

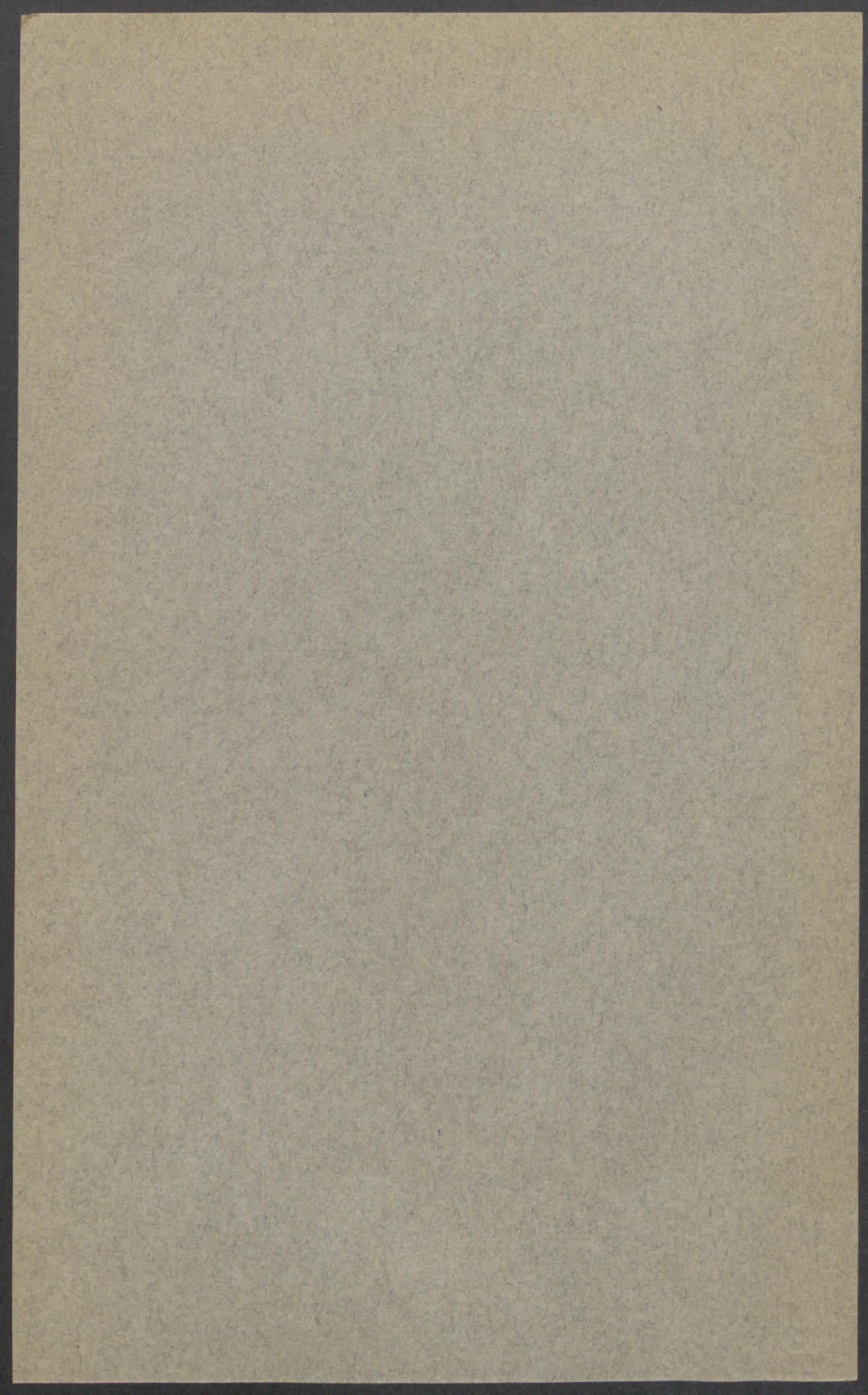
Effect of Thawing and Cooking Frozen Pork and Beef

Alice M. Child and Pauline Paul
Division of Home Economics



University of Minnesota
Agricultural Experiment Station

Accepted for publication July 1937.



Effect of Thawing and Cooking Frozen Pork and Beef

*Alice M. Child and Pauline Paul
Division of Home Economics*

*University of Minnesota
Agricultural Experiment Station*

Accepted for publication July 1937.

Effect of Thawing and Cooking Frozen Pork and Beef

ALICE M. CHILD AND PAULINE PAUL

This bulletin gives data on the effect of freezing and of various thawing temperatures upon palatability, thawing and cooking losses, drip, press fluid, total moisture, and tenderness of frozen pork and beef. The problems investigated were (1) the effect of freezing and of different thawing temperatures upon palatability and (2) the effect of freezing and of different thawing temperatures upon thawing and cooking time, losses, press fluid, drip, total moisture, and tenderness of pork and beef.

MATERIALS

The cuts used for testing palatability included pork chops (single), pork loin roasts (3 to 3½ lbs.), standing beef roasts (5 to 6 lbs.), porterhouse steaks (2 inches thick), and rump pot roasts (2½ to 3 lbs.). For the effect of freezing and thawing temperatures on thawing and cooking time, losses, press fluid, drip, total moisture, and tenderness, the center loin cuts of pork (1½ to 2 lbs.) were used.

METHODS

Freezing was done in a cabinet which maintained a temperature of -18°C . Each cut was weighed and a thermometer inserted so that the bulb was in the center of the largest muscle in all except the pork chops and rump pot roasts. Each cut was wrapped in moistureproof paper and left in the freezer until frozen solid.

For thawing, each cut was unwrapped, weighed, and placed on a rack 1.25 centimeters high in a weighed sheet-iron pan measuring 20x25.25x6.25 centimeters. The roasts to be thawed at 175°C . were placed in an electric oven preheated to 175°C . and removed when the thermometer registered 5°C . The porterhouse steaks to be thawed at high temperature were thawed under the broiler flame with the oven regulator set at 175°C . The pork chops thawed at high temperature were thawed by searing on each side in a frying pan. The pot roasts thawed at high temperature were seared on all sides, water was added, and the roasts were simmered until a skewer could be forced through them, at which point they were considered thawed. The cuts thawed at $24-25^{\circ}\text{C}$. for palatability tests were placed, uncovered, on a shelf in the laboratory and remained until thawed. The pork and beef roasts thawed at $24-25^{\circ}\text{C}$. for the second problem were thawed in a conditioning room where the temperature varied from $24-25^{\circ}\text{C}$. and the

humidity was constant at 65 per cent. Some of the cuts used for palatability were thawed in a mechanical refrigerator where the temperature ranged from 2° to 4° C.

Cooking

Roasting was done in electric ovens having a temperature control accurate to 1° F. The methods of the cooking committee of the Co-operative Meat Investigations (1) were followed. The beef roasts were cooked uncovered to 58° C. in a 175° C. oven. The pork roasts were cooked to 84° C. in a 175° C. oven. Losses were determined by loss of weight of the meat and weight of the drippings collected.

Broiling was done under a gas flame with temperature control set at 175° C., and the pan placed so that the broiler rack was 5½ inches below the flame. Each steak was broiled on one side until the thermometer registered 40° C., and was then turned and broiled on the other side until the interior temperature reached 58° C.

The pork chops were dipped in egg and crumbs and browned on each side. Two tablespoons of water were added, the pan covered tightly, and the chops simmered for one hour. The pot roasts were seared on each side, one-half cup of water was added, the pan covered tightly, and the roasts simmered for two hours.

Sampling

The roasts were allowed to come to maximum interior temperature before cutting and were cut through the thermometer hole across the grain of the meat. For judging, thin slices were cut from the center of the roast. Each slice yielded two judging samples, one from each side of the thermometer hole. For judging the steaks and chops, the larger muscle was removed from the bone. Slices were taken from each side of the thermometer hole in the porterhouse steaks. Pieces were cut from the inside of the muscle next to the bone of the pork chops.

From the center loin pork roasts a slice 1.25 centimeters wide was cut from the left half of the muscle. From this slice five samples were taken with a cylindrical borer having a diameter of 1.25 centimeters. Two of the samples were taken from the center of the muscle, one on each side of the thermometer hole, the other three from the bottom of the muscle. The two taken at the thermometer hole were used for press fluid, the other three for freezing drip determination. The remainder of this slice was used for total moisture determination. Two samples for tenderness determination were cut from the right half of the muscle using a cylindrical borer one inch in diameter.

JUDGING

The meat tested for palatability was scored by four judges who used a grading sheet adapted from the grading sheet of the cooking committee of the Co-operative Meat Investigations (1). (See page 5.)

Grading Chart for Cooked Meat*

Judge_____

Date_____

Factor	Phase	7	6	5	4	3	2	1
Flavor of fat	Intensity	Very pronounced	Pronounced	Moderately pronounced	Slightly pronounced	Perceptible	Slightly perceptible	Imperceptible
	Desirability	Very desirable	Desirable	Moderately desirable	Slightly desirable	Neutral	Slightly undesirable	Undesirable
Flavor of lean	Intensity	Very pronounced	Pronounced	Moderately pronounced	Slightly pronounced	Perceptible	Slightly perceptible	Imperceptible
	Desirability	Very desirable	Desirable	Moderately desirable	Slightly desirable	Neutral	Slightly undesirable	Undesirable
Tender- ness	Intensity	Very tender	Tender	Moderately tender	Slightly tough	Tough	Very tough	Extremely tough
Quantity of juice	Intensity	Very large	Large	Moderately large	Slightly large	Small	Very small	Negligible
	Desirability	Very desirable	Desirable	Moderately desirable	Slightly desirable	Neutral	Slightly undesirable	Undesirable

Place the number of the meat sample above the word which best describes your opinion of the quality.

* Taken from grading sheet of the cooking committee of the Co-operative Meat Investigations.

Determination of Press Fluid

Press fluid is defined by Child and Baldelli (2) as the fluid consisting of moisture plus the soluble material plus the colloidal fraction expressed from the muscle by the use of the pressometer.

Immediately upon cutting, the press fluid samples were placed in tin-foil cups in weighing cans and weighed. Each sample was wrapped in a cloth cross, placed in the tray of the pressometer, and subjected to 250 pounds pressure for 10 minutes. The sample was removed from the cloth wrapping and again weighed. The amount of press fluid is expressed as per cent of weight lost on the basis of the original weight of the sample. For details of the method for determining press fluid see Child and Fogarty (3).

Determination of Drip

Drip is defined by Cook *et al.* (4) as the clear, reddish colored fluid which exudes from all cut surfaces of meat which has been frozen and thawed.

The samples cut for drip estimation were placed immediately in tin-foil cups in weighing cans, weighed, then placed on blotting paper and covered with blotting paper held in place by light pressure (approximately 6 grams per square centimeter). The samples were covered with small boxes to prevent excessive drying from evaporation and left for two hours. At the end of this time the samples were replaced in the weighing cans and weighed again. The difference is considered drip and is expressed as percentage of the weight of the original sample.

Determination of Total Moisture

The remainder from the slice sampled for press fluid and freezing drip was divided between two weighing cans and weighed. Each sample was cut fine with scissors and placed in a weighing can having a piece of filter paper in the bottom. The cans were placed uncovered in a drying oven at 60° C. for two hours, then dried at 100° C. in a Freas vacuum oven maintaining a pressure of 2 to 2.5 centimeters of mercury. At the end of the five hours the cans were removed, covered, cooled, and weighed. The weight lost during drying is considered total moisture and is expressed as percentage of the original weight of the sample.

Determination of Tenderness

Tenderness was measured by means of the Minnesota Shear Stress apparatus. Each sample consisted of a cylinder of meat one inch in diameter and 2 to 2.5 inches long. The sample was sheared through the center, then each of the resulting pieces was sheared through the center again, giving three readings for each sample and six for each roast. The tenderness is given as force in pounds necessary to shear the sample.

Statistical Methods

The *t* test given in Fisher (5), section 24, was used to test the significance of the difference between means. ("*t*" means difference divided by its standard error.) Any *t* value having a probability equal to or less than 0.05 was considered significant.

RESULTS

Palatability

Averages of judges' scores on flavor, tenderness, and juiciness of unfrozen meat and frozen meat thawed at different temperatures are given in Table 1. The results show that there was no decided preference in any of these qualities for meat thawed at any one of the temperatures used or for frozen or unfrozen meat.

Table 1. Averages of Judges' Scores on Flavor, Tenderness, and Juiciness of Frozen and Unfrozen Meat

Cut	Number of samples	Flavor of fat		Flavor of lean		Tender-ness	Quantity of juice	
		Inten-sity	Desira-bility	Inten-sity	Desira-bility	Inten-sity	Inten-sity	Desira-bility
Rump pot roasts								
Thawed at frying temperature	2	5.4	3.9	5.0	5.4	4.7	3.3	3.8
Thawed at 21° C.....	2	5.4	3.7	5.2	4.8	3.8	3.2	3.5
Standing rib roasts								
Unfrozen	2	5.3	5.2	5.3	5.2	5.7	5.0	5.2
Thawed at 150° C.	2	4.8	4.4	5.7	5.1	6.2	5.3	5.3
Thawed at 21° C.....	2	5.0	4.5	5.2	4.4	5.8	4.4	4.6
Porterhouse steaks								
Unfrozen	4	5.8	4.6	5.6	5.3	5.0	5.7	5.8
Thawed at 175° C.	3	6.1	5.0	5.9	5.9	5.3	5.8	5.9
Thawed at 21° C.....	3	5.8	4.7	5.5	5.7	4.5	5.3	5.5
Loin pork chops								
Unfrozen	8	5.5	5.3	5.3	5.4	5.3	4.4	4.5
Thawed at frying temperature	3	5.7	6.4	5.7	5.8	5.2	4.1	4.5
Thawed at 21° C.....	3	5.6	5.6	5.6	6.1	6.0	5.0	5.1
Thawed at 2.4° C.	2	5.9	5.3	5.4	5.9	5.6	4.1	4.4
Rib pork chops								
Unfrozen	8	5.4	4.9	5.4	5.7	5.2	4.4	4.7
Thawed at frying temperature	3	5.6	5.8	5.3	5.5	5.3	4.6	4.7
Thawed at 21° C.....	3	5.1	5.9	6.1	6.4	6.3	4.9	5.0
Thawed at 2.4° C.	2	6.4	3.7	5.5	6.0	6.2	3.9	4.4
Rib end, pork loin roasts								
Unfrozen	3	5.5	5.8	5.5	5.7	6.2	5.2	5.3
Thawed at 150° C.	3	5.2	6.7	6.5	6.8	6.4	5.2	5.4
Thawed at 21° C.....	3	6.3	6.3	6.3	5.7	6.0	5.3	5.3
Thawed at 2.4° C.	2	5.6	6.6	6.0	6.4	6.5	5.8	6.1
Loin end, pork loin roasts								
Unfrozen	3	5.5	5.3	5.5	6.2	5.8	5.2	5.5
Thawed at 150° C.	3	5.9	5.6	6.4	6.0	6.2	5.3	5.4
Thawed at 21° C.....	3	6.7	5.3	6.7	6.3	5.3	5.7	5.7
Thawed at 2.4° C.	2	5.2	4.9	5.3	5.8	4.9	5.0	5.2

Table 2. Thawing and Cooking Time in Minutes per Pound for Frozen Pork Thawed at 175° C. and at 24-25° C., and for Unfrozen Pork, Cooked at 175° C. to 84° C.

Series number	Thawing time		Cooking time		
	175° C.	24-25° C.	175° C.	24-25° C.	Unfrozen.
	Minutes per pound		Minutes per pound		
1.....	28.3	251.5	49.5	58.7	58.0
2.....	30.8	251.5	51.5	56.9	53.3
3.....	22.2	259.9	56.1	53.7	69.2
4.....	25.0	279.2	58.1	61.0	54.5
5.....	34.0	271.6	49.4	58.6	62.3
6.....	29.4	229.2	50.8	56.3	47.6
7.....	36.6	252.9	35.6	52.9	63.4
8.....	34.3	221.7	35.8	45.8	57.0
9.....	28.0	252.9	41.6	51.7	48.6
10.....	36.1	239.0	44.0	55.5	58.5
11.....	31.6	229.2	43.7	46.3	52.8
12.....	41.5	311.3	38.0	61.0	60.5
Mean	31.5	254.2	46.2	54.9	57.1

Table 3. Percentage Evaporation Losses During Thawing of Frozen Pork Thawed at 175° C. and at 24-25° C., Humidity 65 Per cent, Cooked at 175° C. to 84° C., and Total Losses* of Frozen Pork Thawed at 175° C. and 24-25° C. and Unfrozen Pork Cooked at 175° C. to 84° C.

Series number	Evaporation loss		Total losses		
	175° C.	24-25° C.	175° C.	24-25° C.	Unfrozen
	per cent	per cent	per cent	per cent	per cent
1.....	1.56	-1.45	23.60	22.86	20.74
2.....	1.70	-1.59	23.27	21.66	20.18
3.....	0.61	-1.49	19.60	21.15	21.22
4.....	0.83	-1.72	19.30	19.91	20.30
5.....	1.77	-1.36	23.01	20.57	18.86
6.....	1.41	-2.29	22.48	21.18	16.33
7.....	2.54	-1.43	18.96	18.83	20.51
8.....	1.94	-1.85	16.71	14.99	18.13
9.....	1.85	-1.54	21.00	14.39	14.97
10.....	2.39	-1.58	20.56	17.69	18.31
11.....	1.62	-1.63	19.57	16.75	18.88
12.....	3.08	-1.52	19.16	19.94	21.16
Mean	1.78	-1.62	20.60	19.16	19.13
			Mean difference in per cent	t	P
Evaporation loss			3.40	17.44	<0.01
Total losses					
175° C. and 24-25° C.....			1.44	2.30	<0.05
175° C. and unfrozen.....			1.47	1.68	>0.10
24-25° C. and unfrozen.....			0.03	0.04	>0.90

* Total losses are the sum of freezing, thawing, and cooking losses for frozen pork, and the sum of cooking losses for unfrozen pork.

Paired judgments were made by about 15 people at different times during the course of the experiment. For paired judging, samples from the two roasts which are to be compared are submitted to the judge at the same time so that he may state his preference. The results corroborated those from the use of the cooking committee grading sheet, no preference being shown for frozen or unfrozen meat or for any one method of thawing.

Pork

The pork roasts used were directly comparable; therefore the results may be compared statistically.

The thawing and cooking times in minutes per pound for the center loin cuts of pork are given in Table 2. The roasts thawed at 175° C. take much less time to cook than those thawed at 24-25° C., and the roasts thawed at 24-25° C. take less time to cook than those which were not frozen.

Table 3 gives the evaporation losses during thawing, and the total losses for the pork roasts. The evaporation losses during thawing are especially interesting, as the roasts thawed at 175° C. lose weight, while those thawed at 24-25° C. gain weight. The gain in weight is probably due to the high humidity of the conditioning room. There is a significant difference between the total losses, including the freezing, thawing, and cooking losses of the roasts thawed at 175° C. and those thawed at 24-25° C., the roasts thawed at 175° C. having higher losses. There is no significant difference between the losses of the unfrozen pork and the losses of the frozen pork thawed at 175° C. and at 24-25° C.

Press fluid and drip values are given in Table 4. The only significant difference for press fluid is between the frozen pork thawed at 24-25° C. and the unfrozen pork, the frozen pork having more press fluid. There is no difference in drip between frozen pork thawed at 175° C. and at 24-25° C. and unfrozen pork.

Table 5 gives the results on total moisture and tenderness. There is no significant difference between the values of total moisture and tenderness for unfrozen pork and frozen pork thawed at 175° C. and at 24-25° C.

Beef

The effect of freezing and of thawing temperatures of 175° C. and 24-25° C. upon thawing and cooking time, losses, press fluid, drip, total moisture, and tenderness of the 9-10, and 11-12 rolled rib roasts of beef (2½ to 3 lbs.) was studied.

The results indicate that the thawing temperatures used do not affect press fluid, drip, total moisture, or tenderness of beef. The total losses, including the freezing, thawing, and cooking losses, are significantly greater if the roasts are thawed at 175° C. than if they are thawed at 24-25° C.

Table 4. Percentage Press Fluid and Freezing Drip of Frozen Pork Thawed at 175° C. and 24-25 °., and of Unfrozen Pork, Cooked at 175° to 84° C.

Series number	Press fluid			Freezing drip		
	175° C.	24-25° C.	Unfrozen	175° C.	24-25° C.	Unfrozen
1.....	per cent 41.80	per cent 49.57	per cent 45.96	per cent 13.37	per cent 16.64	per cent 11.31
2.....	54.88	46.86	47.20	25.00	19.17	11.63
3.....	42.16	63.88	43.25	11.64	22.05	20.34
4.....	37.16	55.31	40.22	10.47	21.04	19.66
5.....	45.95	43.84	37.59	13.03	12.19	13.21
6.....	46.72	44.53	41.89	14.43	13.63	14.18
7.....	48.77	47.82	44.53	14.18	15.74	15.38
8.....	48.54	48.38	36.87	15.08	16.87	14.72
9.....	48.89	48.92	45.84	15.67	12.55	22.10
10.....	48.01	45.87	53.38	15.02	11.29	20.18
11.....	55.70	48.64	41.57	27.99	15.28	18.00
12.....	51.16	49.20	45.71	24.40	13.17	15.61
Mean.....	47.48	49.40	43.67	16.69	15.80	16.36
			Mean difference in per cent	<i>t</i>	<i>P</i>	
Press fluid						
175° C. and 24-25° C.....			1.92	0.72	>0.40	
175° C. and unfrozen.....			3.81	2.12	>0.05	
24-25° C. and unfrozen.....			5.73	2.71	<0.05	
Freezing drip						
175° C. and 24-25° C.....			0.89	0.43	>0.60	
175° C. and unfrozen.....			0.33	0.16	>0.80	
24-25° C. and unfrozen.....			0.56	0.39	>0.70	

The frozen beef had significantly greater total losses than the unfrozen and significantly less press fluid. The differences between the frozen and unfrozen beef for drip, total moisture, and tenderness were not significant. The complete report of this work will be published in Food Research 2:339-347. 1937.

CONCLUSIONS

Palatability of pork and beef is unaffected by freezing and by the use of different thawing temperatures, under the experimental conditions used.

Frozen roasts thaw more quickly at 175° C. than at 24-25° C. Frozen roasts thawed at 175° C. cook more quickly than those thawed at 24-25° C. Frozen roasts cook more quickly than unfrozen roasts.

From a statistical analysis of the data on beef and pork roasts the following conclusions may be drawn:

Frozen pork and beef thawed at 175° C. have higher total losses than pork and beef thawed at 24-25° C. The difference in total losses between frozen pork thawed at 24-25° C. and unfrozen pork is not significant.

Frozen pork thawed at 24-25° C. has a higher press fluid content

than unfrozen pork. Unfrozen beef has a higher press fluid content than frozen beef when thawed at 175° C. Thawing temperature does not affect the press fluid content of frozen pork and beef.

Total moisture, drip, and tenderness of cooked pork and beef are unaffected by freezing or by different thawing temperatures.

Table 5. Percentage Total Moisture and Tenderness in Pounds Force Required to Shear, for Frozen Pork Thawed at 175° C. and 24-25° C., and for Unfrozen Pork, Cooked at 175° C. to 84° C.

Series number	Total moisture			Tenderness		
	175° C.	24-25° C.	Unfrozen	175° C.	24-25° C.	Unfrozen
	per cent	per cent	per cent	pounds	pounds	pounds
1.....	65.89	66.74	61.46	16.13	16.09	16.00
2.....	64.79	64.43	64.98	14.96	14.83	16.71
3.....	67.06	66.74	65.19	17.42	19.54	18.42
4.....	64.37	62.50	66.56	19.75	18.05	15.92
5.....	63.11	61.83	63.77	22.42	22.46	22.17
6.....	59.92	61.00	60.91	14.42	17.08	16.21
7.....	62.29	62.71	63.64	16.63	17.13	19.59
8.....	68.01	68.69	65.39	15.38	16.54	16.30
9.....	66.68	65.88	64.59	17.17	15.42	16.38
10.....	68.50	68.11	68.65	14.04	13.79	15.75
11.....	68.67	66.19	64.83	19.63	22.46	20.21
12.....	65.15	62.56	63.14	15.58	14.96	11.21
Mean.....	65.37	64.78	64.43	16.96	17.36	17.07

	Mean difference in per cent	t	P
Total moisture			
175° C. and 24-25° C.....	0.59	1.63	>0.10
175° C. and unfrozen.....	0.94	1.52	>0.10
24-25° C. and unfrozen.....	0.36	0.51	>0.50
Tenderness			
175° C. and 24-25° C.....	0.40	0.91	>0.40
175° C. and unfrozen.....	0.11	0.17	>0.50
24-25° C. and unfrozen.....	0.29	0.53	>0.50

LITERATURE CITED

- ALEXANDER, L. M., CLARK, N. G., and HOWE, P. E. (1933) Methods of Cooking and Testing Meat for Palatability. Supplement to National Project Co-operative Meat Investigations. U. S. Dept. Agri., Bur. Home Econ. and Bur. Anim. Indus. Revised. (Mimeographed)
- CHILD, A. M., BALDELLI, M. (1934) Press Fluid From Heated Beef Muscle. Jour. Agr. Research 48:1127-1134. Illustrated.
- CHILD, A. M., and FOGARTY, J. A. (1935) Effect of Interior Temperatures of Beef Muscle Upon the Press Fluid and Cooking Losses. Jour. Agr. Research 51:655-662.
- COOK, G. A., LOVE, E. F. J., VICKERY, J. R., and YOUNG, W. J. (1926) Studies on the Refrigeration of Meat. I. Investigations into the Refrigeration of Beef. Aust. Jour. Expt. Biol. and Med. Sci. 3:15-31.
- FISHER, R. A. (1932) Statistical Methods for Research Workers. Oliver & Boyd, Edinburgh and London. Ed. 4. 307 pp.

