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STUDIES ON VENISON QUALITY: FLAVOR STUDIES; EFFECT OF METHODS OF THAWING, KIND AND LEVEL OF FAT, AND DEGREE OF DONENESS

by

Grace J. Smith

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

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Grace J. Smith

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INTRODUCTION

Venison represents an important resource in this area. The average number of deer killed in Utah during hunting seasons of the ten-year period, 1940 to 1950, was over 50,000 animals annually according to the Utah State Fish and Game Department. For the period from 1950 to 1960 this figure has increased to over 100,000 animals. In terms of dressed weight, 100,000 animals would yield an estimated 8,000,000 pounds of meat. Neighboring states also produce large numbers of deer. This pictures venison not only as an important resource but as one rapidly increasing in importance.

Before the recent advent of locker storage and home freezers it was impossible to avoid wasting much of the venison brought home by the hunters. Limited amounts could be stored for short periods, some could be given to friends, and some could be canned. Today proper refrigeration is available to preserve this meat in a very palatable form, and it is possible, if proper care is given the animals from the field to the table, that all of this meat can be used and enjoyed. Thus an investigation into this problem is of practical importance.

Reliable information concerning the cooking of venison is very limited. Though there is extensive mythology, no articles on the subject can be found in the professional journals. This lack of reports indicates that little scientific work has been done on the problem. Utah State University has one extension bulletin available dealing largely with the

problem of field care of venison which also includes some advice on cooking and a section of recipes. Some general information can be gained from cook books, and during the hunting season sports magazines and newspapers of this region publish information discussing handling, care, and cooking of venison. Much of the above information is not based on systematic inquiry, but comes from the oral tradition; that is, the opinions, experiences, and advice one person passes on to another.

From these typical sources some contradictory beliefs can be gleaned. Some writers advise cooking venison as beef is cooked; others say it should be treated as mutton. One cook book suggests venison is preferred well-done while another claims the consensus is that venison should be eaten rare. The precaution to avoid overcooking because it makes the product dry seems to be the only advice upon which agreement is reached. Besides such differing instructions as to methods of cooking, there are two important notions concerning qualities of venison which are indicated by many sources. First is the notion that venison has a "wild taste" which requires special treatment in order to disguise or enhance it. In many recipes marinades of different types or herbs and spices are suggested to mask or blend the flavor of the meat. The second notion is that the fat of the venison is the source of this wild flavor and must be carefully trimmed from the carcass because it is thought venison fat develops rancidity rapidly during storage. Many people who eat venison regularly and like it, consider these notions erroneous.

It has been of particular interest to undertake a study of venison from the standpoint of the housewife and to search for means by which

better and more satisfactory use of this meat can be made. She may have little or nothing to do with the hunting and field care of the animal; but problems of preservation, thawing, and cooking are her concern. Scientific investigation which might establish what the qualities of this meat are should be helpful in achieving a better solution of these problems. It could also establish the relative validity of prevalent notions; first, that venison has an inherent "wild taste" necessitating special treatment; and second, that the source of this wild flavor is the fat of the animal.

Results from a preliminary study on a limited number of deer indicate that proper field care and the use of good principles of meat cookery give a product not inferior to beef. In order to investigate more thoroughly whether or not venison has a distinctive flavor, a threefold study was conducted: first, to compare the qualities of venison fat with beef suet and pork fat; second, to observe the effect of the degree of doneness on the palatability of venison; and third, to test the effect on flavor of combining venison with other flavors.

REVIEW OF LITERATURE

Chatfield and Adams (1940) reported values for water, protein, fat, and ash content of venison. This information along with a study by Cook et al. (1949), concerned with the influence of seasonal and other factors on acceptability and food value of deer and antelope, is the only source which has been found in recent literature concerning venison. Method of preservation, preparation, and cooking of venison apparently have not been investigated scientifically.

In order to set up worthwhile procedures, and to understand and interpret data from a venison study, it was advantageous to know what scientific work had been accomplished on domestic animals.

Lowe (1955, p. 223) in discussing qualities of meat stated that tenderness is one quality desired universally in meat. She continued:

> Since meat is usually cooked for eating, many factors affect its tenderness. These include not only the inherent factors such as fat content, fibers, and connective tissue but also aging, processing, and preparation for cooking as well as the cooking process.

Kropf and Graf (1959) initiated a study to determine interrelationships of various evaluations of beef qualities to learn what factors are most closely related to eating qualities of beef. They found that of all factors tested, length of carcass, carcass weight, and sensory tenderness were significantly related to over-all preference. In their opinion this supported evidence that tenderness was the most important single sensory determinant of acceptability. Mechanical tenderness tests had a highly significant correlation to sensory tenderness and appeared

to be more sensitive as a measure of tenderness. Fat covering was closely related to marbling, which in turn was closely related to tenderness. Juiciness showed a significant correlation to tenderness but flavor did not show a positive relationship to tenderness. These results showed a complex interrelationship of factors which affected acceptability.

Although carcass grading is based in part on amount, distribution, firmness and texture of fat, recent work on beef by Husaini et al. (1950a), Mathews and Bennett (1961), and studies on lambs by Cover et al. (1944) gave fat a less prominent place than some other factors in its effect on tenderness.

However, where pork was concerned, Murphy and Carlin (1961) found a highly significant positive effect of marbling on both tenderness and juiciness. This significance was not maintained when amount of back fat on the carcass was compared to tenderness. Kauffman, Bray and Schaars (1961) conducted consumer preference tests on pork chops marbled and unmarbled. They found that though there was a taste reaction in favor of marbled over unmarbled chops, this preference was not carried over to the purchase counter.

Hiner, Anderson, and Fellers (1955) studied the character of connective tissue from a wide variety of beef and found that muscles which are used more had larger amounts of elastic and connective tissue. This is supported by Ramsbottom, Strandine, and Koonz (1945) and Ramsbottom and Strandine (1948) who studied comparative tenderness of seventy-five muscles and state that for the most part muscles with small amounts of connective tissue had low shear reading, while muscles with large amounts of connective tissue had higher shear readings. Work by Husaini et al.

(1950a) agreed with this finding in showing that there was a very close negative correlation between tenderness scores and connective tissue or the alkali-insoluble proteins. In a subsequent study, Husaini et al. (1950b) found that connective tissue as represented by alkali-insoluble protein and muscle plasma as represented by muscle hemoglobin were in part responsible for tenderness in meat.

Difference in feeding trials conducted by Wanderstock and Miller (1948) showed animals fed grain on pasture, after pasture, or in dry lot were higher in quality and palatability than those kept on pasture alone. Palatability here included aroma, texture, flavor of the fat and lean, tenderness, quality of juice and juiciness. Jacobsen and Fenton (1956) studied the effect of level of nutrition on palatability and found tenderness tests were inconclusive but flavor was preferred from the medium and high levels of nutrition. Mathews and Bennett (1961) found fast gaining steers produced decided improvement in size and appearance, but tenderness difference was not apparent. Meyer et al. (1960) compared grain and grass finished beef as affected by ripening. Both shear and sensory tenderness tests indicated grain-finished beef was more tender but the difference was significant only as measured by a taste panel.

It is generally accepted that beef from young animals is more tender than that from older mature animals. Ramsbottom and Strandine (1948) and Hiner and Hankins (1950) found that tenderness decreased as the age of the animal increased. They also found differences in tenderness between carcasses, between cuts within a carcass, between muscles within a cut, and occasionally between parts of the same muscle. This was shown by

results which indicated significant differences occurred between age groups but not within age groups.

Aging as an important method of tenderizing beef is a factor which was recognized long ago. One source quoted in the literature dated back to 1907. Paul, Lowe, and McClurg (1944), Ramsbottom, Strandine, and Koonz (1945), Harrison et al. (1949) all reported that tenderness increased with aging and that variation in the tenderizing of the muscles occurred from animal to animal and between steaks cut from the same muscle. Paul and Bratzler (1955) studied eight pair of longissimus dorse from prime, good, and commercial beef to see the influence of various cold storage freezing and thawing methods. They found that length of cold storage tended to minimize the grade difference as it did the difference in steaks from the same muscle.

Freezer locker storage was studied by Hiner, Gaddis and Hankins (1951). They found that the temperature maintained during storage and the method of protection used were important factors in maintaining a desirable product. Oxidation of the fat was responsible for decline in quality. Most home freezer lockers have a storage temperature of 0° F. Though many factors must be considered as influences, Simpson and Chang (1954) have given approximate periods of locker storage for eight kinds of meat maintained at 0° F. They compared hamburger, bacon, and sausage at 0° F. with lower temperatures and found rancidity was retarded by lower temperatures. They also compared kinds of wrapping material and found glassine laminated paper and aluminum foil retarded rancidity of each kind of meat at each level of storage as compared to butcher wrap.

In order that results in one laboratory may be compared with those

in another, the Committee on Preparation Factors National Cooperative Meat Investigations (Anonymous 1942) has published standard directions for cooking of meat for scientific investigations. Following these directions results can be compared to show the methods of cooking which give the most palatable and nutritious product. Griswold (1955) tested fourteen methods of cooking beef rounds and recommended the braising method. Pounding but not scoring increased the tenderness, application of enzymes made the meat more tender but less juicy. Cover, Bannister, and Kehlenbrink (1957) compared four conditions of cooking on loin and round cuts and found home methods now recommended were best for tenderness: loin steaks broiled rare; and round, braised well-done. Lowe (1955) stated that in general, meat is cooked by two methods. Dry heat is used for tender cuts such as roasts and steaks and here the dry air surrounds the meat in an oven or broiler. Moist heat is used on the less tender cuts and with this method the meat is surrounded by liquid as in stews or by steam as in foil in braising. Generally, long slow cooking increases tenderness but the meat is less juicy. However, the time of cooking rather than the temperature appears to be the determinant affecting tenderness.

Fenton et al. (1956) studied roasts from two grades of beef, frozen and unfrozen, using two methods of thawing. Results supported earlier work by Paul and Child (1937) and Vail et al. (1943) in that thawing methods showed no significant difference in regard to tenderness. Lowe (1952) defrosted cuts in the refrigerator, at room temperature, in water, and during cooking. Palatability scores for roasts were not appreciably affected by defrosting methods.

A review of the literature has shown many factors which affect quality in meat and a number of these can be measured by chemical or mechanical means. One aspect which needs to be considered in some of the studies made is the important factor of acceptability by consumers. The military, food manufacturers, distributors, and sellers have recognized the importance of food acceptance and have felt the need of standard methods of measurements. A symposium sponsored by the Quartermaster Food and Container Institute (Peryam et al. 1953) summarized the work to date and then indicated the likely direction of future work.

In the past many methods of taste-testing have been tried and have been found applicable to certain circumstances of the studies under consideration. A practical approach to food evaluation must be taken since time and money are major controlling factors. One procedure which has shown reliable results and is conservative of time and costs is the method of scaling. According to Anderson (1958) this method of testing has demonstrated its greatest application in evaluating the over-all quality of a given product. Scales have been devised ranging from 1 to 5, 1 to 7, 1 to 9, and 1 to 10, according to defined levels of acceptability of the quality being judged. Lowe et al. (1952) stated that the 1 to 7 point scale was a mistake in this study because the judges were accustomed to a 1 to 10 point scale and were experienced in using it. Compressing the ability to discern difference on a broader scale into a lesser one leads to poor scoring. She also noted that Peryam (1950) showed a nine-point scale had higher reproducibility with less variations than a seven-point scale. Also, Peryam (1953) stated that consumer preference evaluation by hedonic scale is used in tests of armed force ration more

often than any other method. One of the applications of such tests was discussed by Polemis (1953) as it related to knowledge required for effective menu planning in the Army.

Some research work done by Gridgeman (1956), Lane et al. (1954), Peryam and Swartz (1950) indicated a decrease in the ability to detect flavor differences as the number of samples increased. Other workers, including Brandt and Hutchinson (1956), Mitchell (1956) indicated that fifteen to eighteen samples may be served at one session without loss of reliability in results. Pfaffmann et al. (1953) found no loss in triangle test discernment with some foods even after seventy-five samples were tested in one session. Sather and Calvin (1960) studied peaches, hamburger, tomato juice, and green beans with known flavor differences. Preference tests were made by means of the hedonic scale and results showed that for mild products such as these, up to twenty samples may be included in one test period with no decrease in the judges' ability to discriminate flavor preference among the samples. Bradley (1953) explained these contradictory findings by suggesting that whether or not there was deterioration in performance depended upon the type of food judged. He felt this was logical since it is known that the flavor senses of taste and smell will adapt to certain flavors much more rapidly or completely than others.

METHOD OF PROCEDURE

Part I. Preliminary Study

History of the animals

Two of the deer used in this study were animals from a feeding experiment currently in progress at Utah State University. They had been in captivity since they were fawns (Table 1). The third deer was an animal killed in the wild during a late November hunt in Daggett County, Utah in 1958. This animal was young but in poor condition.

Table 1. Description of animals included in the tests

Animal	Sex	Age	Diet	Condition of carcass
Deer 1	Male	3½ years	Hay and pellets	Good
Deer 2	Female	1½ years	Oakbrush for 38 days mid-winter	Fair
Deer 3	Not recorded	Young	Off poor range--mostly sagebrush and juniper	Poor

Preparation of the animals

Animals 1 and 2 were killed at the abattoir and handled in the manner of domestic animals. Animal 3 was given careful field care as to cleaning, dressing, cooling, and transportation home but it had been given no special treatment such as washing or immediate skinning since there had been no thought at this time of using the animal in this study. All

animals were aged approximately two weeks before being frozen. Because the animals were killed at different times, the period of storage is varied; but all had been frozen and stored at the same locker plant, and for less than six months' time.

Chops and roasts were the cuts of meat selected for testing. The tests were repeated but meat from venison 3 was not available for the duplicate tests.

Loin chops were cut one inch thick with the exception of those from animal 3 which varied in thickness from one-half to one inch.

Roasts from animals 1 and 2 were paired round roasts as recommended for veal by the Committee on Preparation Factors National Cooperative Meat Investigations (Anonymous 1942). The roast from animal 3 was a chuck roast.

A beef chuck roast which had been frozen and stored in a similar manner to the venison cuts was included for the purpose of comparison.

Method of cooking

In the first tests chops were broiled six minutes on each side which was the time used for small lamb chops by Wilcox and Galloway (1952). They were found to be overcooked. The time was, therefore, reduced to four minutes on each side when the tests were repeated.

Roasts were encased in aluminum foil with the thermometer inserted into the center of the largest muscle. They were roasted at a constant temperature of 325° F. to an internal temperature of 175° F. During the cooking of the first roasts there was an odor detected. To avoid this, when the experiment was repeated roasts were seared twenty minutes in

the oven at 425° F. before they were wrapped in foil. Cooking then proceeded as in the first test, and no objectionable odor was noticed.

Tests

Sample cores of meat were cut with a one-inch cylinder and tests for tenderness were made on the Warner-Bratzler shearing machine. As many such samples were taken from the chops and roasts as could be obtained.

Sensory tests were made by a panel of nine judges on the cooked samples of meat. They were scored for juiciness, tenderness, texture, and like or dislike using a scale from 1 to 9, 9 being the highest score. These were paired-sample tests.

Part II. Ground Meat Studies

Research work done with domestic animals has shown variation in quality of meat between different animals as well as between different cuts of the same animal (Lowe et al. 1952). It was assumed that this would be true with venison, and using ground meat would eliminate these variables. Also, the whole animal could be used if the meat were ground, thus fewer animals would be needed.

It was decided a study of the qualities of venison fat would be facilitated by the use of ground lean meat mixed with fat. Little fat is found in the muscle tissue of deer, and it is considered necessary to add fat in making ground venison. Commonly, beef suet or pork fat are added by the butcher. These two kinds of fat and venison fat were used to make three different mixtures which could be compared to see what qualities each might add to the lean meat.

History of the animals

The animals and the cuts of meat used in these studies were all provided by the Utah State Fish and Game Department. Two animals killed on November 6, 1959, were used in the experiments concerning ground meat. They were Rocky Mountain mule deer obtained from the Cache deer herd; one was from Hardware Ranch in Blacksmith Fork Canyon, the other from the foothills south and east of Hyrum, Utah. Both animals were female and they were approaching two and one-half years of age. Condition of the carcasses was judged as good. Aging took place in a walk-in refrigerator at Utah State University at the temperature of 34° to 36° F. for a period of two weeks.

Cutting, wrapping, and grinding

The meat from the carcasses of the two animals was cut by an experienced meat cutter, mixed thoroughly, and divided into four portions. To each of three portions the desired fat (venison fat, pork fat, beef suet) was added in the proportions of one-half pound, one pound, and one and one-half pounds of fat to five pounds of lean meat. These are referred to as low, medium, and high levels. No fat was added to the fourth portion which was used as a control.

The lean meat and fat mixtures were ground once on a commercial grinder, mixed thoroughly, and reground.

Approximately twelve ounces of meat were molded into a loaf which would fit a small two-by five-inch loaf tin. A total of 126 loaves were used in the ground meat studies--54 for methods of thawing, and 72 for kind and level of fat. These loaves were wrapped with waxed locker paper.

Each was marked according to the kind and level of fat it contained, and all loaves for one day's cooking were stacked together, wrapped in heavy butcher paper, and marked again.

Freezing and storage

The ground meat was frozen at -8° F. in a quick freeze unit at the plant. It was stored at -2° F. in a laboratory freezer until ready for use. Tests were made on the ground meat at two periods of storage. Time of storage for the first period was fifty-five days. The length of storage for the second period was six months.

Defrosting

Two separate studies were made on the ground meat. One was concerned particularly with defrosting methods and for this experiment only the medium level of fat and lean meat mixtures was used. This meat was defrosted by three methods. The first method was to thaw the meat in the process of cooking and was designated as no-thaw. The second was to defrost the meat in the refrigerator to an internal temperature of -2° to 4° C., or the points between which ice crystals disappear (Lowe et al. 1952). This was called medium-thaw. The third method was to thaw the meat to room temperature or approximately 20° C., internal temperature, which was called over-thaw.

The second study on the ground venison was concerning the different kinds and levels of fat and in this experiment all the meat was defrosted to the medium-thaw level of the first study.

Cooking and experimental design

Meat loaves were oven cooked by moist heat method at 325° F. until well-done, internal temperature of 175° F. Before cooking, each pan, thermometer, aluminum foil wrapping, and meat loaf was weighed individually and weights were recorded. The thermometer was inserted into the center of the loaf which was then wrapped tightly in the foil and placed in the loaf tin. In the case of the hard frozen loaves, the thermometer was placed in the center of the loaf after cooking had partially defrosted them. When the meat was cooked it was removed from the oven and the total weight was recorded. Loaves remained wrapped and were allowed to cool to the internal temperature of 140° F. They were then removed from the foil and weight of the pan, foil, and juice together were made and recorded.

The design for cooking meat loaves used in the study of thawing methods is shown in Table 2. Three replications were conducted on each storage period.

Table 2. Design of defrosting study for cooking meat after storage of 55 days or 6 months[a]

Replication	Day cooked	Defrosting methods		
		No-thaw	Medium-thaw	Over-thaw
1	1	B	B	B
1	1	P	P	P
1	2	V	V	V
2	2	B	B	B
2	3	P	P	P
2	3	V	V	V
3	4	B	B	B
3	4	P	P	P
3	5	V	V	V

[a]B = beef fat mixture; P = pork fat mixture; V = venison fat mixture.

Meat loaves containing one kind of fat were defrosted by the three different methods and were compared for flavor on one judging sheet. Two kinds of fat were judged in one day. Rotation of the two kinds of fat compared on any one day was made in order that all combinations of different fats could be tested.

Table 3 shows the design for cooking meat loaves concerned with kind and level of fat study. There were three replications made for each storage period.

Table 3. Design of kind and level of fat study for cooking meat after storage of 55 days or 6 months

Replication	Day cooked	Level of fat[a]	Kind of fat added to lean venison			
			Beef	Pork	Venison	No fat
1	1	½	B	P	V	N
1	1	1	B	P	V	N
1	2	1½	B	P	V	N
2	2	½	B	P	V	N
2	3	1	B	P	V	N
2	3	1½	B	P	V	N
3	4	½	B	P	V	N
3	4	1	B	P	V	N
3	5	1½	B	P	V	N

[a]Pounds of fat added to five pounds of meat.

Flavor tests on this study were conducted as were those in the thawing study with the meat at one level of fat compared on one judging sheet. Samples from two levels were judged in one day.

Objective tests

Tests for tenderness were made on samples of ground meat by means of the Orchard Shear press. Seventy-five grams of cooked meat were used in each sample. After this test was made, the meat sample was placed in a test cylinder of the succulometer machine. Pressure was held at 2500 pounds for five minutes to express the juice from the meat.

Flavor test for preference

The outside of each meat loaf was trimmed off to avoid adding a browned flavor to some of the samples. Test samples were wrapped separately in squares of aluminum foil and were tested at room temperature. Work on testing of meat by Olson et al. (1958) has shown relative rating remained very nearly the same when meat was at room temperature as compared with warmed samples. The convenience was much greater where warming was not necessary.

Flavor tests (Appendix Sheet 1) were made by eight judges using the hedonic scale (Peryam and Gerardot, 1952). Among the judges were two professors from the Food and Nutrition department of the institution, one professor from the Range Management department, the meat cutter who had prepared the venison, and others who are members of a regular testing panel for work done in the Food and Nutrition department.

Chemical tests

Peroxide determinations were made on the samples of meat concerned with kind and level of fat for both storage periods. The procedure used was the method of Rockwood, Ramsbottom, and Mehlenbacher (1947).

Part III. Study of Effect of Degree of Doneness

History of the animals

Thick round steaks were used to study variations which resulted with difference in the degree of doneness. These steaks were cut from venison made available from another study in progress at the University. Animals in this experiment were all yearling mule deer from the Cache deer herd. Comparisons were made between steaks from the same animal rather than between animals to avoid possible variations due to difference in treatment of the deer.

Cutting and wrapping

A round bone leg roast located just below the rump roast was the source of the round steaks. Three steaks one and one-half inches thick were cut from one solid frozen roast. These were marked as top, middle, and lower cuts according to their position in the roast. Each steak was wrapped individually in waxed paper, marked, and the meat for one day's use was wrapped together in butcher paper.

Freezing, storage, and thawing

Round steaks were hard frozen when they were cut. The roasts from which they were obtained had been in storage for six months in a commercial locker plant kept at 0° C. No thawing took place while cutting, marking, and rewrapping were accomplished, and they were then returned to the laboratory freezer for storage until time for thawing and cooking.

All the round steaks were thawed to the point where ice crystals disappear, -2° to 4° C.

Cooking

Round steaks, pans, foil wrapping, and thermometers were weighed separately. The thermometer was placed horizontally in the steak (Anonymous 1942), with the bulk of the thermometer resting in the center of the fleshy part of the meat. No seasoning was added and the meat was browned in the oven at 425° F. for ten minutes before it was wrapped in the aluminum foil. The temperature was then reduced to 325° F. and the steaks were cooked to three different internal temperatures: rare at 150° F., well-done at 175° F., and very well-done at 200° F.

The only variable tested on the round steaks was the degree of doneness. Steaks were rotated in the treatment received as to top, medium, or lower cut from the roasts, and the replications were five.

Objective tests

Tests were made on samples of the round steaks by means of the Orchard test for tenderness and by the succulometer machine for juiciness. In addition to these, tests for tenderness were made on the Warner-Bratzler shearing machine. As many cores of meat as could be obtained from each steak were cut by a cylinder one inch in diameter and tested.

Flavor tests for preference

The same testing panel judged these samples as judged those of the ground meat studies. Judges were given two sets of numbered samples (Anonymous 1942). Scoring was recorded on the hedonic scale.

Part IV. Study of Venison Flavor Combined with other Flavors

No attempt was made to identify the source of the cuts of meat used in a study concerning the use of venison in various recipes, other than that the meat used was all from yearling animals. It had all been in locker storage for a period of six months and it was thawed in a refrigerator to the point where it could be used in the various recipes. Cuts of meat used were steaks, chops, leg and shoulder roasts. Only minor changes were made in the recipes used to fit the availability of certain ingredients or to improve the acceptability of the produce. Sources of the recipes were: Rawley, Lowe and Greaves (1950), Chefs of the West (Anonymous 1956), Mozza (1949), Gorton (1957), and Better Homes and Gardens Cook Book (Anonymous 1947).

Flavor tests for preference were made by the twelve members of the Experimental Cooking class,[1] using the hedonic scale.

Following are the groups of venison dishes compared.

1. Chops
   - Chops with herbs
   - Chops in herb butter sauce
   - Chops in soup
   - Stuffed chops

2. Roasts
   - Standard roast
   - Roast with garlic
   - Roast with herbs
   - Pot roast with herbs and sauce

[1]Preparation of the cooked dishes was done by Mary Jo Harris and Camille Jensen under the direction of Dr. Ethelwyn Wilcox. Flavor tests by the class were conducted under the supervision of Dr. Margaret Merkley.

3. Stews

   Marinated stew

   Stew with herbs

   Stew with tomato

   Stew without tomato

4. Roasts (marinated)

   Saurbraten

   Roast with Marinade 1

   Roast with Marinade 2

5. Steaks

   Standard braised steak

   Braised with tomato

   Braised with mushroom soup

   Braised with sour cream

6. Combination dishes

   Rollups

   Chinese pepper steak

   Tamale pie

   Chili

   Curry

RESULTS AND DISCUSSION

Part I. Preliminary Study

Results of the palatability and shear tests made on the chops and roasts used in this study are shown in Table 4. These results show a favorable reaction towards venison.

Scores for venison as defined by degree of like and dislike range from 7.0 to 8.1. These scores correspond with terms on the hedonic scale (Appendix sheet 1) of like moderately to like very much.

Chops from the small animal in poor condition compared poorly with those from the other two animals on the basis of tenderness, texture, and juiciness, but still held up in comparison of over-all flavor. Since all the chops in the first test were overcooked, and since the chops from animal No. 3 were smaller and thinner, it is possible overcooking was greater in these chops and this contributed to lower scores.

Roasts were cooked with moist heat and the roast from animal No. 3 compared with the others much more favorably than did the chops. This may have indicated that where the quality of meat is poor, the dry heat method emphasized this and was thus a less desirable method to use with venison. Lowe (1955) recommended moist heat for less tender cuts which included cuts from the round. Griswold (1955) compared methods of cooking beef round and recommended standard braising method. In view of the fact that many of the factors concerned with increasing tenderness in domestic animals cannot be controlled with venison, it would seem practical to consider most venison cuts among the less tender.

Table 4. Average ratings by nine judges of meat from venison and beef

Tests	1st replication				2nd replication		
	Venison No. 1	Venison No. 2	Venison No. 3	Beef	Venison No. 1	Venison No. 2	Beef
			Chops				
Shear [a]	18.1	12.7	33.0	--	13.1	24.8	--
Palatability [b]							
Tenderness	6.7	7.2	4.4	--	7.7	3.3	--
Texture	6.0	6.1	4.8	--	6.8	4.7	--
Juiciness	4.7	4.4	4.2	--	7.4	6.7	--
Like	7.9	7.4	7.0	--	7.9	7.2	--
			Roasts				
Shear [a]	13.1	11.9	9.9	21.4	11.6	11.3	15.9
Palatability [b]							
Tenderness	7.3	7.4	7.3	4.9	7.9	7.4	5.9
Texture	7.4	7.2	6.7	4.7	7.4	6.8	5.8
Juiciness	4.2	6.6	6.2	5.5	6.1	5.8	7.0
Like	7.4	7.7	7.1	7.0	8.1	7.4	6.9

[a] Low score indicates best in shear test.

[b] High score indicates best in palatability scores.

At the time the first palatability tests were made on roasts, the individual judges were asked to identify which of the roasts was beef. Only one judge chose correctly. Three chose animal No. 1 as beef, and the rest stated they could not select the beef sample. When the tests were repeated the judges were asked again to select the beef sample. This time four chose venison No. 1 as beef and four chose correctly. Of those who chose correctly, two commented that though they could distinguish the beef they preferred the venison. Thus it was possible with proper field care and good cooking methods used in this study to produce venison which could not be distinguished from beef. This seemed to indicate venison does not have inherent shortcomings which contribute an undesirable flavor.

When an unpleasant odor was observed during the cooking of the first roasts it was decided to try searing before covering when the tests were repeated. This procedure eliminated the odor and was therefore adopted whenever possible.

It appeared that restriction of activity of the penned animals had not made a difference in their acceptability. Nor had the controlled diet on which they were fed contributed flavor change as compared to animal No. 3. It also appeared that as far as this study could determine, good field care compared well to domestic treatment.

Part II. Ground Meat Studies

Defrosting methods

Results of the study on three methods of defrosting the venison meat loaves are shown in Table 5 and Appendix Table 14. There were only

Table 5. Averages of tests for study on thawing methods

Treatment	Kind of fat added	Orchard test[a]	Press for juice	Press for fat and juice	Flavor test[b]	Cooking loss		
						Total	Air	Drip
	lbs.	lbs/sq.in	ml.	ml.		%	%	%
				55 days storage				
Overthaw	Beef	405	-	-	7.4	27.0	8.4	18.6
	Pork	477	-	-	7.0	27.3	7.5	19.8
	Venison	452	-	-	6.8	25.5	7.8	17.7
	Average	444			7.1	26.6	7.9	18.7
Medium-thaw	Beef	426	-	-	7.2	28.0	9.3	18.7
	Pork	408	-	-	7.4	25.3	6.1	19.2
	Venison	462	-	-	7.0	26.3	9.5	16.8
	Average	432			7.2	26.5	8.3	18.2
No-thaw	Beef	418	-	-	7.3	29.4	8.0	21.4
	Pork	370	-	-	7.2	27.2	6.6	20.6
	Venison	485	-	-	7.2	28.3	7.0	21.3
	Average	424			7.2	28.3	7.2	21.1
Average		433			7.2	27.1	7.8	19.3
				6 months storage				
Overthaw	Beef	450	4.0	7.1	7.7	25.1	2.6	22.5
	Pork	453	4.2	7.6	7.2	27.2	3.2	24.0
	Venison	440	4.7	8.0	6.9	26.1	2.9	23.2
	Average	450	4.2	7.7	7.3	26.1	2.9	23.2
Medium-thaw	Beef	468	4.6	9.2	7.4	28.7	4.1	24.6
	Pork	425	5.3	9.0	7.3	27.0	3.2	23.8
	Venison	456	4.6	8.7	6.8	25.9	4.0	21.9
	Average	449	4.8	8.9	7.2	27.2	3.8	23.4
No-thaw	Beef	443	5.3	10.2	6.8	28.7	3.0	25.7
	Pork	433	4.9	9.3	6.8	28.5	2.9	25.6
	Venison	456	4.2	7.4	6.9	26.8	3.7	23.1
	Average	444	4.8	8.9	6.9	28.0	3.2	24.8
Average		448	4.6	8.4	7.1	27.1	3.3	23.8

[a]Low score indicates tenderness.
[b]High score indicates best in flavor test.

slight differences observed among the three methods, none of them reaching the level of significance.

No values are reported for juiciness and amount of fat and juice in the first series of tests. During these first tests there were unexplained variations in the amount of juice that could be expressed from the meat. These were due to variations in the temperature of the meat when the tests were made. Cold meat samples had almost no juice. To avoid this in succeeding tests, meat loaves were placed in the oven twenty minutes apart. This made it possible to perform the tests when each loaf had reached the internal temperature of 140° F.

There was a slightly unpleasant odor noticeable when the loaves were unwrapped but this did not remain long and did not result in lower flavor scores. Searing in the oven or on top of the stove before covering the meat would have prevented this odor as was shown in the preliminary study and in the study on degree of doneness. This was not possible if temperature were to be controlled for juice tests.

Results in this study did not indicate that any method of defrosting was superior in regard to the characteristics tested in this study. This agreed with Lowe (1952) and Fenton *et al.* (1956) in their work on defrosting methods with domestic meat. They suggested other factors such as length of time for cooking, amount of fuel needed, and preservation of some of the nutrients should also be considered in deciding as to thawing methods.

Kind and level of fat

Data for the study on kind and level of fat are shown in Table 6 and Appendix Table 15. Addition of fat to the lean meat improved its quality. This was true with each kind of fat.

Tenderness appeared to be affected considerably by the addition of fat. Mean tenderness score for samples containing fat and meat was 464 pounds per square inch as compared to 563 pounds per square inch for samples to which no fat had been added. Low score in the Orchard test indicates tenderness, hence addition of fat increased tenderness.

For samples with added fat the mean score for juiciness was 3.9 ml. and for juice and fat was 7.0 ml. Without fat added these scores were 3.5 ml. and 5.0 ml.

Flavor scores were almost identical for samples with added fat and those with no fat added. Mean scores were 6.9 and 7.0. This is equal to like moderately on the hedonic scale (Appendix sheet 1).

Cooking losses were slightly higher for samples to which fat had been added. Mean score for total percent loss was 25 for samples having no fat added, and 29 for the samples containing fat. Evaporation losses were 3.7 and 3.9 percent and drip losses were 22 and 25 percent.

Statistical analysis of the data from three kinds of fat added at three levels of each fat showed significant differences in tenderness, fat and juice expressed, and in peroxide values (Table 7).

As the level of fat increased there was an increase in tenderness (Figure 1). Tenderness scores increased from a high reading of 492 pounds per square inch for the low level of fat to 449 pounds for the high level.

Length of frozen storage also was a factor for increasing tenderness.

Table 6. Averages of tests for study on kind and level of fat

Kind of fat added	Level of fat	Orchard test[a]	Press for juice	Press for fat and juice	Flavor test[b]	Peroxide number	Cooking losses		
							Total	Air	Drip
	lbs.	lbs/sq.in.	ml.	ml.		meq/Kg	%	%	%
				55 days storage					
No fat		621	3.2	4.9	6.9	-	25.5	4.0	21.5
Venison	Low	497	2.5	4.2	7.0	2.0	28.3	4.7	23.6
	Medium	498	3.6	6.4	7.1	2.7	27.3	4.2	23.1
	High	453	2.9	6.2	7.0	3.1	31.7	3.4	28.3
	Average	483	3.0	5.6	7.0	2.6	29.1	4.1	25.0
Pork	Low	573	3.7	6.7	7.4	2.9	28.6	4.3	24.4
	Medium	480	3.4	7.8	6.8	8.8	27.8	4.2	23.6
	High	470	3.8	7.7	6.7	8.8	30.6	5.5	25.1
	Average	508	3.6	7.4	7.0	6.8	29.0	4.7	24.3
Beef	Low	490	5.5	9.0	7.2	0.0	24.0	4.9	19.1
	Medium	480	3.8	7.0	7.1	2.0	28.3	4.0	24.3
	High	560	4.1	8.5	7.1	2.1	31.3	6.8	24.5
	Average	510	4.5	6.2	7.1	1.4	27.8	5.2	22.6
Average at 55 days of venison, pork, and beef		500	3.7	6.4	7.0	3.6	28.6	4.7	23.6

Table 6. (continued)

Kind of fat added	Level of fat	Orchard test[a]	Press for juice	Press for fat and juice	Flavor test[b]	Peroxide number	Cooking losses		
							Total	Air	Drip
	lbs.	lbs/sq.in.	ml.	ml.		meq/Kg	%	%	%
				6 months storage					
No fat		505	3.9	5.2	6.8	-	25.3	3.4	21.9
Venison	Low	453	4.2	6.8	6.7	4.0	29.6	4.5	26.1
	Medium	460	4.1	7.3	7.0	5.1	27.8	3.4	24.4
	High	376	2.5	5.4	6.8	6.0	28.8	2.3	26.5
	Average	429	3.6	6.5	6.8	5.0	28.7	3.4	26.3
Pork	Low	493	5.1	9.0	7.0	6.3	26.7	3.2	23.5
	Medium	388	4.3	8.1	7.2	12.1	27.3	2.0	25.3
	High	381	4.5	8.8	6.9	11.4	31.5	2.0	29.5
	Average	421	4.6	8.6	7.0	9.9	28.5	2.4	26.1
Beef	Low	443	4.6	6.1	7.1	2.3	25.5	4.2	21.3
	Medium	406	3.5	7.1	7.2	5.5	29.8	3.3	26.5
	High	450	3.9	8.8	6.7	6.2	30.9	2.7	28.2
	Average	433	4.0	7.3	7.0	4.7	28.7	3.4	25.3
Average at 6 months of venison, pork, and beef		428	4.1	7.5	6.9	6.5	28.6	3.1	26.6
Average at 55 days and 6 months		464	3.9	7.0	7.0	5.0	28.6	3.9	25.1

[a]Low score indicates tenderness.
[b]High score indicates best in flavor test.

Table 7. Analysis of variance of data for study of kind and level of fat

Source of variance	d.f.	Mean squares		
		Orchard test	Press for juice and fat	Peroxide number
Total	53	--	--	--
Treatment	17	8785.57(.01)	5.628(.05)	31.978(.01)
Fat level	2	10268.30(.05)	1.935	62.2768(.01)
Kind	2	1051.63	22.100(.01)	152.1233(.01)
Storage	1	70056.51(.01)	3.580	117.9562(.01)
Level by kind	4	12371.40(.01)	2.705	10.3957(.01)
Level by storage	2	1439.09	.003	.5061
Kind by storage	2	1364.11	6.340	.9434(.05)
Level by kind and storage	4	391.56	5.105	.6139
Error	36	2825.92	2.958	.2740

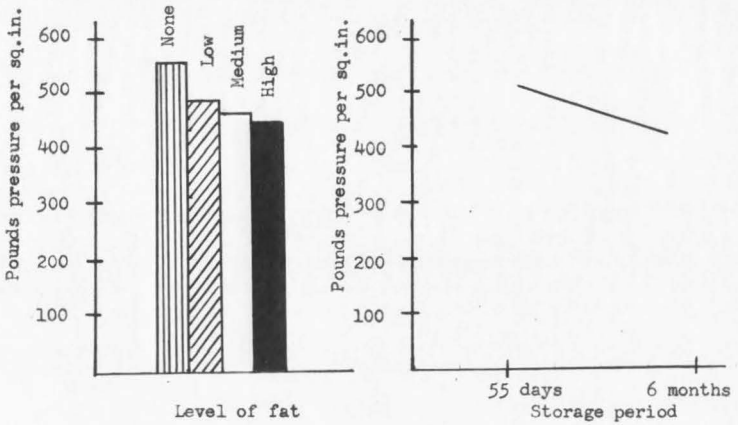

Figure 1. Effect of level of fat and length of storage period on tenderness

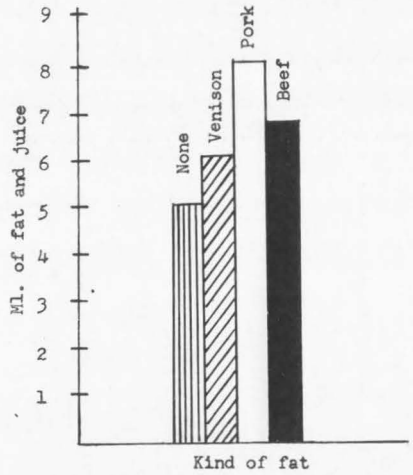

Figure 2. Effect of kind of fat on amount of fat and juice expressed

Average of Orchard test scores for the 55 day storage period was 500 pounds; for six months storage, 428 pounds.

The mean values for level of fat and kind of fat are shown in Table 8. It can be seen that the differences between any two levels for each kind of fat are consistently different. This has been statistically detected and the analysis of variance table confirms the fact that there is significant interaction between the levels and kinds of fat.

Table 8. Effect of level by kind of fat on tenderness

Kind of fat	Level			Average
	Low	Medium	High	
Venison	475	479	415	456
Pork	533	434	426	464
Beef	467	443	505	472
Average	492	452	449	464

Analysis of variance showed that the kinds of fat caused a significant difference in the amount of fat and juice expressed. The average amount of fat and juice increased from 6.0 ml. for the samples containing venison fat to 6.8 ml. for beef and to 8.0 for pork (Figure 2).

Great differences were shown in peroxide number in tests for rancidity. The main effects of three levels of fat, three kinds of fat, and two storage periods caused a significant difference in their peroxide number. It was also found that there was significant interaction of level by kind and kind by storage (Table 7).

Kind of fat showed the greatest variance in the peroxide number;

pork fat had a value of 8.4 milliequivalents per kilogram of fat, venison 3.8, and beef 3.0 (Figure 3). Peroxide values increased when the time of storage period was lengthened to six months and also as the level of fat increased. The values for the high level of fat were 113 percent greater than those for the low level.

The significant interaction of level by kind can be studied in Table 9 and Figure 4. There was a sharp increase in peroxide values with each kind of fat as the level of fat increased from low to medium. Beef showed the least increase. From medium to high level, beef and venison showed a smaller increase than between low and medium levels, and the peroxide value for pork fat was slightly less than at level two.

The significant interaction of kind of fat by length of storage period may be seen in Table 10 and Figure 5. Percent of increase between peroxide values for the two storage periods for the different kinds of fat was 45 for pork, 93 for venison, and 246 for beef. Although percent of increase for the venison and beef was many times greater than that of the pork, their values at 6 months were still below the beginning pork value; and they had not begun to approach a detectable degree of rancidity. Watts and Peng (1947) termed samples rancid at the peroxide value of 20 as expressed in milliequivalents. This figure is often referred to in the literature concerning rancidity.

The flavor test for preference did not reflect the increased peroxide number. This was because rancidity had not yet progressed to the point where it had affected the over-all flavor of the meat since the highest peroxide value for any individual sample was 12.

Results of this study supported those concerning defrosting methods

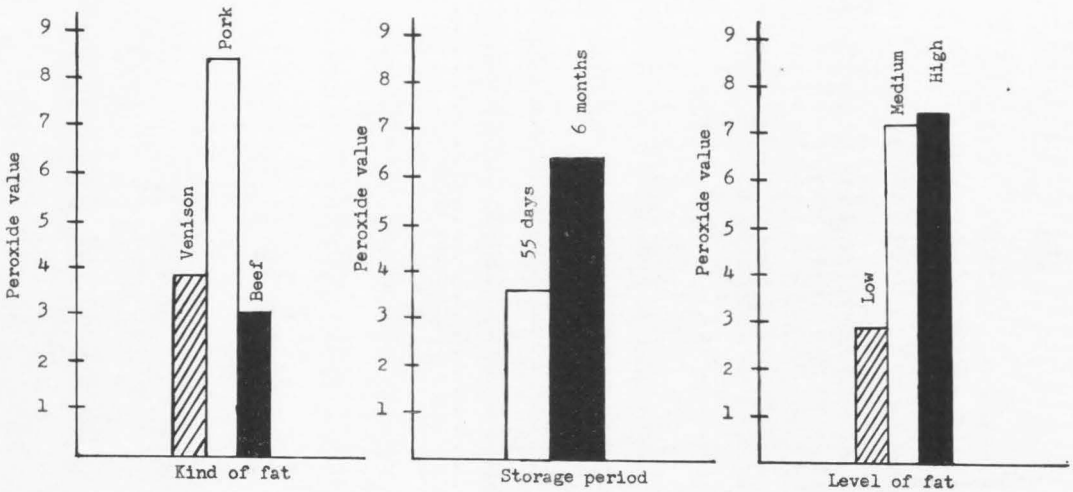

Figure 3. Effect of kind of fat, length of storage period, and level of fat on peroxide value

Table 9. Effect of kind of fat by level of fat on peroxide number

Kind	Level			Average
	Low	Medium	High	
Venison	3.01	3.94	4.53	3.83
Pork	4.64	10.45	10.12	8.40
Beef	1.16	3.72	4.15	3.01
Average	2.94	6.04	6.27	

Table 10. Effect of kind of fat by storage of fat on peroxide number

Storage	Venison	Pork	Beef	Average
55 days	2.61	6.85	1.35	3.60
6 months	5.05	9.96	4.67	6.56
Average	3.83	8.40	3.01	

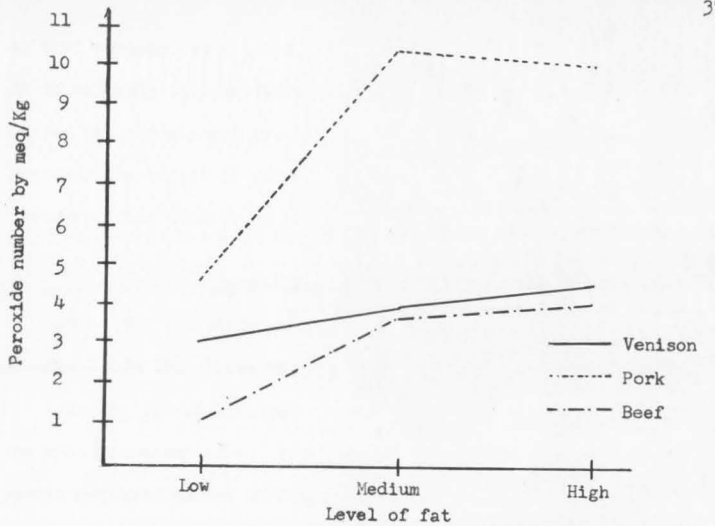

Figure 4. Interaction of level of fat by kind of fat as it affects peroxide number

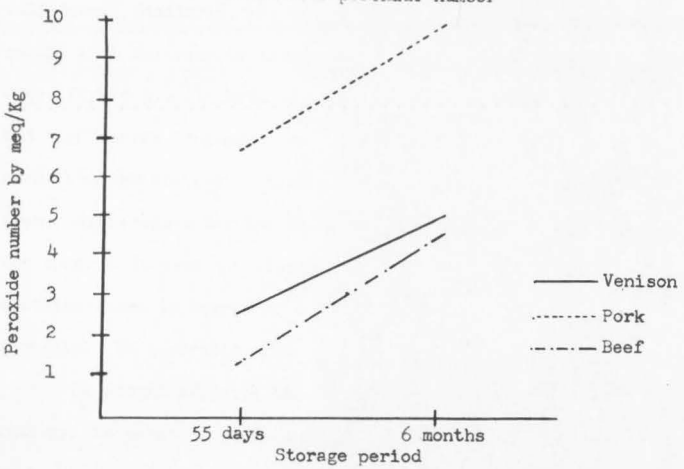

Figure 5. Interaction of storage by kind of fat as it affects peroxide number

in that venison fat did not contribute to poorer quality of the meat. It is unlikely venison fat would be used in making ground venison hamburger since most deer are too lean for enough fat to be available. However, the belief is common that venison fat is objectionable but results of the studies on ground meat did not agree with this.

Part III. Degree of Doneness

Data for the study on degree of doneness are shown in Table 11 and Appendix Table 16. These results indicated some definite trends.

As the internal temperature of the meat increased, toughness of the meat increased also. The mean score for shear test, measured in pounds required to cut through a core of meat 1 inch in diameter, increased from 10.3 for rare to 12.6 for well-done and to 13.3 for very well-done. Similarly, the Orchard test increased from 1069 pounds per square inch for rare to 1195 for well-done and to 1289 for very well-done (Figure 6). In both of these tests low scores indicate tenderness and high scores toughness, or the number of pounds required to cut or press through the meat. However, though mean scores showed the same trend, differences for the Orchard test were significant, while those for shear test were not (Table 12). The increase in toughness as the meat increased in degree of doneness showed a significant linear relationship. No quadratic effects were detected.

The amount of juice that could be expressed dropped sharply as the internal temperature increased. These differences were highly significant and showed a linear relationship (Table 12). There were no quadratic effects detected. For rare meat 10 ml. of juice could be expressed;

Table 11. Averages of tests for study on degree of doneness

Treatment of meat	Shear test	Orchard test[a]	Press for juice	Flavor test[b]	Cooking loss		
					Total	Air	Drip
	lbs.	lbs/sq.in.	ml.	ml.	%	%	%
150° F. rate	10.3	1069	10.2	7.0	19.1	5.4	13.7
175° F. well-done	12.6	1195	5.3	7.3	25.3	9.4	15.9
200° F. very well-done	13.3	1289	1.5	6.9	31.7	19.2	12.5
LSD[c]		184.3	3.101				

[a] Low score indicates tenderness.
[b] High score indicates best in flavor test.
[c] LSD = least significant difference at 5%

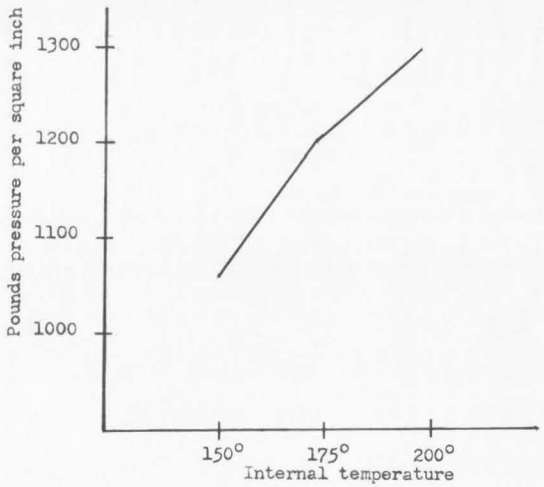

Figure 6. Effect of internal temperature on tenderness

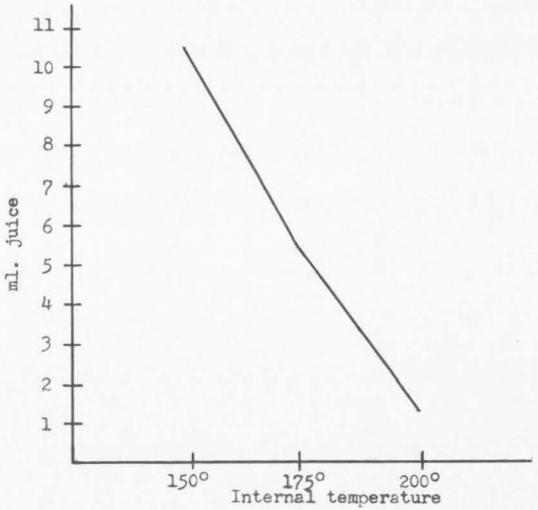

Figure 7. Effect of internal temperature on juiciness

Table 12. Analysis of variance of data for study on degree of doneness

Source of variance	d.f.	Mean squares: Press test for juice	Mean squares: Orchard test for tenderness
Total	14		
Between treatment	2	94.0415(.01)	61136.27(.01)
Linear 1	1	187.056(.01)	121440.4(.01)
Quadratic 1	1	1.027	832.1
Within treatment	12	2.2593	9093.93

for well-done, 5 ml.; and for very well-done, 1 ml. (Figure 7).

Cooking losses increased as internal temperature increased. Total loss for rare meat was 19 percent. Five percent of this total was from evaporation and 14 percent was drip loss. At well-done, the total percent of cooking loss was 25 with 9 from evaporation and 16 from drip. At very well-done the total percent loss was 32. Loss from evaporation had risen sharply to 19 and drip loss had dropped to 13.

These results show that the more rare the meat, the more tender it is, and the more juicy it is. Flavor scores do not conform to this pattern. This is at least partly due to personal preference as to how people like meat cooked. Comments of several judges showed they had a preference for meat well-done over that cooked rare. However, comments also showed the judges found the flavor stronger in the rare meat which may have influenced their preference for well-done samples.

Part IV. Flavor Study

Mean scores for the taste test for venison flavor combined with other flavors are shown in Table 13.

The best score for chops, 8.1 or like very much, was given to those that were browned and then braised in cream of chicken soup. Comments were made to the effect that these chops were tender, mild in flavor, and very good. Chops basted with herb and butter sauce scored slightly higher than those which had the herb mixture rubbed on, 7.9 and 7.1, respectively. Chops stuffed with sage dressing scored 7.4, between like moderately and like very much.

Steaks were considered best when braised in cream of mushroom soup.

Table 13. Averages for 12 judges for flavor of venison combined with other flavors

Dishes prepared	Average score
Chops with herbs	7.2
Chops with herb-butter sauce	7.8
Chops with chicken soup	8.1
Stuffed chops	7.4
Standard braised steak	7.0
Steak braised with tomato	7.1
Steak braised with mushroom soup	7.8
Steak braised with sour cream	7.0
Marinated stew	7.5
Stew with herbs	7.5
Stew with tomatoes	7.7
Stew without tomatoes	7.1
Standard roast	7.0
Roast with garlic	7.8
Roast with herbs	7.9
Pot roast	8.3
Sourbraten	7.8
Roast with marinade (soaked)	7.2
Roast with marinade (unsoaked)	7.5
Rollups	7.9
Chinese pepper steaks	8.2
Tamale pie	7.7
Chili	8.0
Curried venison	7.6

They scored 7.8 while the others were close to the plain control steak at 7.0.

Stews scored high as a group except when tomatoes were left out of the recipe. This was done because it had been suggested tomatoes did not blend with venison. Results did not verify this.

The roast with garlic, the roast with herbs, and the post roast with garlic, herbs, vegetables, and other flavors, all scored close to or above the level of like very much. The pot roast scored the highest of any dish prepared. Roasts marinated in solutions containing mixed flavors were high with the exception of the one which was marinated for four days. This one received a lower score than other marinated roasts because it had acquired a strong sour flavor from the marinade, not because of any poor flavor of the meat.

Combination dishes also scored close to like very much. These dishes were considered well liked by most people and using venison in them appeared to have no influence on their acceptability.

In the process of tasting the dishes prepared for this study, many flavors and combinations of flavors were tried. Compared to the control cuts prepared without added seasoning, all flavors and combinations of flavors had blended with the venison flavor to increase its acceptability.

SUMMARY

A study of venison was made in order to determine what the qualities of this meat were in terms of tenderness, juiciness, and flavor; and to investigate how these characteristics are affected by frozen storage, thawing, and degree of doneness. Also, the venison was prepared in many ways to investigate how its flavor combined with other flavors.

Chops and roasts from three deer differing in background in regard to feeding, activity, and handling of the meat were compared with each other and with beef. Results indicated that proper field care and the use of good principles of meat cookery gave a product not inferior to beef. Activity and controlled diet did not appear to affect the venison under the conditions of this study.

The qualities of venison fat were investigated by making a comparison of beef suet, pork fat, and venison fat each combined with ground lean venison. There were three levels of each kind of fat and meat combinations. Low level contained $\frac{1}{2}$ pound of fat to 5 pounds of lean meat, medium was 1 pound of fat to 5 pounds of lean, and high was $1\frac{1}{2}$ pounds of fat to 5 of the lean ground venison. The ground meat was frozen and after 55 days of locker storage, each kind of fat and lean meat mixture was tested for tenderness, juiciness, flavor, and peroxide values. Because thawing procedure might have influenced the product, samples of the three types of meat containing the medium level of fat

were thawed by three different methods and comparisons were made of tenderness, juiciness, and flavor. Also, since length of frozen storage was known to affect quality in other meats, the whole study was repeated after six months of locker storage.

Scores for tests concerning thawing methods showed there were no significant differences due to either thawing methods or kind of fat used in the ground meat. This indicated venison fat compared well with beef or pork fat under the conditions of this study.

In the study of kinds and levels of fat, tenderness was increased significantly by increase in level of fat and by a longer storage period. The amount of juice and fat expressed was affected significantly by the kind of fat used, pork fat contributing the most. Peroxide number, as a measure of rancidity, increased with the difference in kind of fat; beef had the lowest values, venison had slightly higher, and pork had much higher values than either beef or venison. Level of fat and length of storage both contributed to higher peroxide values. These were significantly different. However, though these differences occurred in peroxide values, no samples reached a value high enough to be rejected by the judges because of rancidity. Flavor scores for all kinds and levels of fat were very similar, indicating that venison fat was not a source of a disagreeable flavor in this study.

Round steaks were cooked to a rare, well-done, and very well-done stage to observe the effect this difference in degree of doneness would have on the palatability of the meat. As the internal temperature of the meat increased, the tenderness and juiciness of the meat decreased

significantly. Flavor scores showed a slight preference for well-done samples.

Types of meat used in the venison dishes prepared for comparisons were chops, steaks, roasts, ground venison, and stew meat. Recipes were chosen which would give a broad selection of flavors, and a variety in methods of preparation. In all of the dishes prepared the scores given indicated the venison had combined with other flavors to show improvement over the plain control samples. All scores were above 7 on the hedonic scale which equals like moderately, and many of them were close to or above 8 which is like very much. This study indicated venison flavor combined well with other flavors.

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APPENDIX

Table 14. Defrosting methods data on quality appraisal tests and cooking losses

Treatment	Kind of fat added	Replication	Orchard test[a]	Flavor test[b]	Cooking loss		
					Total	Air	Drip
		lbs.	lbs/sq.in.		%	%	%
			55 day storage				
Over-thawing	Venison	1	465	7.1	24.5	5.8	18.7
		2	435	6.7	26.4	10.4	16.0
		3	455	6.5	25.7	7.3	18.4
		Average	452	6.8	25.5	7.8	17.7
Medium thaw		1	475	7.1	29.1	12.1	17.0
		2	420	6.6	23.7	9.7	14.0
		3	490	7.4	26.3	6.8	19.5
		Average	462	7.0	26.3	9.5	16.8
No-thaw		1	480	7.5	27.4	9.5	17.9
		2	495	7.1	29.9	5.3	24.6
		3	480	7.0	27.6	6.1	21.5
		Average	485	7.2	28.3	7.0	21.3
Over-thaw	Pork	1	435	7.1	26.9	8.7	18.2
		2	510	6.5	27.4	9.3	18.1
		3	485	7.4	27.7	4.6	23.1
		Average	477	7.0	27.3	7.5	19.8
Medium thaw		1	370	7.2	24.4	3.0	21.4
		2	435	8.0	24.1	8.1	16.0
		3	418	7.0	27.5	7.0	20.5
		Average	408	7.4	25.3	6.1	19.2
No-thaw		1	376	7.7	23.1	5.1	18.0
		2	385	7.0	28.4	9.1	19.3
		3	350	7.0	30.1	5.5	24.6
		Average	370	7.2	27.2	6.6	20.6
Over-thaw	Beef	1	435	7.7	30.9	13.3	17.6
		2	455	7.1	26.0	6.0	20.0
		3	325	7.4	24.2	6.0	18.2
		Average	405	7.4	27.0	8.4	18.6
Medium		1	470	7.2	31.2	12.5	18.7
		2	385	7.2	25.9	8.3	17.6
		3	422	7.0	27.0	7.1	19.9
		Average	426	7.1	28.0	9.3	18.7
No-thaw		1	420	7.5	30.9	10.3	20.6
		2	455	7.0	29.8	7.3	22.5
		3	380	7.5	27.4	6.2	21.2
		Average	418	7.3	29.4	8.0	21.4

Table 14. (continued)

Treatment	Kind of fat added	Replication	Orchard test[a]	Press for juice	Press for juice and fat	Flavor test[b]	Cooking loss		
							Total	Air	Drip
		lbs.	lbs/sq.in.	ml.	ml.		%	%	%
				6 months storage					
Over-thaw	Venison	1	430	4.5	7.5	6.7	25.5	2.6	22.9
		2	450	4.9	8.5	7.0	26.7	3.2	23.5
		3	440	4.7	8.0	6.9	26.1	2.9	23.2
		Average	440	4.7	8.0	6.9	26.1	2.9	23.2
Medium thaw		1	470	4.0	6.1	6.7	26.8	4.2	22.6
		2	465	5.3	10.5	6.9	25.6	4.3	21.3
		3	435	4.6	9.4	6.7	25.4	3.6	21.8
		Average	456	4.6	8.7	6.8	25.9	4.0	21.9
No-thaw		1	490	3.7	7.1	7.1	26.1	4.1	22.0
		2	410	4.6	8.1	6.9	27.6	3.4	24.2
		3	470	4.3	7.1	6.7	24.9	2.6	22.3
		Average	456	4.2	7.4	6.9	26.8	3.7	23.1
Over-thaw	Pork	1	440	3.9	8.0	7.6	27.8	5.4	22.4
		2	420	5.0	8.4	6.9	28.1	1.9	26.1
		3	500	3.6	6.5	7.0	25.8	2.3	23.5
		Average	453	4.2	7.6	7.2	27.2	3.2	24.0
Medium thaw		1	520	3.4	7.2	7.9	28.2	3.2	25.0
		2	405	5.5	11.2	7.3	26.4	3.2	23.2
		3	350	7.0	8.5	6.7	26.3	3.0	23.3
		Average	425	5.3	9.0	7.3	27.0	3.2	23.8
No-thaw		1	450	3.5	6.0	7.6	30.5	2.7	27.8
		2	470	3.7	8.6	6.3	28.4	3.0	25.4
		3	380	7.5	13.2	6.6	26.7	2.9	23.8
		Average	433	4.9	9.3	6.8	28.5	2.9	25.6
Over-thaw	Beef	1	510	3.5	6.1	7.6	29.3	3.3	26.0
		2	450	3.6	8.0	6.9	27.8	1.9	25.9
		3	390	4.8	7.3	7.0	18.3	2.5	15.8
		Average	450	4.0	7.1	7.7	25.1	2.6	22.5
Medium thaw		1	515	4.3	8.2	7.9	28.1	2.4	25.7
		2	470	3.5	7.8	7.3	32.3	5.9	26.4
		3	420	6.0	11.5	6.7	25.8	4.0	21.8
		Average	468	4.6	9.2	7.4	28.7	4.1	24.6
No-thaw		1	420	6.4	12.0	7.6	27.2	2.8	24.4
		2	480	4.8	9.3	6.3	30.4	4.1	26.3
		3	430	4.8	9.4	6.6	28.5	2.2	26.3
		Average	443	5.3	10.2	6.8	28.7	3.0	25.7

[a]Low score indicates tenderness.

[b]High score indicates best for flavor test.

Table 15. Kind and level of fat data on quality appraisal tests and cooking losses

Kind of fat added	Level of fat	Replication	Orchard test[a]	Press for juice	Press for juice and fat	Flavor test[b]	Peroxide number	Cooking losses		
								Total	Air	Drip
			lbs/sq.in.	ml.	ml.		meq/Kg	%	%	%
					55 day storage period					
Venison	Low	1	470	1.8	3.4	7.0	1.9	24.9	2.9	22.0
		2	530	2.6	4.8	7.0	1.9	30.6	6.2	24.4
		3	490	3.1	4.4	7.1	2.1	29.4	4.9	24.5
		Average	497	2.5	4.2	7.0	2.0	28.3	4.7	23.6
	Medium	1	560	3.5	6.2	7.1	2.7	27.3	3.1	24.2
		2	495	3.5	6.3	7.1	2.7	27.6	6.3	21.3
		3	440	3.9	6.7	7.0	2.7	27.0	3.1	23.9
		Average	498	3.6	6.4	7.1	2.7	27.3	4.2	23.1
	High	1	420	4.2	8.5	6.9	3.0	30.7	3.4	27.3
		2	470	2.1	4.5	6.9	3.3	32.2	3.4	28.8
		3	470	2.4	5.5	7.2	3.0	32.3	3.3	29.0
		Average	453	2.9	6.2	7.0	3.1	31.7	3.4	28.3
Pork	Low	1	600	2.9	5.0	7.7	2.7	28.4	4.3	24.4
		2	590	5.0	8.8	6.5	3.1	28.9	4.9	24.0
		3	530	3.3	6.2	7.9	3.0	28.5	3.7	24.8
		Average	573	3.7	6.7	7.4	2.9	28.6	4.3	24.4
	Medium	1	515	3.9	8.5	7.2	8.4	27.4	2.7	24.7
		2	470	3.4	8.3	6.7	8.4	26.5	5.3	21.2
		3	455	3.0	6.7	6.5	9.7	29.6	4.7	24.9
		Average	480	3.4	7.8	6.8	8.8	27.8	4.2	23.6
	High	1	440	2.8	6.0	5.7	8.6	30.3	7.0	23.3
		2	500	5.5	10.1	7.4	8.9	29.0	3.3	25.7
		3	470	3.1	7.0	7.1	8.8	32.5	6.2	26.3
		Average	470	3.8	7.7	6.7	8.8	30.6	5.5	25.1

Table 15. (continued)

Kind of fat added	Level of fat	Replication	Orchard test[a]	Press for juice	Press for juice and fat	Flavor test[b]	Peroxide number	Cooking losses		
								Total	Air	Drip
			lbs/sq.in.	ml.	ml.		meq/Kg	%	%	%
					55 day storage period (cont'd)					
Beef	Low	1	510	3.3	6.0	7.4	0.0	24.6	5.3	19.3
		2	470	6.3	9.5	7.2	0.0	24.7	7.2	17.5
		3	490	7.0	11.6	6.9	0.0	22.8	2.4	20.4
		Average	490	5.5	9.0	7.2	0.0	24.0	4.9	19.1
	Medium	1	510	3.3	6.3	6.9	2.0	28.0	4.5	23.5
		2	475	5.0	8.6	7.7	2.3	28.6	5.7	22.9
		3	455	3.0	6.0	6.7	1.6	28.2	1.7	26.5
		Average	480	3.8	7.0	7.1	2.0	28.3	4.0	24.3
	High	1	520	4.5	9.3	7.0	2.1	29.8	8.9	20.9
		2	580	3.2	7.3	6.7	1.8	31.9	5.2	26.7
		3	580	4.5	9.0	7.5	2.4	32.4	6.4	26.0
		Average	560	4.1	8.5	7.1	2.1	31.3	6.8	24.5
No fat		1	650	2.6	4.2	7.2	-	25.8	3.8	22.0
		2	600	2.7	4.0	6.4	-	27.4	4.3	23.1
		3	610	4.3	6.2	7.0	-	23.8	4.3	19.5
		4	625	3.4	5.1	7.0	-	25.1	4.8	20.3
		Average	621	3.2	4.9	6.9	-	25.5	4.0	21.5

Table 15. (continued)

Kind of fat added	Level of fat	Replication	Orchard test[a]	Press for juice	Press for juice and fat	Flavor test[b]	Peroxide number	Cooking losses		
								Total	Air	Drip
			lbs/sq.in.	ml.	ml.		meq/Kg	%	%	%
					6 months storage					
Venison	Low	1	470	6.1	9.9	6.6	5.0	27.6	3.3	24.3
		2	430	3.2	5.0	6.7	4.6	28.7	5.9	22.8
		3	460	3.2	5.6	6.9	2.5	32.6	4.4	28.2
		Average	453	4.2	6.8	6.7	4.0	29.6	4.5	26.1
	Medium	1	410	3.2	6.2	7.1	5.2	26.8	2.1	24.7
		2	440	5.8	9.6	6.9	5.1	26.6	3.7	22.9
		3	530	3.2	6.2	7.1	5.1	29.9	4.4	25.5
		Average	460	4.1	7.3	7.0	5.1	27.8	3.4	24.4
	High	1	360	2.1	4.8	6.7	6.2	28.8	1.3	27.5
		2	350	2.0	3.8	6.9	6.2	28.5	2.2	26.3
		3	420	3.4	7.5	6.9	5.4	29.2	3.4	25.8
		Average	376	2.5	5.4	6.8	6.0	28.8	2.3	26.5
Pork	Low	1	500	4.5	7.5	7.0	6.6	29.7	5.0	24.7
		2	470	4.5	8.1	7.4	5.8	25.9	2.8	23.1
		3	510	6.2	11.5	6.7	6.6	24.6	1.9	22.7
		Average	493	5.1	9.0	7.0	6.3	26.7	3.2	23.5
	Medium	1	395	3.7	7.6	7.7	11.7	27.4	2.2	25.2
		2	380	4.3	8.8	7.1	12.9	27.3	2.0	25.3
		3	390	4.9	7.8	6.7	11.7	27.2	1.9	25.3
		Average	388	4.3	8.1	7.2	12.1	27.3	2.0	25.3
	High	1	410	4.7	9.4	7.2	11.7	31.5	2.0	29.5
		2	370	5.0	9.7	6.7	11.2	28.8	1.8	27.0
		3	365	3.9	7.2	6.9	11.4	34.3	2.3	32.0
		Average	381	4.5	8.8	6.9	11.4	31.5	2.0	29.5

Table 15. (continued)

Kind of fat added	Level of fat	Replication	Orchard test[a]	Press for juice	Press for juice and fat	Flavor test[b]	Peroxide number	Cooking losses		
								Total	Air	Drip
			lbs/sq.in.	ml.	ml.		meq/Kg	%	%	%
					6 months storage (cont'd.)					
Beef	Low	1	450	2.8	3.7	6.9	2.3	25.3	3.3	22.0
		2	410	5.3	8.1	6.9	1.7	24.1	3.6	22.5
		3	470	5.6	6.6	7.6	2.9	27.2	5.7	21.5
		Average	443	4.6	6.1	7.1	2.3	25.5	4.2	21.3
	Medium	1	420	3.4	6.6	7.7	5.0	28.4	2.5	25.9
		2	380	3.5	6.8	7.7	6.3	29.2	3.8	25.4
		3	420	3.7	7.9	7.1	5.1	31.8	3.6	28.2
		Average	406	3.5	7.1	7.2	5.5	29.8	3.3	26.5
	High	1	410	4.0	8.9	6.6	6.9	29.3	3.8	25.5
		2	470	3.4	8.7	6.1	6.0	32.4	2.3	30.1
		3	470	4.4	8.7	7.5	5.7	30.7	2.0	28.7
		Average	450	3.9	8.8	6.7	6.2	30.9	2.7	28.2
No fat		1	510	3.5	4.3	7.1	-	24.8	4.1	20.7
		2	500	3.7	5.1	6.7	-	26.0	3.6	22.4
		3	460	4.6	5.9	6.7	-	24.3	3.3	21.0
		4	550	4.0	5.7	6.8	-	26.0	2.7	23.3
		Average	505	3.9	5.2	6.8	-	25.3	3.4	21.9

[a]Low score indicates tenderness.
[b]High score indicates best for flavor test.

Table 16. Degree of doneness data on quality appraisal tests and cooking losses

Treatment of meat	Replication	Shear test	Orchard test[a]	Press for juice	Flavor test[b]	Cooking loss		
						Total	Air	Drip
		lbs.	lbs/sq.in.	ml.		%	%	%
150° F. rare	1	10.9	1030	9.1	6.8	16.1	7.2	8.9
	2	12.4	1110	12.7	7.0	18.8	5.1	13.7
	3	9.3	1080	11.5	6.9	20.9	5.2	15.7
	4	10.2	1105	11.0	7.2	20.7	4.3	16.4
	5	8.6	1020	6.5	7.3	19.1	5.4	13.7
	Average	10.3	1069	10.2	7.0	19.1	5.4	13.7
175° F. well-done	1	13.1	1180	4.8	7.2	22.4	14.3	8.1
	2	17.4	1260	4.7	7.1	25.3	9.4	15.8
	3	8.7	1110	5.6	7.6	23.5	8.8	14.7
	4	12.4	1260	6.2	7.7	25.6	5.0	20.6
	5	11.1	1165	5.1	7.1	29.7	9.6	20.1
	Average	12.6	1195	5.3	7.3	25.3	9.4	15.9
200° F. very well-done	1	15.9	1160	2.6	7.0	28.3	19.7	8.6
	2	13.1	1260	1.4	6.6	31.6	19.7	12.6
	3	11.9	1360	1.8	6.9	31.2	20.7	10.5
	4	14.3	1505	.8	6.7	33.9	21.9	12.0
	5	11.5	1162	.9	7.4	33.3	14.0	19.3
	Average	13.3	1289	1.5	6.9	31.7	19.2	12.5

[a]Low score indicates tenderness.

[b]High score indicates best for flavor test.

Appendix Sheet 1

Name_____ Date_____

Sample _____	Sample_____	Sample_____	Sample_____
Like Extremely	Like Extremely	Like Extremely	Like Extremely
Like Very Much	Like Very Much	Like Very Much	Like Very Much
Like Moderately	Like Moderately	Like Moderately	Like Moderately
Like Slightly	Like Slightly	Like Slightly	Like Slightly
Neither Like Nor Dislike	Neither Like Nor Dislike	Neither Like Nor Dislike	Neither Like Nor Dislike
Dislike Slightly	Dislike Slightly	Dislike Slightly	Dislike Slightly
Dislike Moderately	Dislike Moderately	Dislike Moderately	Dislike Moderately
Dislike Very Much	Dislike Very Much	Dislike Very Much	Dislike Very Much
Dislike Extremely	Dislike Extremely	Dislike Extremely	Dislike Extremely
Comments	Comments	Comments	Comments

Directions: Completely encircle the category which best describes your reaction to the sample written above the column. Then under Comments give your reasons for rating the sample as you did. (i.e. Flavor too strong, odor not pleasant, too much seasoning, etc.)