THE EFFECT OF THREE TEMPERATURES OF THAWING UPON CERTAIN CHARACTERISTICS OF COOKED FROZEN PORK

by

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INTRODUCTION

The preservation of meat for home use by freezing and holding in a frozen food locker plant is a practice which has increased rapidly in the last few years. Its acceptance has spread so rapidly that scientific studies on the effects of thawing of this meat when preparing it for cooking have failed to keep ahead of this advance, with the result that many questions concerning this practice remain unanswered.

The purpose of this study was to determine the effect upon the shear, press fluid, moisture content and percentage cooking losses when frozen pork was thawed as follows: (a) room temperature for 15 hours; (b) refrigerator temperature for 48 hours; and (c) oven temperature of 350° F.

REVIEW OF LITERATURE

Child and Paul (1937) and Paul and Child (1937) carried on a study of the effect of thawing and cooking upon frozen beef and pork. They found that the palatability, total moisture, drip and tenderness of cooked beef and pork were unaffected by freezing or by the different thawing temperatures used; that the roasts thawed at 175° C. took less time to cook, had greater evaporation losses during thawing and had higher total losses. The roasts thawed at 24-25° C. required a little longer time to cook than those thawed at 175° C. They did not have any

evaporation losses during thawing but gained in weight, perhaps due to absorption of moisture in the room. These roasts also had more press fluid. The unfrozen meat required the longest period of cooking.

Sair and Cook (1938) found that the quantity of drip obtained from meat frozen at a constant rate was affected by the period between slaughter and freezing and the pH of the tissue. These two factors appeared to act independently. In precooled meats the maximum drip was obtained at about pH 5.2; as the pH increased the net drip decreased to zero at about a pH 6.4. Beef, pork and mutton behaved similarly with respect to the form of the drip, pH relationship, and quantity exuded at a given acidity.

They stated that beef, pork and mutton will drip to the same extent after freezing and thawing provided they have the same pH and the same freezing rate was used. These workers referred to the experiences of practical operators and to the results of investigations to show that more drip is obtained on slowly thawed frozen beef, than on mutton or pork. This they attributed to the pH values of these meats, the pH value of beef being relatively constant and close to the value at which maximum drip occurs. Pork and mutton vary in pH from carcass to carcass, are generally less acid, and the acidity decreases during storage. This, they believe, explains the practical absence or small amount of drip from frozen pork and mutton.

Lowe (1937) stated that defrosted meat should be cooked in the same way as unfrozen meat. If cooking is started before the

meat is defrosted, the temperature and time of cooking need to be changed to allow the meat both to thaw and to cook. This author recommended that frozen steaks and chops which have extensive cut surfaces and tend to "drip" should be started to cook while frozen, then there will be no loss of fluid or flavor, but she also pointed out the fact that the cooking time must be increased to three or four times that for unfrozen meat.

Ramsbottom and Koonz (1939) found that irrespective of freezing temperature there was little drip from the large rib cuts where the area of cut surface was small in relation to the volume of meat. In small steaks, where the area of the cut surface was large in relations to the volume of meat, the amount of drip was dependent upon the freezing temperature. When small steaks are frozen rapidly, intrafiber freezing occurs, and when defrosted the fluids are retained by the fibers, so there is a small amount of drip. If frozen slowly extrafiber freezing takes place, and upon being defrosted, more of the fluid is lost as drip before it can be reabsorbed by the partially dehydrated muscle fiber.

It was found also by Ramsbottom and Koonz (1940) that drip decreased as time between slaughter and freezing increased. After the first day the drip became progressively less, while the pH remained constant throughout the aging period. Thus in this work pH was not responsible for decreased drip. Ice crystals in the meat became progressively larger as the time after slaughter increased, although the drip actually decreased. Large ice crystals do not always accentuate the drip.

These workers believed that the gradual decrease in drip as the time of freezing after slaughter increased must be attributed to changes which take place in aging meat. It is known that progressive changes occur in muscle proteins, during the aging period, which increase the capacity of the proteins to absorb water. Consequently the "frozen out" water is more readily reabsorbed and drip is decreased.

Empey (1933) showed that factors such as age, sex, breed, condition of animal, period between slaughter and commencement of freezing, period of storage in the frozen state, and variations in the rates of thawing and freezing had no definite influence on the susceptibility of the muscle to drip and that the H-ion concentration was primarily responsible for drip. The least drip resulted when the beef had a pH of 6.3 or higher.

Moran and Hale (1932) found that the temperature of freezer storage was a very important factor in regulating the amount of drip, higher storage temperatures and fluctuating storage temperature, increased the drip.

According to Empey (1933), Richardson and Schewbel in 1908 found that the rate of thawing beef affected the amount of drip. The drip decreased when frozen beef was thawed slowly.

Kallert (1933) demonstrated that thawing frozen beef slowly decreased the amount of drip, and that it should be frozen fast enough to prevent the separation of water from the muscle fibers. An increase in the rate of freezing appeared to Cook, Love, Vickery and Young (1926) to be the most important factor in the reduction of drip.

In a study carried on by Adams (1942) it was found that the tenderness of aged beef was not affected by freezing or by storing it in the frozen condition. Similar results were obtained by Shrewsbury, Horne, Braun, Jordon, Milligan, Vestal and Weitkamp in their work on frozen pork.

The results reported in the literature are contradictory perhaps due to the methods used in carrying on the studies and the interpretation of the results obtained.

PROCEDURE

The meat used for this study was from experimental animals of known history from the Department of Animal Husbandry at Kansas State College, Manhattan, Kansas.

Six paired roasts were cut from the loins of eight hogs after the removal of the excess fat covering. As soon as a roast was cut, it was weighed on a Harvard Trip Balance, the weight recorded, and a tag with the number of the loin and cut was placed on it. It was then wrapped in freezer-locker wrapping paper, tied with a cord, again weighed, and the weight recorded. The number of each loin and cut was marked on the wrapper for identification.

All wrapped cuts were placed in a freezer at a temperature of approximately -10° F. for a week. They were removed to a second freezer having a temperature of about 0° F. and held there until ready to be thawed, at which time the cuts were removed from the locker, weighed and the temperature determined by inserting a thermometer into the center of the muscle. The weight

and temperature were recorded. The roast was then subjected to the thawing procedure previously determined for that cut.

Three temperatures of thawing were used: (a) room temperature for 15 hours, (b) refrigerator temperature for 48 hours, and (c) an oven temperature of 350° F. The method by which each cut was to be thawed was chosen at random. All cuts which were thawed at the oven temperature of 350° F. were placed in the freezing unit of the refrigerator in the Experimental Cookery laboratory, if they were removed from the freezer a few hours before roasting.

The cuts thawed at room temperature were placed on a table in the Experimental Cookery laboratory at 5 p.m. and left until 8 o'clock the next morning.

At the end of the thawing period, except for those roasts thawed at 350° F., the temperature of the meat was again recorded. The roast was weighed before and after removing the wrapping paper and cord. A meat thermometer was inserted into the center of the longissmus dorsi muscle, and a wire number placed in the roast for identification.

Some drip formed when the roasts were thawed at room temperature and at refrigerator temperature. The drip as considered here was the fluid lost from the meat between the time of removing from the freezer locker, and placing in the oven for roasting. The amount of drip was determined by the difference between the weights of a piece of absorbent paper before and after it had absorbed this fluid.

A special type of experimental oven, with a revolving hearth

was used to roast the meat. It was preheated to a temperature of 350° F.

The roast was placed on a wire rack in a weighed pan with the fat side up and with a thermometer inserted in a position such that the temperature could be read without opening the oven door. The roasts were placed equal distances apart on the revolving hearth of the oven, and the time recorded.

When the roast had reached an internal temperature of 180° F. it was removed from the oven, the time recorded, the thermometer and the wire number removed and the meat weighed.

A core one inch in diameter was cut from the center of the longissmus dorsi muscle. The tenderness of the cooked meat was determined by shearing this core in a Warner-Bratzler Modified Shearing Apparatus, beginning with the anterior end. The shear reported is an average of seven determinations made on each core.

All visible fat was removed from the remaining muscle. The lean portion was ground twice in a Kitchen Aid food grinder, first using a coarse knife, then a fine. This ground meat was used to determine the press fluid which was the fluid containing fat and soluble materials which could be pressed from the cooked meat using a Carver laboratory press. For this determination, two forty-gram samples of the ground meat were used. Each 40 gram sample was divided into four equal parts. Two absorbent pads were weighed, then one was placed in the bottom of the pressing cylinder. Five filter papers were weighed, one placed on top of the absorbent pad. One portion of the 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. The other absorbent pad was placed on top, and the cylinder plunger adjusted. The cylinder was placed in the press. 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 increased to 5000 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, the tube containing the press fluid carefully removed and the amount recorded. The two absorbent pads were removed and weighed to determine the amount of press fluid they had absorbed. To determine the weight lost, the filter papers plus the pressed meat were removed and weighed. The other 40 gram sample was treated in the same manner. The reported press fluid which is the average of the two determinations, was centrifuged to separate the fat and serum and the amount of each recorded.

The drippings, which may be defined as the fat and other non-volatile materials that escaped from the meat during roasting and were caught in the pan, were determined by subtracting the weight of the empty roasting pan from the weight of the pan and drippings.

The moisture content of the unpressed and pressed ground meat from 16 pairs of roasts was determined by the method outlined in the Revised Program of Research of Conference on

Cooperative Meat Investigations. (1940)

CALCULATIONS

The loss due to freezing was determined only on those roasts which were thawed at an oven temperature of 350° F. for they were the only ones unwrapped previous to thawing. It was calculated by dividing the difference between the weight of the meat as it was ready to be roasted and the weight of the meat before it was wrapped, by the weight of the meat before it was wrapped.

The percentage of total loss was determined by dividing the difference between the weight of the roast before it was wrapped and its weight when removed from the oven, by the weight before it was wrapped.

Calculation of the percentage cooking loss was obtained by dividing the difference between the weight of the cut of meat when placed in the oven and when it had reached an internal temperature of 180° F., by the weight of the meat when placed in the oven.

The percentage of drippings was determined for each method of thawing by dividing the weight of the drippings by the weight of the meat when ready to be roasted.

For determining the percentage loss due to evaporation in the oven was calculated by subtracting the weight of the drippings from the total loss in weight during roasting, and dividing that number by the weight of the meat when ready to be roasted.

The percentage moisture for unpressed meat was calculated by taking the difference between the weights of the meat before

and after drying, and gave the percentage of moisture. This same procedure was used for the pressed meat.

The percentage of fat in the press fluid was determined by dividing the amount of fat by the total volume of the press fluid. This number subtracted from 100 gave the percentage of serum.

RESULTS

The data in Table 1 give number and cut of animal used, weight in grams before freezing, percentage of total loss, percentage loss in oven, percentage loss in oven due to evaporation, shear in pounds, press fluid in milliliters, and percentage of serum in press fluid, when the pork roasts were thawed at room temperature. The animal number is given at the left in column 1, the number of the cut at the right in this same column, L and R being used to designate the side of the animal from which the cut was taken. The numbering of the loins began at the anterior end of the loin, thus cut No. 1 was the first roast cut from the shoulder end of the loin.

As is evidenced by a study of Table 1, there was a wide range in results. The roasts varied from 735.5 g in weight to 414 g; total loss from 43.07 percent to 20.42 percent; loss in the oven from 43.33 percent to 19.71 percent; loss due to evaporation in the oven from 33.58 percent to 10.24 percent; shear from 19.89 lbs. to 5.64 lbs.; amount of press fluid from 11.85 ml to 2.5 ml; and serum in the press fluid from 98.31 percent to 22.91 percent.

Table 2 gives the same data as Table 1 but for meat thawed

Table 1. Data for pork roasts when thawed at room temperature.

No. of cut	Wt. before freezing (g)	Total loss (percent)	Loss in oven: (ev. + drip in pan) (percent)	Loss due to: evaporation in oven (percent)	Shear (lbs.)	Press fluid (ml)	Serum in press fluid (percent)
9 - 2L	581.0	33.01	30.70	21.23	16.10	6.95	93.03
9 - 6L	449.0	34.38	31.88	21.92	15.21	6.90	88.93
9 - 1R	715.5	32.37	30.69	--- *	14.25	4.65	83.62
9 - 5R	521.5	37.51	35.57	24.60	18.71	7.10	93.13
10 - 1L	645.0	34.42	32.58	19.61	9.54	4.10	22.91
10 - 6L	414.0	36.28	34.17	19.79	10.57	9.00	68.33
10 - 1R	682.0	29.09	27.61	20.27	11.07	9.05	28.73
10 - 6R	451.0	33.39	31.31	17.33	13.14	10.00	55.57
11 - 3L	447.0	33.44	28.59	21.05	11.75	8.45	84.59
11 - 4L	461.0	34.75	31.69	18.09	16.18	8.05	93.12
11 - 5L	438.5	33.98	31.32	22.41	15.82	10.20	88.26
11 - 1R	735.5	34.56	31.63	19.59	10.80	4.70	83.24
11 - 4R	437.0	32.84	29.75	17.28	13.71	9.25	94.13
12 - 2L	598.5	36.11	32.56	18.89	13.29	6.80	79.43
12 - 3R	499.5	33.57	30.38	20.75	14.29	9.00	89.46

* Not weighed.

Table 1. (concluded)

12 - 4R	472.5	36.95	33.07	23.63	18.93	8.30	94.63
12 - 6R	440.0	38.70	35.26	23.14	11.11	7.60	67.13
13 - 2L	657.0	36.24	34.24	20.74	11.46	5.15	93.78
13 - 6L	477.5	39.06	35.92	22.66	9.54	5.80	75.47
13 - 3R	524.0	36.58	33.09	21.81	12.79	2.50	94.12
13 - 4R	541.0	36.39	34.52	23.27	13.75	5.50	95.83
14 - 1L	641.0	25.12	24.49	15.54	9.68	8.80	75.50
14 - 3L	451.0	20.42	19.71	11.16	7.26	10.65	97.67
14 - 5L	463.5	21.21	20.42	10.24	9.96	11.85	98.31
14 - 6L	602.0	26.91	26.09	14.23	5.64	10.00	78.94
15 - 1L	696.0	31.38	29.70	19.00	17.71	4.65	54.85
15 - 4L	519.0	31.26	29.28	17.26	19.89	4.05	95.36
15 - 2R	517.0	29.40	27.51	17.08	16.75	7.75	94.85
15 - 5R	530.5	36.27	33.02	16.47	18.03	6.80	88.25
17 - 1L	651.5	43.07	42.17	22.12	12.70	6.80	46.50
17 - 5L	484.0	39.46	36.9 48.33 ?	33.58	10.96	5.90	84.07
17 - 3R	615.0	38.85	36.56	20.96	10.03	7.05	85.10
17 - 6R	519.0	38.52	35.56	24.51	7.96	6.00	75.75

Table 2. Data for pork roasts when thawed at refrigerator temperature for 48 hours.

No. of cut	Wt. before freezing (g)	Total loss (percent)	Loss in oven (ev. + drip in pan) (percent)	Loss due to evaporation in oven (percent)	Shear (lbs.)	Press fluid (ml)	Serum in press fluid (percent)
9 - 1L	660.0	32.82	32.59	--- *	18.82	8.30	90.96
9 - 5L	453.5	36.93	36.23	24.10	19.96	5.00	96.90
9 - 2R	614.0	32.26	32.02	21.96	15.07	8.30	97.05
9 - 4R	526.0	34.90	34.59	22.19	21.36	6.90	96.66
10 - 2L	496.0	35.26	34.67	19.17	14.29	6.90	58.07
10 - 4L	407.0	35.01	34.27	22.64	11.39	7.90	69.00
10 - 5L	391.5	30.73	30.12	17.24	11.39	8.55	73.68
10 - 2R	515.0	33.61	32.64	18.40	11.68	6.90	51.95
11 - 2R	491.5	26.49	25.32	18.71	10.50	10.50	88.09
11 - 3R	479.5	33.26	31.17	21.40	9.25	9.60	86.98
11 - 6R	483.5	26.12	25.16	15.84	19.36	9.75	86.38
12 - 4L	454.0	35.46	34.39	23.04	16.36	6.85	95.68
12 - 1R	639.5	32.68	31.57	21.84	16.90	9.20	76.70
12 - 2R	550.5	31.88	30.68	19.82	12.21	9.45	89.90
12 - 5R	427.5	33.82	32.90	22.96	18.07	8.00	87.18

* Not weighed.

Table 2. (concluded)

13 - 3L	532.0	30.56	29.26	21.95	12.68	3.20	98.33
13 - 1R	569.5	23.92	34.50	25.17	12.61	5.55	90.58
13 - 5R	425.5	37.65	36.27	25.05	14.89	6.85	89.30
13 - 6R	522.5	37.19	36.58	22.72	13.07	5.80	67.94
14 - 1R	645.0	22.66	21.57	14.31	8.86	9.80	80.06
14 - 2R	587.0	25.16	24.70	13.97	6.89	9.05	97.79
14 - 4R	485.0	22.21	21.31	14.49	8.07	11.10	94.55
14 - 6R	423.0	22.22	21.27	13.23	7.39	10.00	97.70
15 - 2L	587.0	30.10	29.49	18.24	20.82	7.60	97.38
15 - 3L	535.0	29.89	29.08	19.06	17.32	7.75	94.90
15 - 5L	447.0	31.75	30.97	20.00	20.70	7.05	95.52
15 - 4R	523.0	41.32	40.64	26.03	21.03	3.60	93.70
17 - 2L	692.5	34.61	34.12	17.13	20.00	7.05	66.90
17 - 4L	498.5	38.17	37.48	22.76	13.07	7.45	73.35
17 - 2R	791.0	36.64	34.91	17.23	15.32	5.35	46.45
17 - 5R	502.0	38.01	44.65	31.32	15.75	8.05	72.20

Table 3. Data for pork roasts when thawed in an oven temperature of 350° F.

No. of cut	Wt. before freezing (g)	Total loss (percent)	Loss in oven: (ev. + drip in pan) (percent)	Loss due to: evaporation: in oven (percent)	Shear (lbs.)	Press fluid (ml)	Serum in press fluid (percent)
9 - 3L	576.0	31.94	31.52	21.02	16.82	8.95	97.37
9 - 4L	515.5	35.52	35.27	25.62	19.96	3.80	97.16
9 - 3R	485.0	32.95	32.71	23.84	17.36	8.60	96.48
9 - 6R	563.5	35.71	35.69	24.26	17.04	5.25	89.22
10 - 3L	444.5	36.13	35.78	21.17	14.57	6.10	91.88
10 - 3R	467.5	29.83	29.46	18.99	13.71	7.05	76.90
10 - 4R	400.0	28.25	28.27	18.49	12.57	5.80	79.95
10 - 5R	389.0	36.76	36.26	22.74	12.18	6.90	71.08
11 - 1L	666.0	29.58	30.21	20.98	12.14	8.95	83.81
11 - 2L	505.0	29.60	29.08	20.58	10.68	10.95	91.82
11 - 6L	485.5	28.28	27.83	18.07	20.50	10.05	90.21
11 - 5R	395.5	29.61	29.12	18.10	13.10	10.00	95.13
12 - 1L	706.5	35.56	35.27	24.07	18.50	6.50	82.31
12 - 3L	479.0	32.05	31.64	22.01	13.71	9.10	96.80
12 - 5L	436.5	33.75	33.33	22.33	13.64	9.25	88.66

Table 3. (concluded)

12 - 6L	433.5	31.95	31.49	21.43	14.04	10.65	90.64
13 - 1L	732.0	36.95	36.52	26.12	14.00	8.70	83.31
13 - 4L	533.0	37.04	36.81	24.96	12.43	7.65	97.45
13 - 5L	473.0	38.33	38.02	24.29	14.39	6.85	99.00
13 - 2R	593.0	34.88	34.52	23.74	10.43	6.95	94.54
14 - 2L	508.5	25.55	25.76	13.74	10.97	7.10	96.26
14 - 4L	439.0	24.24	24.37	15.35	15.64	10.55	91.16
14 - 3R	545.0	23.41	23.04	11.76	10.36	11.50	94.17
14 - 5R	468.0	26.15	25.66	12.95	7.32	10.60	97.70
15 - 6L	598.5	34.67	34.70	20.09	17.50	6.15	74.85
15 - 1R	787.0	31.35	30.98	18.78	21.82	10.10	85.53
15 - 3R	504.0	29.45	28.38	18.99	20.00	6.05	93.26
15 - 6R	598.0	34.73	34.37	18.40	20.00	5.30	24.00
17 - 3L	511.0	36.13	35.80	22.40	11.43	7.20	88.60
17 - 6L	558.0	35.84 7.6	37.34	24.63	13.07	7.15	58.05
17 - 1R	693.0	39.29	39.03	22.33	10.35	6.15	9.35
17 - 4R	476.5	37.48	37.00	25.00	12.11	9.85	80.35

in the refrigerator for 48 hours. The roasts varied from 791 g in weight to 391.5 g; total loss from 41.32 percent to 22.21 percent; loss in the oven from 44.65 percent to 21.31 percent; loss due to evaporation in the oven from 31.32 percent to 13.23 percent; shear from 21.36 lbs. to 7.39 lbs.; press fluid from 11.1 ml to 3.20 ml; and serum in the press fluid from 98.33 percent to 46.45 percent.

Table 3 gives the same data for meat which was thawed at an oven temperature of 350° F. The roasts varied from 732 g in weight to 389 g; total loss from 39.29 percent to 24.24 percent; loss in oven from 39.03 percent to 23.04 percent; loss due to evaporation in the oven from 24.96 percent to 11.76 percent; shear from 21.82 lbs. to 7.32 lbs.; amount of press fluid from 11.50 ml to 3.80 ml; and serum in the press fluid from 99 percent to 9.35 percent.

The loss due to freezing was very slight, several roasts had no loss, the greatest loss was a little less than 1.5 percent. This loss was determined only on those roasts which were thawed at an oven temperature of 350° F. The loss due to freezing was considered as the difference between the weight of the cut of meat before it was wrapped and the weight when it was ready to be put into the oven. Three roasts weighed the same, 19 roasts had a loss of 3 g or less; and the greatest losses were 7.5 g, 5 g, 4.2 g, and 3.7 g.

A study of Tables 1, 2 and 3 shows that Animal No. 14 was outstanding in that it had the lowest percentage total loss, loss in oven, and loss due to evaporation in the oven; it had the

least shear, the highest amount of press fluid, and the greatest percentage of serum in the press fluid. The meat of this animal was moist and gummy when roasted, it gave off a "piggy" odor while roasting, and the press fluid was a milky colored liquid differing markedly in appearance from the press fluid from the other roasts. The animals were all fed a similar diet so no explanation has been found for these differences.

Table 4 gives average shear, press fluid, percentage cooking loss, percentage evaporation in the oven and percentage total loss for the individual loins thawed by each of the three methods. This table also gives the average for all roasts thawed by the three methods.

Examination of Table 4 shows that the meat thawed at room temperature was the most tender as determined by the shear. The shear for the meat thawed at room temperature averaged 12.96 lbs., for that thawed at refrigerator temperature for 48 hours it was 14.23 lbs., and for that thawed at an oven temperature of 350° F., it was 14.53 lbs. This shows a difference of 1.57 lbs. in the three methods of thawing, so apparently the method of thawing made little, if any, difference in the tenderness of the meat.

The results indicate that meat thawed at refrigerator temperature contained a slightly larger amount of press fluid than when thawed by the other methods. The amount of press fluid from the meat thawed at room temperature had a range from 11.85 ml to 2.5 ml; for that thawed in the refrigerator for 48 hours from 11.1 ml to 3.2 ml; for that thawed in an oven temperature of 350° F. from 11.5 ml to 3.8 ml. The averages for the above

Table 4. Summary of determinations for each animal at the three thawing temperatures.

Animal no.	Shear (lbs.)			Press fluid (ml)			Percentage cooking loss			Evaporation in oven (%)			Percentage total loss		
	Room temp.	Refrig-erator	Oven-350°F.	Room temp.	Refrig-erator	Oven-350°F.	Room temp.	Refrig-erator	Oven-350°F.	Room temp.	Refrig-erator	Oven-350°F.	Room temp.	Refrig-erator	Oven-350°F.
9	16.07	18.06	17.79	6.40	7.12	6.65	32.21	33.61	33.79	22.58	22.76	23.69	34.32	34.32	34.03
10	11.08	12.19	13.26	8.04	7.56	6.46	30.67	32.92	32.44	19.25	19.49	20.35	33.29	33.65	32.74
11	13.65	13.03	14.10	8.13	9.95	9.98	26.59	27.22	29.06	19.63	18.65	19.43	33.91	28.62	29.27
12	14.40	15.88	14.99	7.92	8.38	8.88	32.82	32.38	32.93	21.60	21.91	22.46	36.33	33.46	33.58
13	11.88	13.31	12.81	4.74	7.13	7.54	34.44	34.15	36.47	22.12	23.72	24.78	37.07	32.33	36.80
14	8.13	7.80	11.07	12.82	13.31	9.94	22.68	22.21	24.71	12.79	14.00	13.45	23.41	23.06	24.84
15	18.09	19.82	19.83	5.81	6.50	6.90	29.88	32.54	32.11	17.45	20.88	19.06	32.08	33.26	32.55
17	10.41	13.79	12.39	6.44	6.97	7.59	40.50	37.79	37.29	25.29	22.11	23.59	39.97	36.86	37.18
Average	12.96	14.23	14.53	7.54	8.36	7.99	31.22	31.60	32.35	20.09	20.44	20.85	33.80	31.93	32.62

methods were 7.54 ml; 8.36 ml and 7.99 ml respectively.

The percentage of serum and fat in the press fluid was determined by centrifuging it. The percentage of fat in press fluid from meat thawed at room temperature ranged from 77.09 to 1.69, with an average of 21.48; from that thawed at refrigerator temperature for 48 hours, from 89.04 to 1.67, with an average of 18.65; and from that thawed at an oven temperature of 350° F. from 90.65 to 1.0 with an average of 16.13. The percentage of serum was determined by subtracting the percentage of fat from 100. There seems to be no relationship between the amount of press fluid, and the fat content, nor between the amount of drip and the fat content of the press fluid.

Table 4 likewise shows the percentage loss due to evaporation in the oven varied slightly with the three methods of thawing. The meat thawed at room temperature had a percentage loss of 20.09; that thawed at refrigerator temperature for 48 hours, 20.44; and that thawed at an oven temperature of 350° F., 20.85, a difference of only .76 percent.

The results indicate that the percentage cooking loss by each method of thawing did not vary much. The meat thawed at room temperature had a percentage range from 48 to 19.71, with an average of 31.22; that thawed at refrigerator temperature for 48 hours, had a range from 44.65 to 21.27, with an average of 31.60; that thawed at an oven temperature of 350° F. had a range from 39.03 to 23.04, with an average of 32.35. The meat thawed at room temperature had a slightly lower loss than the meat thawed by the other two methods.

The average percentage loss as drippings by the three methods of thawing was 11.83, 11.27 and 11.57, respectively. The meat thawed at refrigerator temperature for 48 hours had the least percentage loss as drippings.

Included in Table 4 are results which show that the meat thawed at refrigerator temperature for 48 hours had the least percentage total loss, 31.93; that thawed in an oven temperature of 350° F. had a percentage total loss of 32.62; and that thawed at room temperature the greatest loss, 33.80, but there was a difference of only 1.87 percent by the three methods of thawing.

Meat thawed at room temperature had the least shear, the least press fluid, the lowest percentage cooking loss, the lowest percentage loss due to evaporation in the oven, and the highest percentage total loss (Table 4).

The length of time per pound required for roasting the meat was the shortest when the meat was thawed at room temperature, which was 80.5 minutes; the meat thawed at refrigerator temperature for 48 hours required an average of 87.1 minutes; the meat thawed at an oven temperature of 350° F., 95.2 minutes. The cooking period for roasts thawed at room temperature varied from 131 minutes per pound to 64.4 minutes. Only one roast required 131 minutes and one roast 92 minutes. Fourteen of the roasts averaged 84.3 minutes per pound and 13 roasts averaged 76.1 minutes per pound. The roast which required 131 minutes per pound weighed 512.5 g, and was an average size roast. No explanation was found for this extremely long cooking period. When the meat was thawed at refrigerator temperature, one roast which

Table 5. Summary of moisture content of meat (in percent).

Animal no.	Unpressed meat			Pressed meat		
	Room temp.	Refrigerator	Oven-350° F.	Room temp.	Refrigerator	Oven-350° F.
14	64.13	64.47	64.66	54.33	55.92	55.25
15	57.40	58.20	55.74	55.47	51.40	53.22
17	53.84	55.03	50.69	50.25	49.65	50.69
Average	58.44	59.23	57.03	53.35	52.32	53.05

weighed 453.5 g required 160 minutes per pound. Two roasts required 109 and 101 minutes, respectively, one required 65.8 minutes, seven required an average of 84.14 minutes per pound and 10 roasts required an average of 75.91 minutes per pound. Obviously the average length of time for these two methods of thawing would be lowered if the two extreme lengths of time were eliminated. When meat was thawed at an oven temperature of 350° F., 15 roasts required an average of 105.5 minutes per pound; 10 roasts required an average of 94.18 minutes per pound; five roasts required an average of 81.0 minutes per pound; the other two roasts required only 58.7 minutes and 59.8 minutes per pound, respectively.

The roasts thawed at room temperature had the greatest amount of drip. Because the drip contains water, extractives and minerals, there are slight losses of food value when the roasts are thawed by this method. The average drip for this method of thawing was 9.03 g, and for that thawed at refrigerator temperature for 48 hours, 1.98 g. The meat thawed at an oven temperature of 350° F. was put in the oven while hard frozen so had no drip.

Table 5 shows that the percentage of moisture for unpressed meat ranged from 64.1 to 53.8 and for the pressed meat from 54.3 to 50.2 when the meat was thawed at room temperature; from 64.4 to 55.03 for unpressed meat and from 55.9 to 49.6 for the pressed meat when thawed at refrigerator temperature for 48 hours; and from 64.6 to 50.6 for unpressed meat and from 55.2 to 50.6 for pressed meat when thawed at oven temperature of 350° F. The

average percentages of moisture for unpressed meat were 57.0, 58.4 and 59.2, the greatest being when the roasts were thawed at refrigerator temperature for 48 hours. For the pressed meat the percentage of moisture varied less, being 52.3, 53.0, 53.3 respectively. Moisture loss determinations were made on only 16 paired roasts due to a lack of time. It will be noted that the moisture content of roasts from Animal No. 14 was definitely greater for the unpressed meat. This confirms the earlier observation that the results for roasts from Animal No. 14 show them to behave differently from those from the other animals considered.

SUMMARY

1. This study was made upon certain effects of thawing frozen pork; primarily to determine the effect upon the shear or tenderness; press fluid; moisture content and percentage of cooking losses when frozen pork was thawed at (a) room temperature for 15 hours, (b) at a refrigerator temperature for 48 hours, and at a (c) oven temperature of 350° F. Ninety-six roasts were used.

2. The method of thawing had little effect upon the sheer or tenderness of the meat, there being but a slight difference in the three methods used. Thawing at room temperature gave the most tender meat.

3. The meat thawed at a refrigerator temperature for 48 hours contained the most press fluid, which determines the moistness or "juiciness" of the meat.

4. The lowest percentage of cooking loss was obtained when

the meat was thawed at room temperature. Some drip was formed during the thawing procedure which perhaps reduced the loss due to cooking. Less moisture was lost during the cooking period, perhaps for the same reason.

5. Meat thawed at room temperature had the highest percentage of total loss which is the sum of the losses due to drip formed during the thawing period, the evaporation in the oven during roasting and the drippings formed while roasting. These losses may mean a loss of food value since they consist of fat, water and extractives from the meat.

6. The cooking time per pound was less for the meat thawed at room temperature. The cost of roasting the meat should be considered especially if the fuel used is costly.

7. Moisture lost means a drier meat. Thawing meat at an oven temperature of 350° F. retained the most moisture; hence a more juicy and palatable meat.

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