3.94 ± .90	3.80 ± .80	4.13 ± .82

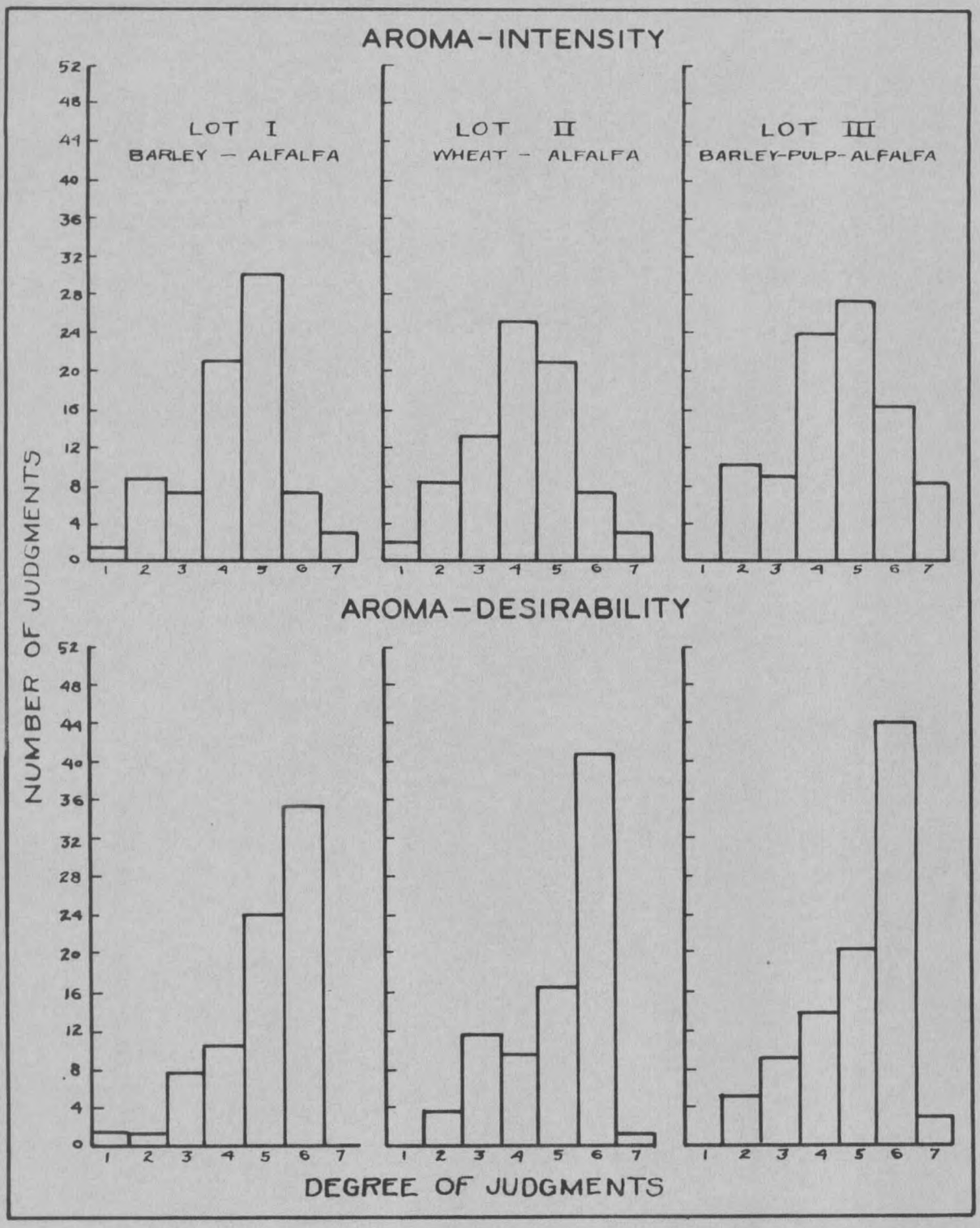

Fig. 2. Distribution of judgments on aroma of lamb.

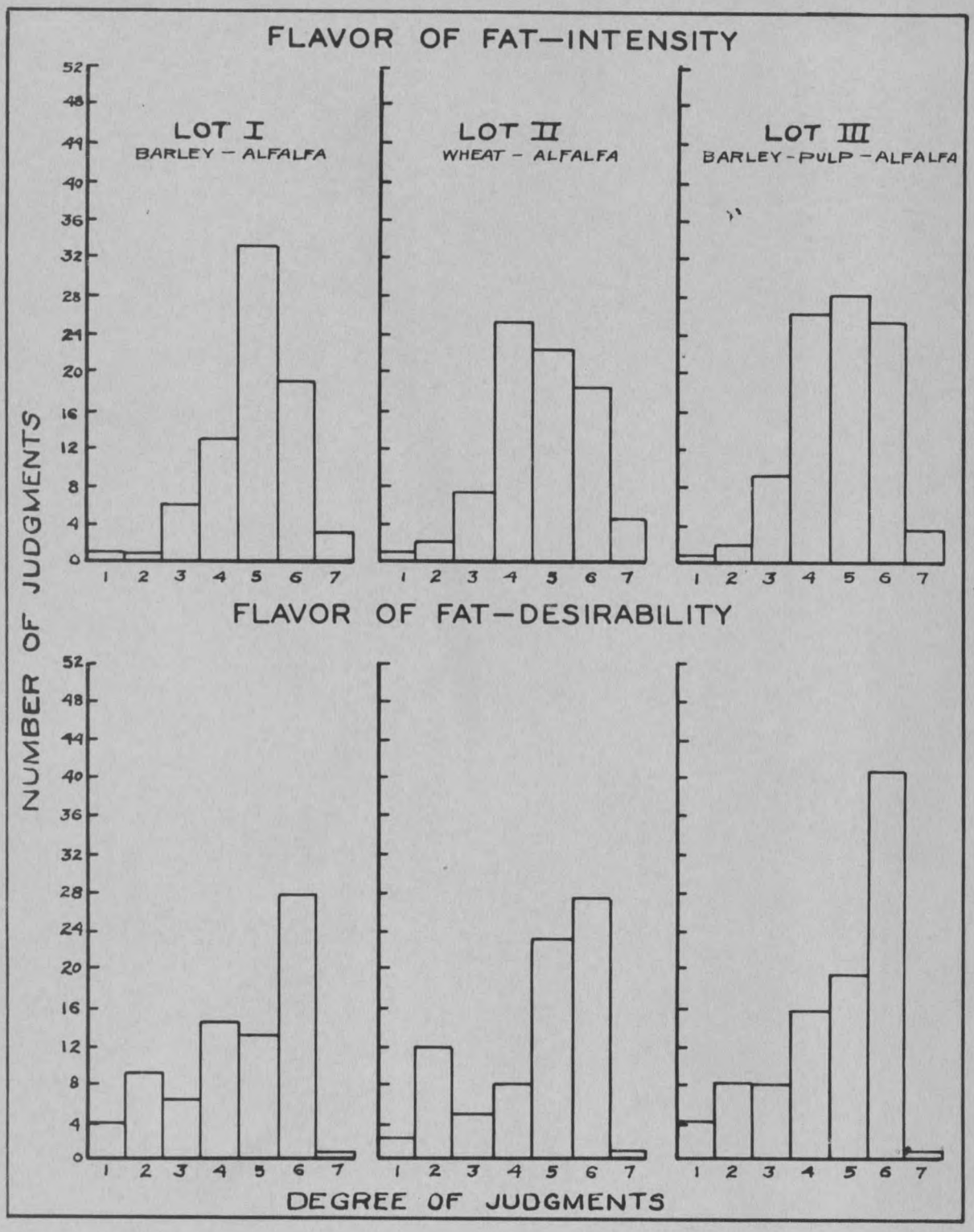

Fig. 3. Distribution of judgments on flavor of fat of lamb.

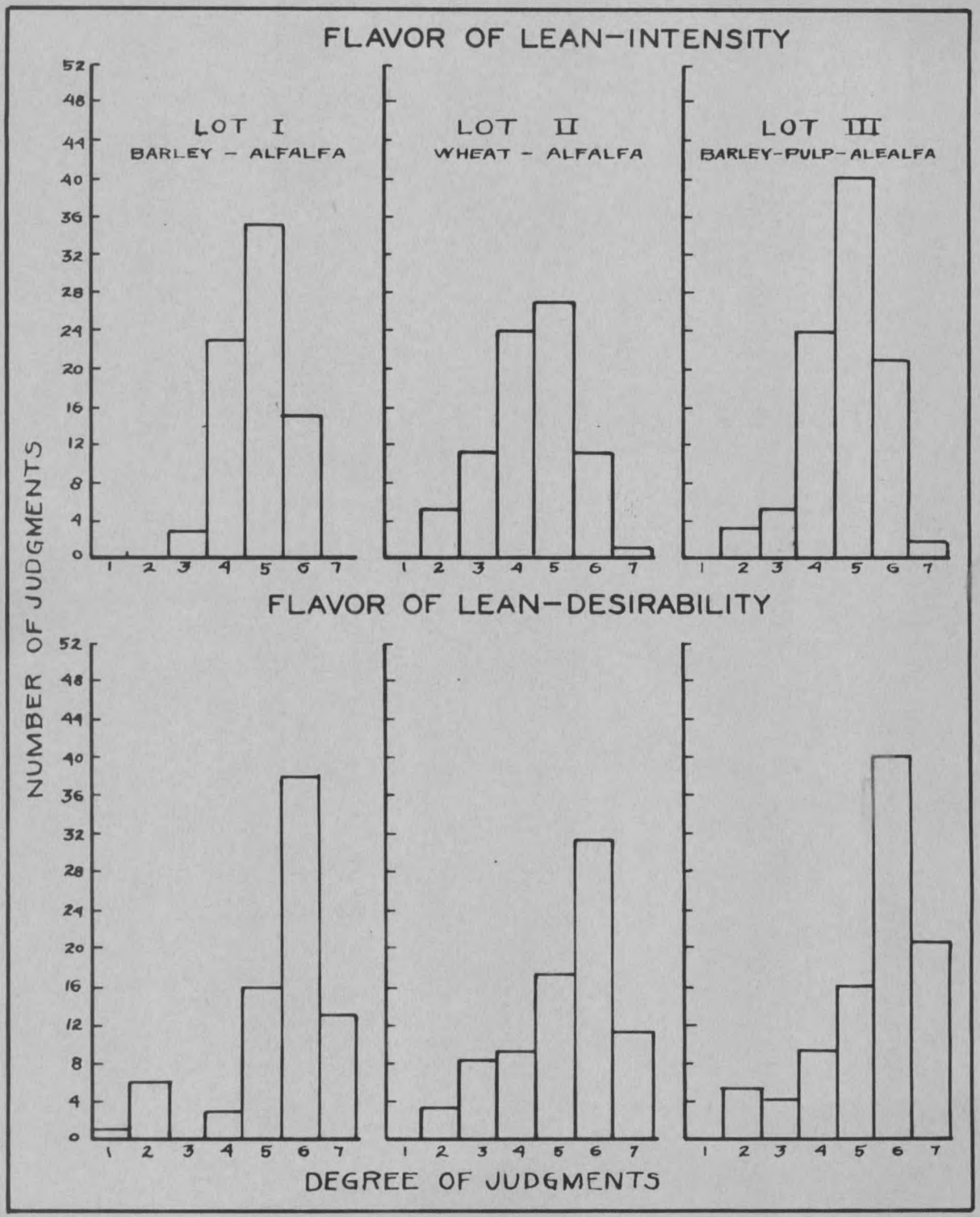

Fig. 4. Distribution of judgments on flavor of lean of lamb.

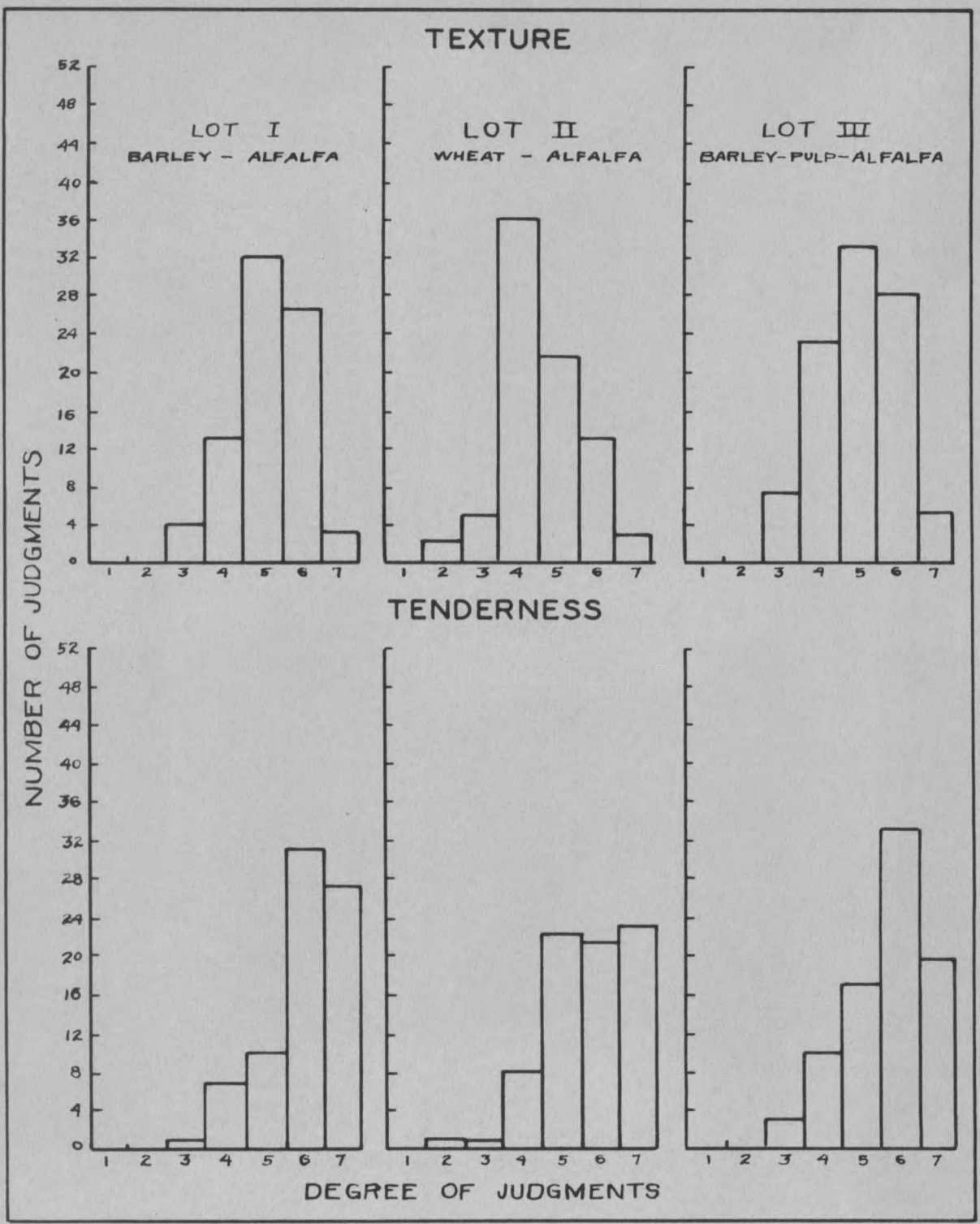

Fig. 5. Distribution of judgments on texture and tenderness of lamb.

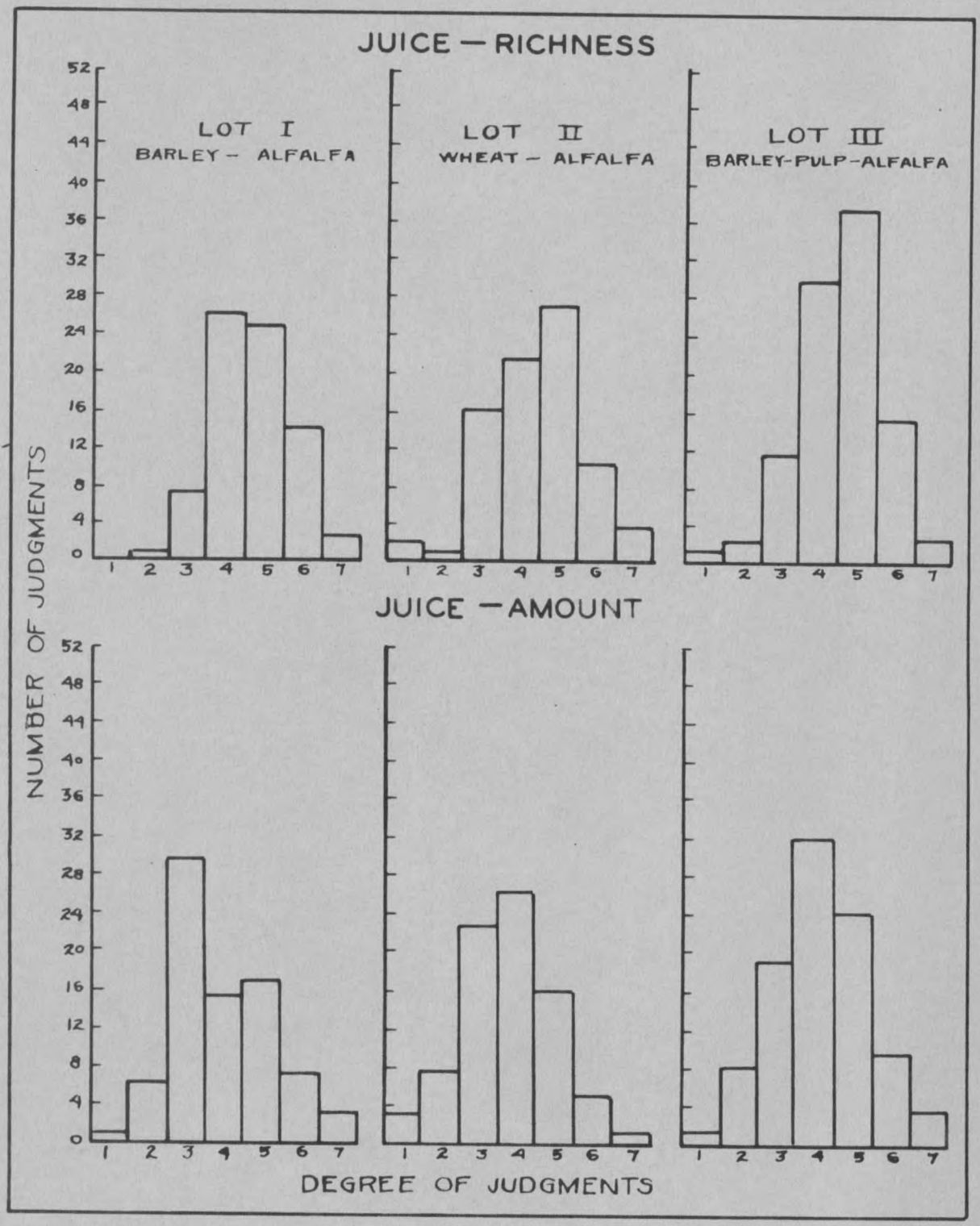

Fig. 6. Distribution of judgments on juice of lamb.

than that from the wheat-fed lamb, yet the desirability of the aroma from the three kinds of lamb seems to be quite uniform. In considering the flavor of the fat, figure 3, the judgments on Lots II and III indicate greater diversity of opinion than for Lot I. For the desirability of the flavor of fat, a more decided preference is given to Lot III, the barley and pulp-fed lamb.

The distribution of scores for the flavor of lean, figure 4, coincides very well with the average judgments recorded in table VIII, in that, while both of the barley-fed lambs show a greater intensity in flavor, they are also more desirable.

In figure 5, the scores for texture show that wheat-fed lamb appears to be more coarse-grained than the barley-fed lamb, and not quite as tender. This also agrees with the average judgments found in table VIII.

In judging the quality and quantity of juice in the meat samples, figure 6, the barley and pulp-fed lamb stands out as being the juiciest meat and also the richest.

A summary of all the items that were considered in comparing the lamb from the three feeding lots is presented in table IX.

TABLE IX. A SUMMARY OF THE ITEMS CONSIDERED IN THE COMPARISON OF LAMB FROM THE DIFFERENT FEEDING LOTS.

Items	Lot I Barley-alfalfa	Lot II Wheat-alfalfa	Lot III Barley-pulp-alfalfa
Av. volume before roasting	1933.5 c.c.	2096.3 c.c.	1973.0 c.c.
Av. weight before roasting	2151.0 gms.	2327.0 gms.	2195.0 gms.
Av. weight after roasting	1619.2 gms.	1773.6 gms.	1674.4 gms.
Av. per cent loss by evaporation	11.97 %	9.64 %	11.57 %
Av. per cent loss by drippings	12.76 %	14.11 %	13.05 %
Av. per cent fat in drippings	35.77 %	33.21 %	33.04 %
Av. per cent liquid in drippings	64.14 %	66.77 %	66.92 %
Av. per cent total loss	24.70 %	23.75 %	24.65 %
Av. shearing strength	1.58 lb.	1.75 lb.	1.64 lb.
Av. time of cooking per lb.	37.3 min.	32.6 min.	39.8 min.

DISCUSSION

Throughout this investigation of the effect of the feeds,- (1) barley and alfalfa hay, (2) wheat and alfalfa hay, and (3) barley, alfalfa hay, and wet beet pulp,- on the cooking quality of lamb, it has been observed that the lamb produced by these three feed combinations requires three different cooking periods. The average roasting time of the barley-fed lamb, Lot I, (table IX), was 37.3 minutes. The addition of wet beet pulp to the barley feed, Lot III, lengthened the roasting period to 39.8 minutes. The wheat-fed lamb required the shortest roasting period of only 32.6 minutes per pound. The barley-fed lamb, therefore averaged from five to seven minutes more per pound than did the wheat-fed lamb.

The curves, (figure 1), representing the average relationship between the time and temperature during the roasting of these three lots of lamb, show that the wheat and barley-fed lambs are somewhat alike in the way in which they permit the heat to flow from the surface to the center of the roast, although the wheat-fed lamb required a shorter cooking period. In the case of Lot III, in which wet beet pulp was added to the barley feed there is an indication of a lag in the rate of heat penetration through the meat. This seemed to cause a need for a longer cooking period. It is evident, then, from a study of the tables and the graphs, that the addition of wet

beet pulp to a ration of barley and alfalfa hay does have an effect upon the rate of heat penetration in the lamb, thus lengthening the roasting period. In spite of the longer cooking period of the lamb produced by the pulp, it was juicier after roasting. This is contrary to the usual idea that the longer a meat is roasted the drier is the resulting product.

It would seem probable that this factor of juiciness and the cooking losses of the meat would be closely related to each other. In table IX the average per cent of total cooking losses for each lot show that the per cent total loss of the two lots of barley-fed lambs are practically the same, 24.77; while the wheat-fed lot shows a slightly smaller total loss of 23.75%.

The total cooking losses are composed of two different kinds of losses (a) by evaporation, and (b) by drippings. By evaporation the two lots of barley-fed lamb lost about the same amount, 11.57% to 11.97%, while the wheat-fed lamb lost only 9.64% in weight. These losses by evaporation closely follow the relative total losses that have just been stated. From calculations based on table IX, the average losses of the liquid in the drippings for the three lots of lamb show that there is a similarity in the two barley-fed lots, 8.18% to 8.73%; while the loss in the wheat-fed lot is greater, being 9.42%. When these two kinds of losses of liquid are

added together, the total for the two barley-fed lots range from 20.15% to 20.30%; while the total loss for the wheat-fed lot is 19.06%. Although the total losses of liquid during the roasting of the barley-fed lamb were slightly greater than that of the wheat-fed lamb, they were recognized as being juicier. This was also borne out in the average scoring, table VIII, where approximately one hundred judgments rendered on each lot of lamb show an average of 4.13 for barley and pulp-fed; 3.94 for barley-fed; and 3.80 for wheat-fed lamb. Figure 6, which presents a distribution of the judgments made, also indicates that pulp-fed lamb from Lot III had the juiciest meat.

Again attention should be called to the fact that it would seem probable that this factor of juiciness and the losses during roasting would be closely related. However, from a study of the data just presented this situation seems to exist, that the barley-fed lamb requires the longer cooking period, with slightly greater cooking losses, but the resulting meat is juicier. Whereas, the wheat-fed lamb requires the shorter cooking period, with the smaller cooking losses, but the cooked lamb is drier. The question arises as to why the barley-fed lamb, especially when wet beet pulp has been added to the feed, requires a longer roasting period, with the greater cooking losses, yet has a juicier meat when done.

Apparently there has been little work done that would assist in answering this particular question. In analyzing the situation the first assumption that may be made is that the barley and pulp-fed lamb must have had a higher moisture content than the meat from the other two lots, since it was the juiciest meat at the end of the roasting period but at the same time had sustained somewhat greater cooking losses.

A second assumption may be that the higher moisture content of the barley and pulp-fed lamb influenced the rate of roasting by causing a lag in the heat penetration. Whether this lag is brought about by the utilization of part of the heat in converting the moisture into steam, or whether it is caused by some unusual cooking quality of the meat is difficult to answer. Meat consists of a muscular tissue of tiny, tubular fibers, which are bound together in bundles by the connective tissue. Langworthy and Hunt (11) explain that when the meat is cooked the water is forced out from these individual muscle fibers, and they are shortened and thickened by the application of heat. The other changes that take place are the separating of the muscular fibers showing that the connective tissues have been destroyed, and a coagulation of protein occurred in the cooked fiber.

The entire question of protein coagulation is practically a new one. There has never been an agreement among the workers

as to exactly what happens when a protein is coagulated. Gortner (7) presents the various viewpoints. "Some workers believe that the initial reaction is one of dehydration in which free amino and carboxyl groups within the protein molecule react, with the formation of an anhydride structure.

$$HOOC-(R)_x-NH_2 \rightarrow \underline{CO-(R)_x-NH} + H_2O$$

where $(R)_x$ represents the most of the protein molecule.

This viewpoint is diametrically opposed to the viewpoint of others who insist that the initial reaction appears to be an incipient hydrolysis, this argument being based upon the fact that there is always a small amount of non-heat-coagulable nitrogen remaining in the solution from which the heat-coagulated protein has been removed by filtration."

"One group of workers regards protein coagulation as an initial dehydration of a hydrated micelle, while another group believes that the colloidal micelle has taken on additional water molecule and increased the hydration. Still another group has suggested that coagulation may be synonymous with polymerization, several protein molecules combining into a larger polymer or aggregate."

"The only point at which there appears to be unanimity of opinion is that the coagulation process occurs in two stages, a preliminary stage of sensitization followed by a secondary stage in which flocculation takes place."

Since there is such a variety of theories for the explanation of protein coagulation, it is impossible in a study like this to find out whether a variation in feeds may affect the coagulation of proteins by heat.

The judgments (table VIII) and the mechanical tests (table III) indicate that the barley produces a finer grained and more tender lamb than wheat. The lamb fed on wheat was coarse and slightly tough. The Montana experiment station (26) in 1927 also found that the meat produced when wheat was used for fattening was slightly tough. The results regarding the tenderness and texture of the meat correspond to those obtained by a series of tests, described by Hammond (9), in comparing the tenderness of cooked lamb legs. There was a slight tendency for the tenderest muscles to have the finest grain.

Although the differences in the palatability of the lamb fed on the three kinds of feeds were not outstanding, there was a slight tendency for most of the judges to favor the barley-fed lamb (figure 4 and table VIII).

The service of a judging committee was the only means of securing a comparison of the quality of meat from the different feeding lots. Individuals vary so much in their judgments, that it is widely agreed that there is a definite need for a more specific way of measuring the comparative quality

of meats. N. G. Barbella (18) of the Bureau of Animal Industry has conducted a study on the individual threshold values for tastes. This study is to be continued and it is hoped to develop a method which will provide judges with a better opportunity for detecting and measuring differences in flavor of meat, and to determine the qualification of the individual to serve as a judge of flavor. It was found that judges familiar with the plan of testing were able to detect meat flavor more consistently than those judges who knew nothing of the plan of experiment. Since the judging committee in this study was familiar with the plan of scoring, it seems possible that their judgments are as reliable as any that could be obtained. Although some of the indications from this study are based upon mechanical tests, observations, and recorded data, some are taken from the average scoring of the judging committee (table VIII).

SUMMARY

1. The lambs used in this study were Rambouillet wether and ewe lambs, approximately eight months old.
2. These lambs were fed by the Animal Husbandry Dept. on three different lots of feed:- barley and alfalfa hay; wheat and alfalfa hay; and barley, wet beet pulp, and alfalfa hay.
3. Complete records of the general observations made before roasting and after roasting were kept to use in comparing the lamb from the three feeding lots.
4. All legs of lamb were roasted according to the standard method by searing for 30 minutes in an oven at 480° F., then reducing the oven temperature rapidly to 300° F. and cooking without water in an uncovered pan until the desired internal temperature of 182° F. - 183° F. or 83° C. was reached.
5. Thermocouples were used in this study to follow the internal temperature of the lamb during the roasting. The hot-end junctions of two thermocouples were inserted in each roast in manners as nearly alike as possible.
6. The wheat-fed lamb required the shortest cooking period and roasted at the average rate of 32.6 minutes per pound. The barley-fed lamb required a longer period with an average roasting rate of 37.3 minutes per pound. When wet

beet pulp was added to the barley and alfalfa feed, the lamb required the longest cooking period, roasting at an average rate of 39.8 minutes per pound.

7. Each leg of lamb was scored by a committee of ten judges who used the meat grading chart as prepared by the national meat committee.

8. According to the average judgments, the barley-fed lamb produced a lean meat that was slightly more intense in flavor but more desirable than that produced by the wheat or barley and pulp-fed lamb.

9. The barley and pulp-fed lamb produced the juiciest cooked meat. The wheat-fed lamb gave the driest cooked meat.

10. From the tests for tenderness determined both from the judgments and from the shearing strength, the barley-fed lamb seemed to be more tender than the wheat-fed lamb.

CONCLUSIONS

1. The results of this study indicate that the feeds, (1) barley and alfalfa hay, (2) wheat and alfalfa hay, and (3) barley, wet beet pulp and alfalfa hay, show only slight difference in their effect on the cooking quality of lamb.
2. In the roasting of the legs of lamb from the three feeding lots, the barley, pulp, and alfalfa-fed lamb required the longest cooking time per pound; the barley and alfalfa-fed lamb required a slightly shorter cooking time per pound; and, the wheat and alfalfa-fed lamb required the shortest cooking time per pound.

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