CERTAIN FACTORS AFFECTING THE QUALITY OF SELECTED CUTS OF PRECOOKED FROZEN BEEF AND PORK

by

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INTRODUCTION

Freezing as a means of preserving meat has been used since about 1880, but the frozen food locker plant with its services of freezing and storing foods is little more than a decade old. Its acceptance has spread so rapidly that according to Turpin (1944), who quoted Warrington, there are now in use 5,345 locker plants serving 1,500,000 families and handling an average of 430 pounds of food per locker.

Frozen cooked foods are among the newer products of the frozen food industry, and it is predicted that their use will increase rapidly after the war.

Commercial companies and individual users of frozen food lockers are experimenting with cooked foods, but the literature reveals no reports on the results of scientific experimentation with these new products.

The purpose of this study was to determine the effects of methods of packing, of freezing and of reheating upon the palatability, shear, press fluid and losses in weight of selected cuts of precooked beef and pork.

REVIEW OF LITERATURE

Although no information is available on scientific studies of precooked frozen meats, work has been done in associated fields which is applicable to this problem.

Tressler (1943) stated that a few companies have experimented with the freezing of cooked meats, poultry and other foods.

The use of such foods would be a great convenience in places having little kitchen space such as efficiency apartments, airplanes, dining cars, and drug stores. According to Tressler, the freshly frozen cooked products were excellent, but if they were to be stored longer than two or three months, low temperature storage was necessary to prevent rapid deterioration.

It was believed by Fitzgerald (1944a) that the production of cooked foods might present many more problems than their frozen raw counterparts. He stated that cooked fats have been found to be less stable than raw fats, but the use of antioxidants may extend the storage life of the cooked fats. He added that the cooked foods are more susceptible to bacterial spoilage than the raw foods because they are partially predigested. For this reason, they should not be allowed to remain at room temperature except during a short defrosting period.

Fitzgerald (1944b) also stated that recent developments in emulsifiers and antioxidants probably will assure the chemical and physical stability of gravies which have been difficult to handle, and as a result have retarded progress in the development of precooked frozen meats.

According to Tanner (1944), most bacteria and parasites survive freezing, but their numbers are greatly reduced. Microbial development is markedly retarded, but not entirely eliminated by freezing. Experimental work showed that a temperature of -5° C. was not sufficiently low to inhibit growth of microorganisms on frozen meats but -10° C. was satisfactory.

Trichinella spiralis in pork was killed by freezing at -15° C. for 24 to 36 hours. Tanner recommended that to insure freedom from these parasites the meat be held at this temperature for not less than 20 days.

A number of investigations have been made of factors affecting the quality of raw frozen beef and pork, including methods of packaging, rates of freezing, time and temperature of storage and methods of thawing.

Hankins and Hiner (1941) studied the effect of freezing temperatures on the quality of meat. They found that meat kept as low as 14° F. could be stored without the growth of microorganisms; that the basic causes of rancidity were (a) oxidation, (b) enzymes and (c) microorganisms; and that beef and lamb fats were comparatively resistant to oxidative changes. An undesirable degree of rancidity was found in pork stored two months at 15° F., although there was little if any indication of rancidity after 12 months storage at 0° F.

These workers stated that temperatures of -40° and -10° F. had a more tendering effect upon beef than 20° F., but beef stored at 20° F. increased in tenderness and after 168 days equaled that stored at -40° or -10° F. The results of this study indicated that freezing had no appreciable effect on the nutritive value of meat.

In a previous study Hankins and Hiner (1940) showed that there was no real difference in the tendering effect of the -40° and -10° F. temperatures, therefore the -10° F. would seem to be more economical and practical.

A third study by these workers (Hiner and Hankins, 1941) was made on the influence of aging and freezing on the tenderness of beef. Aging periods of five, 15, 25 and 35 days were each followed by freezing at -10° F. and 20° F. Samples aged five days and frozen at 20° F. were less tender than the samples aged 35 days without subsequent freezing. All others were either more tender or as tender as the latter. From their results, these workers advised aging cuts from low-grade beef carcasses not more than 15 days at 34° F. and then freezing at -10° F.

Bray (1941) and Adams (1942) studied the influence of freezing on beef that had been aged. Both of these workers found that freezing and storing in the frozen state had no effect upon the tenderness of previously aged beef. Bray stated that freezing had no significant effect upon cooking losses or amount of press fluid.

These workers found that the amount of drip was affected by the temperature of freezing and the length of time in freezer storage. The temperature of freezer storage was not important in regulating the amount of drip.

Ramsbottom and Koonz (1941) found that meat frozen at -10° F. was considerably darker than meat frozen at -30° F. The dark appearance of slowly frozen meat is due to the presence of large ice crystals. The lighter color of fast frozen meat is caused by the presence of small ice crystals. The growth of ice crystals during a one-year storage period did not significantly affect the color, but the color was affected by long storage due to the oxidation of hemoglobin to methemoglobin.

It was shown by Tressler (1943) that when meat was frozen slowly the large ice crystals formed were chiefly located outside the muscle fibers. When such meat was thawed the water was not reabsorbed by the muscle fiber, and there was an appreciable amount of drip. In rapid freezing the crystals formed were smaller in size and were within the fibers. When thawed such muscle did not show an appreciable amount of drip.

Empey (1933) at an earlier date had carried on a study of the effect on drip of rates of freezing and thawing, length of period between slaughter and freezing, period in frozen state, age, sex, and breed of animal and composition of muscle including pH. Of these factors only pH was found to be important, for a definite relationship existed between the pH of the muscle and the amount of drip.

It was found by Sair and Cook (1938) that maximum drip occurred between a pH of 5.2 and 5.5. They believed that the high drip observed at this pH was due to the isoelectric condition of the principal muscle proteins.

These workers found that the amount of drip from meat which froze in less than three days was not affected by the rate of freezing at a pH of 6.4 or higher, but at a pH of 5.2 to 5.5 the amount of drip was reduced by more rapid freezing. This behavior was explained on the basis of the high water-retaining capacity of the tissue proteins at a pH of 6.4 resulting in the complete retention of the water produced on thawing regardless of the size of the crystals formed during freezing. At a pH of 5.2 to 5.5 the water-retaining capacity of the proteins was lower

and drip resulted. These losses were lessened by rapid freezing which produced smaller ice crystals and a more uniform distribution of water when they melted.

It was shown by Moran and Hale (1932) that time of frozen storage at any one temperature had little effect on the amount of drip, but that temperature of storage made a difference, the higher storage temperature resulting in increased drip.

Cook and White (1941) found that storage temperature was the primary factor affecting the color of the lean and development of rancidity in the fat of pork. They showed that storage temperatures of at least -18° C. or lower were necessary if rancidity of pork fat was to be avoided over storage periods of one year's duration.

Brady and others (1942) studied the effect of freezing rate on quality of steaks. The freezing temperatures used were 0° F. and -15° F. Results showed that slow frozen meat had a higher evaporation loss during storage than quick frozen. The smallest cooking losses (drip and evaporation) were found in quick frozen steaks, broiled while frozen. The largest losses occurred in slow frozen steaks, thawed before broiling. These workers stated it is desirable to quick freeze thin cuts of meat and cook while still frozen to prevent a high loss in evaporation and drip.

The effects of freezing and thawing beef were studied by Paul and Child (1937). Two temperatures of thawing were used, 175° C. and 24° to 25° C. They found that the different thawing temperatures did not affect press fluid, drip, total mois-

ture or tenderness. The total losses, including freezing, thawing and cooking losses, were higher for roasts thawed at 175° C. than for those thawed at 24° to 25° C. The frozen beef had greater total losses than the unfrozen, but the differences between the frozen and unfrozen for tenderness, drip and total moisture were not significant.

It was found by Jeffrey (1942) that method of thawing had little effect upon losses, shear and press fluid of frozen pork roasts. Three methods of thawing were used in this study, (a) room temperature for 15 hours, (b) refrigerator temperature for 48 hours and (c) oven temperature of 350° F. Room temperature thawing gave the highest percentage of total loss, and the least press fluid but the most tender meat. Cooking time per pound was less for meat thawed by this method.

Vail and others (1943) made a similar study of effect of method of thawing upon losses, shear and press fluid of frozen beef steaks. The most press fluid was obtained from steaks thawed in the oven and the least from steaks thawed at room temperature. The steaks thawed in the oven required about one and one-half times as long to reach a given internal temperature as those thawed at room temperature. Thawing at oven temperature gave slightly less tender meat than thawing by the other two temperatures.

Wellington (1940) carried on a study of several factors affecting the quality of pork loin roasts and sausage stored in freezer lockers. Different types of wrappers, use of oat flour as an antioxidant and time of storage were factors included in

this investigation. He found that white butcher paper, freezer paper, vegetable parchment paper and brown waxed paper each allowed approximately the same amount of shrinkage and degree of freezer burn. Double wrapping the roasts decreased the loss in weight. Sausage treated with 2.0 per cent oat flour was not found to be superior to untreated sausage. Results of this study indicated that, under these conditions, pork roasts should not be stored longer than 150 days and sausage not longer than 120 days. However, the storage temperature ranged from 7.0° F. to 18° F. and on one occasion reached 28° F. This is considered a high storage temperature and does not prove that pork cannot be satisfactorily stored for a longer period of time at a lower temperature.

Lowe (1943) stated that low cooking temperatures gave tenderer meat under some conditions, but the meat required a longer cooking period. Factors affecting the time required to cook meat are cooking temperature, weight, surface, distance to center of thickest portion, stage to which meat is cooked, composition of meat, degree of post mortem changes, method of cooking and initial temperature of meat.

Many factors also affect losses that occur during the cooking of meat. These include stage of cookery, composition of meat, surface area, degree of ripening, cooking temperature and method of cooking. Losses may vary from 5.0 to 50 per cent.

According to Tressler (1943) all packaging materials for frozen foods must be moisture-vapor-proof to prevent desiccation. With the exception of rubber latex bags, which are not now avail-

able, moisture-vapor-proof cellophane is as good a packaging material as any on the market.

A study was made by Griswold and Blakeslee (1939) on the effect of different wrappings, temperatures and length of storage on keeping qualities of frozen pork chops. Six types of wrappings were used--kraft wrapping paper, whale hide, Thermo M, lard, lard and tallow and cellophane. The wrappings had little effect on the palatability of the chops but had a decided effect on moisture loss. Kraft wrapping paper permitted the greatest loss while cellophane allowed less moisture to escape than any of the other materials.

Hiner and Kauffman (1944) showed that a coating of fat protects meat against freezer burn. Coating materials used were lard, beef tallow, ice and combinations of lard and beef tallow. These workers found that coating of pure lard gave the smallest weight losses, lard and beef tallow combinations ranked second and pure beef tallow third. Ice glaze was unsatisfactory unless renewed frequently. They concluded that meats may be frozen, dipped in melted lard at 100° to 200° F. and stored at 0° F. for 64 weeks with very satisfactory results relating to control of weight loss. They recommended wrapping the coated meat in butcher paper to protect the fat coating from scratching and the person handling the meat from grease.

The literature on this subject, all of which is recent, shows that meats can be satisfactorily frozen and that low temperatures for both freezing and storage are highly desirable.

PROCEDURE

The meat used in this study consisted of pork loin roasts, beef top clod roasts, pork loin chops and porterhouse steaks. All meat was purchased from the Williams Meat Company of Kansas City, Kansas.

From each of four pork loin roasts, weighing approximately eight pounds, two pounds were cut, wrapped, frozen and reserved for tasting as freshly cooked pork at such time as the cooked frozen meat should be tasted. The remainder of the meat was weighed on a Torsion Balance and a thermometer inserted in the thickest muscle. It was then placed, fat side up, on a wire rack in a weighed Russian iron pan 8.5 inches by 15.5 inches and cooked in an electric oven preheated to a temperature of 350° F. When the roast had reached an internal temperature of 180° F., it was removed from the oven, the time recorded and the meat and drippings weighed. After cooling in the room to an internal temperature of 100° F., the meat was covered loosely with cellophane and placed in the refrigerator over night. The following morning the meat was again weighed and cut in two near the center.

Two adjacent cores one inch in diameter were cut from the longissimus dorsi muscle. One core was tested immediately and one was frozen for future testing. The roast was boned, sliced and divided into four lots. One lot was reserved for immediate testing and the remaining three prepared for freezing. All scraps were weighed and divided into edible and inedible portions. The edible scraps were prepared for freezing in the same

manner as the sliced meat. Each lot was weighed and placed in double moisture-vapor-proof cellophane bags and heat sealed. One-half was packed dry and one-half in drippings. About one-fourth of the drippings was used for each lot. From roasts numbers one and three, two lots were packed dry and one in drippings. This procedure was reversed for roasts numbers two and four, one lot being packed dry and two lots in drippings. A label giving number, date, cut, weight of meat and weight of drippings was placed in each package between the two layers of cellophane.

As the meat was packaged it was placed immediately in a freezing unit at 0° F. until the three lots were ready to be quick frozen. It was then placed in a sharp freeze at a temperature of approximately -10° F. and held for 24 hours or longer, then removed to a freezer locker having a temperature of about 0° F. and held there until ready to be thawed and reheated.

A portion of the fourth lot was scored by a palatability committee consisting of five members of the Department of Food Economics and Nutrition, using a grading chart for cooked meat compiled by the Committee on Preparation Factors, National Cooperative Meat Investigations.

The tenderness of the meat was tested by shearing the core in a Warner-Bratzler Modified Shearing Apparatus. The shear reported is an average of five determinations made on each core.

All visible fat was removed from the remaining sliced meat. The lean portion was ground three times in a Universal Food Chopper. This ground meat was used to determine the press fluid,

using a Carver Laboratory Press. For this determination two 40-gram samples of the ground meat were used. Each sample was divided into four equal parts. An absorbent pad was placed in the bottom of the pressing cylinder and a filter paper placed on top of the absorbent pad. One portion of ground meat was placed on top of the filter paper, then another filter paper, then another portion of meat until all of the meat and filter papers were used. Another absorbent pad was placed on top and the cylinder plunger adjusted. The cylinder was placed in the press and pressure was applied to the meat for 30 minutes in the following manner: At the end of the first seven minutes the pressure had been brought up to 5,000 pounds, at the end of 14 minutes to 10,000 pounds, at the end of 21 minutes to 15,000 pounds and at the end of 25 minutes to 16,000 pounds. This pressure was maintained for five minutes. The press fluid was collected in a graduated centrifuge tube attached to the cylinder. At the end of 30 minutes the pressure was released, and the tube containing the press fluid carefully removed. After standing an hour or more to allow for separation of fat and serum, the total press fluid and serum were recorded. The other 40-gram sample was treated in the same manner. The reported press fluid is the average of the two determinations.

Twelve chops were cut from each of four pork loins and braised. The following method was used for treating the four groups: The chops were numbered consecutively from 1 to 12 with previously weighed wire numbers, and the 12 chops weighed together. They were then seared, six at a time, on the broiler

of an electric oven, at 400° F. for three minutes on each side. The door of the oven was left ajar two and one-half inches. The chops were then placed on a rack in a weighed enamel roaster, the drippings added, covered and cooked in an electric oven preheated to 325° F. for one hour. They were removed from the oven and weighed. Evaporation losses were determined by subtracting the weight of the cooked meat plus drippings from the weight of the meat when placed in the oven for searing. The amount of drippings was determined by subtracting the weight of the empty roasting pan from the weight of the pan and drippings. The chops were then divided into four lots in the following manner: Lot I contained numbers 1, 5, 9; Lot II, numbers 2, 6, 10; Lot III, numbers 3, 7, 11; and Lot IV, numbers 4, 8, 12.

A portion of Lot I was scored immediately by the palatability committee using the same score card that was used for the pork roasts. The remaining meat was placed in the refrigerator over night and tested the following day for shear and press fluid in the same manner as the pork roasts were tested.

The other three lots were packaged and frozen in the manner previously described for the pork roasts.

Four beef roasts, two Grade B top clod and two Grade AA top clod, were used. It was originally planned to use Grade AA meat, but the first shipment was Grade B.

Each rolled roast was weighed on a soils balance and two thermometers were inserted in the thickest muscle. It was then placed, fat side up, on a rack in a weighed Russian iron pan 8.5 inches by 15.5 inches and cooked in an electric oven preheated

to 290° F. until an internal temperature of 160° F. was reached. It was removed from the oven, the time recorded and the roast and drippings weighed. After cooling in the room to a temperature of 100° F., the meat was covered loosely with cellophane and placed in the refrigerator over night. The following morning the roast was again weighed, and two adjacent cores one inch in diameter were removed from the infraspinatus muscle. One core was used for immediate testing and one packaged and frozen for later testing.

The meat was sliced on an electric slicer to a thickness of 3/16 inch and divided into seven lots. One lot was used for immediate testing and the remaining six were packaged and frozen in the same manner as the pork roasts. Three lots were packed dry and three packed in drippings. Since the proportion of drippings per pound of meat was small, all drippings were used for the three lots so packed.

The same determinations were made on the reserved lot of cold roast beef as on the pork, namely palatability, shear and press fluid. The only change in technique was in the method of applying pressure for the press fluid determination. The pressure was applied to the meat for 15 minutes in the following manner: At the end of the first four minutes, the pressure had been brought up to 5,000 pounds, at the end of eight minutes to 10,000 pounds and at the end of 12 minutes to 16,000 pounds. This pressure was maintained for three minutes.

Sixteen choice porterhouse steaks, divided into four groups, were broiled. Each steak was numbered with a wire number, skew-

ered and weighed.

A thermometer was inserted in the longissimus dorsi muscle. The steak was placed on a wire rack in a weighed Russian iron pan 6.25 inches by 8.0 inches and cooked in an electric oven preheated to 390° F. The oven door was left ajar 2.5 inches. The steak was turned when an internal temperature of 120° F. was reached and cooking was continued to an internal temperature of 150° F. Upon removal from the oven the steak and drippings were weighed. One steak from each group was reserved for immediate testing and the remaining three packaged and frozen by the method previously described. Approximately one-third of the drippings was used for each steak packed in drippings.

The reserved steak was scored by the palatability committee and tested for shear and press fluid by the same methods used for beef roasts.

All precooked frozen meat was removed from freezer storage at 0° F. just before reheating. Twelve samples each of pork roasts, pork chops and beef steaks were reheated in the following manner: Two samples of meat frozen in drippings and two samples frozen dry were reheated in the double boiler, and four samples of meat frozen in drippings and four samples frozen dry were reheated in the oven, pork roasts at 350° F., pork chops at 325° F. and beef steaks at 300° F. Equal numbers of the 24 samples of beef roasts, one-half frozen dry and one-half frozen in drippings, were reheated in a double boiler, in a 300° F. oven and in a 400° F. oven. One-half cup of water was added to each sample reheated in the 400° F. oven.

Time of reheating and weight after reheating were recorded for each sample.

The reheated meat was scored by the palatability committee and tested for press fluid and shear in a manner identical to that used for the freshly cooked meat.

The percentage cooking losses (drip and evaporation) were obtained by dividing the losses in weight of the meat during cooking by the weight of the meat when placed in the oven.

The percentage losses due to freezing and reheating were determined by dividing the difference between the weight of the meat when placed in the freezer locker and when it was reheated ready for serving by the weight of the meat when placed in the freezer locker.

Total percentage loss in preparation was determined by adding cooking losses and losses due to freezing and reheating.

RESULTS

The data in Table 1 give palatability scores, percentage loss in freezing and reheating, total losses in preparation, shear in pounds and press fluid and serum in milliliters for freshly cooked and frozen reheated pork roasts.

Total palatability scores varied from 47.3 to 44.0 points or a range of 3.3 points. Averages show the meat frozen dry scored 1.2 points higher than meat frozen in drippings, and the freshly cooked meat scored 1.2 points higher than the meat frozen dry. The shear ranged from 11.4 pounds to 13.8 pounds, indicating small differences in tenderness in favor of the

Table 1. Average judging scores, shearing force, press fluid and losses in preparation for pork roasts

Palatability scores	Frozen - packed dry and/or in drippings: Method of reheating: Double boiler: Dry	Double boiler: Drippings	Oven - 350° F.: Dry	Oven - 350° F.: Drippings	Averages: Dry	Averages: Drippings	Freshly cooked
Intensity							
Aroma	4.4	4.6	4.9	4.8	4.8	4.7	5.2
Flavor of fat	5.2	4.9	5.6	5.3	5.6	4.1	4.8
Flavor of lean	4.9	4.9	4.9	5.0	4.9	5.0	5.0
Tenderness	5.4	4.4	5.2	5.4	5.2	5.2	5.1
Juiciness							
Quantity	4.8	4.2	4.6	4.6	4.3	4.6	5.4
Quality	5.4	5.0	5.1	5.2	5.0	5.2	5.6
Desirability							
Aroma	5.6	5.5	5.8	5.6	5.8	5.6	5.4
Flavor of fat	5.3	5.2	5.3	5.0	5.2	5.0	5.2
Flavor of lean	5.4	5.3	5.4	5.6	5.3	5.5	5.6
Total score	46.4	44.0	46.8	46.5	46.1	44.9	47.3
Other factors							
Shearing force (lb.)					13.8	11.6	11.4
Press fluid (ml.)	6.6	8.9	5.5	7.1	5.9	7.7*	7.0
Serum in press fluid (ml.)	3.0	4.5	3.1	3.2	3.3	3.6	4.8
Percentage loss in freezing and reheating	2.99	3.21	4.22	6.56	3.81	5.44	
Total percentage loss in preparation	31.75	31.97	32.98	35.32	32.57	34.20	28.76

*Average of seven pressings - In sample 3c there was not enough meat for two determinations

freshly cooked meat. The palatability committee did not find this difference.

Losses in freezing and reheating varied from 3.0 per cent to 6.6 per cent and total loss in preparation from 28.8 per cent to 35.3 per cent. Meat frozen in drippings had a 1.6 per cent greater loss than meat frozen dry. Meat reheated in the double boiler had smaller losses than meat reheated in the oven. Added to this total loss in preparation was a 27.2 per cent loss in bone and edible scraps. The loss due to bone was 18.6 per cent and edible scraps 8.6 per cent.

Total press fluid ranged from 8.9 ml to 5.5 ml, and serum in press fluid from 4.8 ml to 3.0 ml. Meat frozen in drippings had the greatest amount of press fluid but less serum than the freshly cooked meat, indicating that the increased press fluid was probably due to fat absorption by the meat. The palatability committee found the freshly cooked pork roasts more juicy than the frozen. The meat frozen dry was scored 4.3 points on juiciness, that frozen in drippings 4.6 points and freshly cooked meat 5.4 points. These scores correlated with the amount of serum in the press fluid; 3.3 ml for meat frozen dry; 3.6 ml for meat frozen in drippings; and 4.8 ml for the freshly cooked meat.

The three types of pork roast, freshly cooked, frozen dry and frozen in drippings, were rated according to tenderness, juiciness and desirability of aroma, flavor of fat and flavor of lean, factors thought most likely to be affected by freezing and reheating. These ratings placed them in the same order as the total palatability scores, namely, fresh, first; frozen dry, sec-

one; and frozen in drippings, third.

Table 2 gives similar data for pork chops. The chops varied in total palatability score from 46.9 points to 43.3 points; loss in freezing and reheating from 0.29 per cent to 2.01 per cent; total loss in preparation from 30 per cent to 32 per cent; shear from 16.0 pounds to 19.5 pounds; press fluid from 7.9 ml to 3.7 ml; and serum in the press fluid from 3.1 ml to 0.5 ml.

A study of this table shows that pork chops varied 3.6 points in palatability score. Average scores show the meat frozen in drippings was only 0.1 of a point higher than meat frozen dry, but an interesting variation was the score of the freshly cooked chops. These scored 2.4 points lower than the chops frozen in drippings and 2.3 lower than those frozen dry.

Losses in meat frozen dry were 1.1 per cent greater than in meat frozen in drippings.

Tenderness varied little, according to either objective test or palatability score. The mechanical test showed the meat frozen dry to be the most tender, freshly cooked meat second and meat frozen in drippings the least tender of the three. The palatability committee also rated the meat frozen dry as the tenderest, but the other two were in reverse order.

The frozen meat showed much more press fluid and serum than the freshly cooked meat. The latter had only 55 per cent as much press fluid and 16.7 per cent as much serum as the chops frozen in drippings. The palatability committee rated the three samples in the same order as they were placed by the objective test. Chops frozen in drippings were the most juicy, chops fro-

Table 2. Average judging scores, shearing force, press fluid and losses in preparation for pork chops

Palatability scores	Frozen - packed dry and/or in drippings						
	Method of reheating						
	Double boiler		Oven - 350° F.		Averages		Freshly cooked
	Dry	Drippings	Dry	Drippings	Dry	Drippings	
Intensity							
Aroma	5.0	5.0	4.8	5.0	4.9	5.0	4.5
Flavor of fat	4.8	5.2	4.9	5.3	4.8	5.2	4.8
Flavor of lean	5.0	4.8	5.2	4.6	5.1	4.7	4.6
Tenderness	4.6	4.0	4.9	5.1	4.8	4.6	4.1
Juiciness							
Quantity	4.0	4.2	4.6	4.5	4.3	4.4	3.9
Quality	4.6	4.2	5.2	4.9	4.9	4.6	4.8
Desirability							
Aroma	6.0	6.1	6.1	5.9	6.0	6.0	6.2
Flavor of fat	4.6	5.2	5.5	5.5	5.2	5.4	4.5
Flavor of lean	5.7	5.7	5.7	5.8	5.6	5.8	5.9
Total score	44.3	44.4	46.9	46.6	45.6	45.7	43.3
Other factors							
Shearing force (lb.)					16.0	19.5	17.7
Press fluid (ml.)	7.9	7.5	5.6	6.3	6.4	6.7*	3.7
Serum in press fluid (ml.)	2.8	2.9	1.4	3.1	1.9	3.0	.5
Percentage loss in freezing and reheating	1.45	.29	2.01	1.0	1.83	.76	
Total percentage loss in preparation	31.40	30.24	31.96	30.95	31.78	30.71	29.95

*Average of six pressings. Press was out of order and only one determination was made on samples 2c-1 and 3c

zen dry second and freshly cooked chops were the driest. The differences in palatability scores for juiciness were not as great as the objective test would indicate.

Data for beef roasts are given in Table 3. Palatability scores varied from 47.5 points to 44.5 points; losses in freezing and reheating from 1.6 per cent to 11.2 per cent; total loss in preparation from 30.5 per cent to 41.7 per cent; shear from 12 pounds to 17.7 pounds; amount of press fluid from 6.1 ml to 1.1 ml; and serum in the press fluid from 4.9 ml to 0.3 ml.

A study of the results given in Table 3 shows a variation of three points in palatability scores of beef roasts. Average scores for the three types show that the meat frozen in drippings had the highest score, but this was only 0.2 of a point higher than the freshly cooked beef and 1.1 points higher than meat frozen dry. The freshly cooked meat was scored cold and the frozen meat hot. This probably made a difference in the total scores. The freshly cooked meat rated lower on intensity of aroma, flavor of fat and of lean and desirability of flavor of fat. Judges apparently do not like the texture or flavor of cold fat.

Losses in freezing and reheating were greatly increased in the meat reheated in a 400° F. oven. Double boiler reheating resulted in the smallest losses.

The three samples of meat varied only slightly in tenderness, according to both the scores of the palatability committee and the mechanical test. The meat frozen in drippings was the

Table 3. Average judging scores, shearing force, press fluid and losses in preparation for beef roasts

Palatability scores	Frozen - packed dry and/or in drippings								
	Methods of reheating								
	Double boiler		Oven - 300°F.		Oven - 400°F.*		Averages		Freshly cooked
	Dry	Drippings	Dry	Drippings	Dry	Drippings	Dry	Drippings	
Intensity									
Aroma	5.1	5.2	5.1	5.2	5.0	5.2	5.1	5.2	5.0
Flavor of fat	5.0	5.5	5.2	5.3	5.4	5.4	5.2	5.4	4.8
Flavor of lean	5.1	4.9	4.9	5.5	4.9	5.0	5.0	5.1	4.9
Tenderness	4.7	5.0	5.2	5.0	5.5	5.1	5.1	5.0	4.9
Juiciness									
Quantity	4.1	4.4	4.8	5.1	4.6	4.7	4.5	4.7	5.0
Quality	4.3	4.8	5.0	5.2	4.8	5.0	4.7	5.0	4.8
Desirability									
Aroma	5.6	5.6	5.7	5.5	5.3	5.5	5.5	5.5	6.1
Flavor of fat	5.3	5.5	5.5	5.1	4.7	5.2	5.2	5.3	4.9
Flavor of lean	5.3	5.5	5.5	5.6	5.1	5.4	5.3	5.5	6.1
Total score	44.5	46.4	46.9	47.5	45.3	46.5	45.6	46.7	46.5
Other factors									
Shearing force (lb.)							14.3	12.0	17.7
Press fluid (ml.)	1.1	3.4	1.5	1.6	1.6	2.4	1.4	2.5	6.1
Serum in press fluid (ml.)	.4	1.3	.3	.6	.3	.6	.3	.8	4.9
Percentage loss in freezing and reheating	1.6	3.12	6.19	6.58	11.22	7.64	6.34	5.78	
Total percentage loss in preparation	32.11	33.63	36.70	37.09	41.73	38.15	36.85	36.29	30.51

* ½ cups water added

most tender. The mechanical test indicated that meat frozen dry was second and freshly cooked meat third. Palatability scores were in reverse order.

Frozen roast beef contained much less press fluid and serum than freshly cooked meat. The amount of press fluid in the meat frozen in drippings was only 41 per cent and the serum 16 per cent of that in the freshly cooked meat. Press fluid and serum in the meat frozen dry was even less. Palatability scores placed the samples in the same order as the objective test, freshly cooked meat, first; frozen in drippings, second; and frozen dry, third; but the range in these scores did not indicate as great a difference as the objective test showed.

Table 4 gives the data for beef steaks. Palatability scores ranged from 48.4 points to 47.2 points; loss in freezing and reheating from 0.7 per cent to 3.9 per cent; total loss in preparation from 30.2 per cent to 34 per cent; shear from 23.6 pounds to 30.5 pounds; amount of press fluid from 6.9 ml to 3.1 ml; and serum in press fluid from 6.0 ml to 1.7 ml.

A study of this table shows freshly cooked steaks scoring only 0.3 of a point higher than steaks frozen in drippings and only 0.9 of a point higher than those frozen dry. One judge rated the meat frozen dry and reheated in the double boiler as the most desirable, and the meat frozen in drippings and reheated in the oven as the least desirable. Two judges thought the meat frozen in drippings was too fat-saturated.

Meat frozen in drippings had a slightly larger percentage loss than meat frozen dry. The freshly cooked steaks showed

Table 4. Average judging scores, shearing force, press fluid and losses in preparation for beef steaks

Palatability scores	Frozen - packed dry and/or in drippings						Freshly cooked
	Method of reheating						
	Double boiler		Oven - 300° F.		Averages		
	Dry	Drippings	Dry	Drippings	Dry	Drippings	
Intensity							
Aroma	5.3	5.4	5.5	5.3	5.5	5.4	4.9
Flavor of fat	5.4	5.6	5.4	5.2	5.4	5.3	5.1
Flavor of lean	5.1	4.8	5.0	5.2	5.0	5.1	5.3
Tenderness	5.3	5.0	4.9	5.3	4.9	5.2	5.3
Juiciness							
Quantity	5.3	5.4	5.0	5.7	5.1	5.6	5.5
Quality	5.0	5.4	5.0	5.7	5.0	5.7	5.1
Desirability							
Aroma	5.7	5.4	5.8	5.6	5.7	5.6	5.8
Flavor of fat	5.4	4.8	5.1	4.9	5.2	4.9	5.2
Flavor of lean	5.6	5.4	5.7	5.3	5.7	5.3	6.2
Total score	48.1	47.2	47.4	48.2	47.5	48.1	48.4
Other factors							
Shearing force (lb.)					30.5	23.6	28.1
Press fluid (ml.)	4.6	3.1	5.2	5.5	5.1	4.7	6.9
Serum in press fluid (ml.)	3.8	1.7	4.2	4.4	4.1	3.6	6.0
Percentage loss in freezing and reheating	.72	3.91	3.33	3.25	2.49	3.47	
Total percentage loss in preparation	30.19	33.99	32.90	31.64	32.03	32.42	32.31

more total loss in preparation than some of the frozen steaks. This was due to a variation in the cooking losses of the individual steaks, and a higher average percentage loss for the steaks tested fresh than for those subsequently frozen.

According to the mechanical test meat frozen in drippings was the most tender of the three samples, freshly cooked meat second and meat frozen dry was the least tender. Palatability scores placed them in a different order, freshly cooked meat, first, frozen in drippings, second and frozen dry, third. Since each steak was a unit or sample, the palatability committee scored one muscle, and another muscle was used for the mechanical test. This could have made a difference in the tenderness rating.

The quantity of press fluid and serum was less in the frozen meat than in the freshly cooked meat, but the variation was not great. Steaks frozen dry had more press fluid and serum than those frozen in drippings. The palatability committee's score did not agrde with the mechanical test. Meat frozen in drippings was rated juiciest by the committee, but the mechanical test placed it as the least juicy of the three.

DISCUSSION OF RESULTS

The results indicate that frozen roast pork is an acceptable product and, by all tests and scores used in this study, the frozen meat varied only slightly from the freshly cooked meat. There was also very little difference in the pork frozen dry and that frozen in drippings, the scores favoring the meat

frozen dry.

In the use of precooked frozen pork, time and labor required for reheating would be an important factor. The average time required to heat the samples of pork roast, weighing from 204 g to 298 g, was 50 minutes for the oven and 56 minutes for the double boiler. As previously stated the frozen meat was reheated immediately after removal from freezer storage, no attempt being made to thaw the meat at room or refrigerator temperature. Thawing would have greatly reduced the reheating period. Time of reheating could be lessened by packaging the meat with layers of cellophane between each serving, so that the slices of meat could be divided before reheating. Use of steam would also probably shorten the reheating time. Neither special equipment nor skill is required for the reheating process. Two square aluminum cake pans were used for reheating the meat in the oven.

Results indicate that food establishments with limited cooking equipment, space and unskilled help could profitably serve precooked frozen roast pork. Meat slicing by untrained help usually results in a high percentage waste in edible scraps. The precooked frozen meat would eliminate this loss.

Results of this study indicate that precooked frozen pork chops are a more palatable product than the freshly cooked meat. Not only did the frozen chops receive the highest score of the palatability committee, but the mechanical test showed more press fluid and serum than the freshly cooked chops. As with the pork roasts, there was little difference in the meat frozen

dry and that frozen in drippings.

Although the precooked frozen chops are an acceptable product, their use might be questioned because of the time required for reheating, which averaged 92 minutes in the oven and 99 minutes in the double boiler. The original cooking period was 60 minutes plus searing time, hence there would be no advantage, as far as time is concerned, in using the precooked frozen chops. However, no particular skill and no watching are required in reheating the chops. Had the chops been thawed at room or refrigerator temperature, the reheating time would have been shortened.

A summary of tests and scores shows that precooked frozen roast beef is not only an acceptable product, but equally as palatable as the freshly cooked meat. The mechanical test showed the frozen meat to be much less juicy than the freshly cooked meat, but the palatability committee's score showed only 0.5 of a point difference in the quantity of juice. As previously mentioned, the freshly cooked meat was scored cold and the frozen meat scored hot, a point favoring the frozen meat.

The time required for reheating the frozen beef averaged 70 minutes for the double boiler, 48 minutes for the 300° F. oven and 38 minutes for the 400° F. oven. As previously noted the losses were greater in the meat reheated in the hotter oven. The weights of the samples of beef ranged from 404 g to 772 g. As with the pork, no attempt was made to thaw the beef prior to reheating. Thawing before heating, packaging with layers of cellophane between each serving and use of steam for reheating are practices which would shorten the reheating time.

This study indicates that precooked frozen roast beef could be used by food establishments in a way similar to roast pork with a saving of time, labor and cooking space.

As shown by the results of this study, precooked frozen beef steaks are an acceptable palatable product, only slightly less desirable than the freshly cooked steaks.

The steaks present the same reheating problems as the pork chops. The time required for reheating averaged 63 minutes for the oven and 92 minutes for the double boiler. Since this is two and three times as long as the original cooking time, their use could not be recommended from the standpoint of saving time in preparation. Thawing the steaks at room or refrigerator temperature would have shortened the reheating time. As with the pork chops, skill and watching are not required in the reheating process, and under certain conditions, the precooked frozen steaks might be used to an advantage.

SUMMARY

This study was made to determine the effects of freezing upon the palatability, shearing resistance, press fluid and loss in weight of precooked pork roasts, pork chops, beef roasts and beef steaks.

The precooked meat was frozen dry or in drippings and was stored at approximately 0° F. for about 30 days. It was then reheated in a double boiler or in an oven.

Palatability, shearing resistance and press fluid determinations were made and loss in weight calculated on both the freshly

cooked and the reheated frozen meat.

All of the precooked frozen meat was acceptable and palatable. The palatability committee detected little difference in the precooked frozen and the freshly cooked products.

Pork chops, beef roasts and beef steaks frozen in drippings were scored slightly higher than those frozen dry, but the pork roasts frozen dry were scored higher.

Freezing had little effect upon the shear or tenderness of the meat.

The frozen pork chops yielded much more press fluid and serum than the freshly cooked chops. The frozen pork roasts and beef steaks did not vary greatly from the freshly cooked products in press fluid and serum content. The frozen beef roasts yielded much less press fluid and serum than the freshly cooked meat.

Pork roasts, pork chops and beef roasts frozen in drippings yielded more total press fluid and more serum than the same products frozen dry.

Pork roasts and beef steaks frozen dry showed smaller losses on freezing and reheating than those frozen in the drippings, but beef roasts and pork chops frozen in the drippings had smaller losses.

All meats reheated in a double boiler had smaller losses than those reheated in the oven at 350° F. The 400° F. oven, used for beef roasts only, resulted in the highest losses.

Under the conditions of this study the time required for reheating the frozen, precooked pork chops and beef steaks was so

long as to make the use of these products questionable.

The roast pork and roast beef could probably be used to advantage in many places where cooking equipment, space and/or time is limited.

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APPENDIX

FORM I

MEAT COOKING RECORD

Grading Chart for Cooked Meat

Cooking Laboratory No_____ Sample No_____ Kind_____ Date_____

FACTOR	PHASE	7	6	5	4	3	2	1	REMARKS
Aroma	Intensity	very pro.	pro.	m. pro.	s. pro.	per.	s. per.	imper.	
	Desirability	very des.	des.	m. des.	s. des.	neutral	undes.	undes.	
Texture (Grain)	Intensity	very fine	m. fine	fine	s. coarse	coarse	very coarse	ext. coarse	
Flavor of Fat	Intensity	very pro.	pro.	m. pro.	s. pro.	per.	s. per.	imper.	
	Desirability	very des.	des.	m. des.	s. des.	neutral	s. undes.	undes.	
Flavor of Lean	Intensity	very pro.	pro.	m. pro.	s. pro.	per.	s. per.	imper.	
	Desirability	very des.	des.	m. des.	s. des.	neutral	s. undes.	undes.	
Tenderness	Intensity	very tender	tender	m. tender	s. tough	tough	very tough	ext. tough	
Juiciness	Quality of juice	very juicy	juicy	m. juicy	s. dry	dry	very dry	ext. dry	
	Quality of juice	very rich	rich	m. rich	s. rich	per	s. per.	imper.	

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 white
4. Yellowish brown
5. Yellow
6. Amber

Key to Abbreviations

pro. - pronounced
m. - moderately
s. - slightly
imper. - imperceptible
des. - desirable
undes. - undesirable
ext. - extremely
per. - perceptible

_____
Signature of Judge