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To the Graduate Council:

I am submitting herewith a thesis written by Joan Forrester entitled "Effects of Roasting, Braising, and Stewing on the Cesium-134 Content of Beef from Orally Dosed Steers." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Food Science and Technology.

Bernadine Meyer, Major Professor

We have read this thesis and recommend its acceptance:

John T. Smith, M. C. Bell

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

December 1, 1960

To the Graduate Council:

I am submitting a thesis written by Joan Forrester entitled "Effects of Roasting, Braising, and Stewing on the Cesium-134 Content of Beef from Orally Dosed Steers." I recommend that it be accepted for nine quarter hours credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Foods and Institutional Management.

Bernadine Meyer
Major Professor

We have read this thesis and recommend its acceptance:

John T. Smith

M. C. Bell

Accepted for the Council:

Dean of the Graduate School

EFFECTS OF ROASTING, BRAISING, AND STEWING ON THE CESIUM-134 CONTENT OF BEEF FROM ORALLY DOSED STEERS

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

Joan Forrester

December 1960

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It is with deep gratitude that I acknowledge the contribution to this study of the many people who have so generously devoted time and thought to it. Sincere appreciation is expressed to the people at the University of Tennessee-Atomic Energy Commission Agricultural Research Laboratory, Oak Ridge, Tennessee, as follows:

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J. F.

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CHAPTER I

INTRODUCTION

In recent years there has been considerable interest in the effects of radioisotopes in food. Some quantity of radioactive material is ingested at each meal. With the testing of atomic weapons and other applications of atomic energy, foods are slowly becoming contaminated with additional radioactivity. Therefore nuclear fallout presents a problem of universal interest and concern. However, George Larrick (1), Commissioner of the Food and Drug Administration, stressed that there was no evidence of any dangerous level of radioactivity in the food supply in 1957. In the event of an atomic war or of mishaps with nuclear reactors in peacetime, the problem could become acute, and the population would need to be advised about the use of food which had been subjected to radioactivity.

Of the 189 fission-produced radioisotopes strontium-90 and cesium-137 are 2 of the most hazardous having half-lives of approximately 27 to 30 years. Strontium-90 is metabolized like calcium and tends to concentrate in milk and bone; whereas cesium-137 is more uniformly distributed in the body through the muscle tissues (8).

Somers (12) explains that since bones are not consumed by man that there will be little possibility of man obtaining strontium-90 from the meat of contaminated animals. He states further that if forage, vegetables, and grains were to become contaminated with

strontium-90, then animals could be used as "strainers" to remove strontium-90 from the food. However, Bell and Buescher (3) have shown that some strontium-89 migrates from the bone to muscle tissue when meat is roasted.

Since cesium is a soft-tissue constituent, animals could not be used effectively as "strainers" for its radioisotopes. Some method whereby cesium could be reduced to a very low level or removed would need to be developed before milk and meat from contaminated animals could be used for human consumption. A few studies (2, 4, 5) with milk indicate that a large percentage of cesium-134 and strontium-89 could be removed from milk by ion-exchange. Since the American people eat a high meat-protein diet, meat contaminated with radioactive cesium would present a serious problem. Therefore the importance of studying methods to reduce the radioactive cesium content in meat is apparent.

Personnel at the University of Tennessee-Atomic Energy Commission Agricultural Research Laboratory, Oak Ridge, Tennessee, have been studying the metabolism of cesium-134 in steers. From this project meat with a measurable level of radioactivity was made available for cooking tests. Therefore this study was initiated to ascertain whether the cesium-134 activity of beef from 10 orally dosed steers could be influenced by different methods of cooking.

The primary purpose was to investigate the possibility of reducing the radioactivity associated with cesium-134 by increases in the surface area of meat and the amount of liquid used for cooking.

For this purpose, loin roasts representing small surface area in proportion to weight of meat were cooked by dry heat with no added liquid. Round steaks with increased surface area were braised in a small amount of water. Cubed beef from round representing large surface area was stewed with a larger amount of water. The retention of the radioactivity in the meat cooked by these 3 methods was determined.

In the present study cesium-134 was used rather than cesium-137, because it is a safer isotope with which to work and has no radioactive decay product. Cesium-134 is an alkaline metal having a half-life of 2.26 $\pm$ 0.05 years (6).

It was hoped that the data obtained from this study would furnish some clues as to whether radioactivity in meat could be reduced by suitable cooking procedures.

CHAPTER II

REVIEW OF LITERATURE

Cesium was first discovered in 1860 by the German scientists, Gustav Robert Kirchhoff and Robert Withelem Bunsen. However, cesium was not seen by human eyes till 1881 when a tiny amount was purified from its ore by the German chemist, Setterburg. The silvery, pasty, soft metal will burst into a brilliant blue flame and will burn with an intense glow the minute free oxygen touches it. Cesium will cause a steam explosion when thrown into water (14).

Ingested radioactive cesium should be considered a potentially serious source of damaging irradiation (7). Metabolically, cesium-134 might be expected to behave similarly to sodium, potassium, and rubidium (9, 10). Since cesium can be distributed through the entire soft tissue and fluid systems of the body and its radiations are very penetrating in nature, the irradiation dose from ingested cesium can be delivered uniformly to the whole body (7).

Hood and Comar (7) reported a relatively large accumulation of cesium-137 in the muscle tissue of rats and farm animals after dosing with cesium-137. Accumulation of cesium-137 in the edible tissues would indicate that exposure of food producing animals to radioactive cesium may render them and their products unfit for human consumption.

Love and Burch (9) reported that potassium-42 and cesium-134 behaved similarly in human erythrocytes. However, cesium-134 exchanged at a slower rate.

Williams and Patrick (13) studied the metabolism of cesium-134 in rabbits. Data from this study showed a consistent tendency toward greater excretion and lowered retention of cesium-134 in the body tissues as the dietary potassium intake was increased.

Likewise, Mraz and co-workers (11) working with rats reported a decrease in retention and an increase in excretion of cesium-134 when the dietary potassium was increased. They explained that cesium was probably present in bound forms in the soft tissues such as muscle and kidney and was freed chiefly after catabolism and not by ionic exchange.

At the time the present study was undertaken no reports as to the effects of cooking on cesium-134 activity in beef could be located.

However, Bell and Buescher (3) recently studied the effects of cooking on strontium-89 activity in beef roasts from orally dosed steers. Most of the strontium retained by the animals was deposited in the bone. Therefore it was important to determine if strontium would be released from the bone to the muscle tissue in the cooking process. This study indicated that the meat from roasts cooked with bone attached contained more strontium-89 activity than cooked meat from boneless roasts. The concentration of radioactivity in the cooked meat was inversely proportional to the distance from the bone. Drippings from boneless roasts contained less strontium-89 than drippings from roasts cooked with the bone attached. Presumably, strontium-90 would migrate in a similar manner during the cooking of meat.

CHAPTER III

PROCEDURE

I. DESIGN OF STUDY

Meat for the present study was obtained from 10 Hereford steers used in a study of the metabolism of cesium-134 at the University of Tennessee-Atomic Energy Commission Agricultural Research Laboratory, Oak Ridge, Tennessee. For the metabolism study there were 3 lots of steers with 6 steers in each lot. Three steers in each lot had been on a low (0.5%) potassium diet and 3 on a high (1.5%) potassium diet. Nine days before slaughter each animal was orally dosed with 1 millicurie of cesium-134. Blood, urine, and fecal material were collected daily for 9 consecutive days. On the day of slaughter samples of the liver, heart, kidney, spleen, and muscle were removed for analysis. These data will be reported elsewhere.

The meat cooked in the present study was obtained from the 6 steers of Lot II and 4 of the steers from Lot III of the metabolism study.

II. CUTS OF BEEF USED

The loin roasts, round steaks, and stew meat used in this study were taken from the 10 beef carcasses just described. Adjacent pairs of roasts and steaks were used. One roast and one steak from each pair was used for determining the radioactivity of the raw meat. The

other roast and steak were cooked before determining radioactivity. The roasts were boneless. The steaks were top round cut 1-inch thick with bone removed. For stews approximately 2 lb of bottom round were cut into 1-inch cubes and thoroughly mixed. Approximately 1 lb was used for cooking, and the remaining stew meat was tested raw.

The desired cuts were removed on the day of slaughter. Each cut of meat was wrapped in heavy duty aluminum foil and sealed with masking tape. The meat was then frozen and stored at -4°F (-20°C) until it was used. Cooking tests were carried out within 3 months after slaughter.

III. COOKING METHODS

The roasts, steaks, and stew meat were thawed at room temperature on the day preceding a cooking test. The thawed meats were then refrigerated overnight. All cooking was done on a household electric range at the University of Tennessee-Atomic Energy Commission Agricultural Research Laboratory, Oak Ridge, Tennessee.

Roasts

The roasts represented tender cuts of small surface area usually cooked without added moisture. They were cooked in a preheated oven at 300°F $\pm$ 10° (149°C $\pm$ 5.5°). The weighed roasts were cooked in tared pyrex baking dishes. Roasts were cooked until an internal temperature of 154°F (68°C) (medium-done) was reached. After removal from the oven they were cooled at room temperature for 10 min to allow for any

temperature rise before weighing to determine evaporation loss. The roasts were then allowed to drain for 3 min, after which the dishes and drippings were weighed to determine drippings loss.

Steaks

The round steaks represented a large surface area of a less-tender cut usually cooked with a small amount of water. A 10½-inch cast aluminum skillet weighing 1092 g was used for braising the steaks. The skillet containing 1 tablespoon of hydrogenated fat was preheated for 3 min on high heat. The steaks were seared on each side for 1 min on high heat. One-half cup of boiling water was then added and the heat reduced to simmer. The skillet was covered with aluminum foil and a meat thermometer was inserted through the foil into the steak. After the internal temperature of the steaks reached 185°F (85°C) they were simmered for 1½ hr. Steaks were then cooled in the pan at room temperature for 10 min before weighing to determine evaporation loss. Steaks were allowed to drain for 3 min before removing from the skillet. Skillet and drippings were weighed to determine the weight of the drippings.

Stews

The stews represented large surface area of less-tender meat cooked with a large amount of water. A 10½-inch cast aluminum skillet weighing 1092 g was used for the stews. The skillet containing 1 tablespoon of hydrogenated fat was preheated for 3 min on high heat.

The cubed meat was seared for 4 min on high heat, with occassional stirring to obtain even browning. Two cups of boiling water were then added, heat was reduced to simmer, and the skillet was covered. The meat was allowed to cook for 1½ hr. Meat, drippings, and skillet were allowed to cool for 10 min before weighing. Weight of cooked meat and drippings were determined.

IV. SAMPLING FOR MEASUREMENT OF RADIOACTIVITY

Samples of the raw and cooked meats were removed with a cork borer. Five cores averaging about 3 g per core were taken at random from each raw and cooked roast, steak, and lot of stew meat. The cores were placed in tared 16 X 150 mm test tubes and stoppered. The cork borer was rinsed in a weak HCl solution between taking each sample to prevent cross contamination of samples. Drippings were quantitatively transferred to a separatory funnel, and the aqueous and fat phases were separated by adding boiling water. Each fraction was then weighed. Three-ml samples of each fraction were pipetted into tared 16 X 150 mm test tubes and stoppered. In most cases 2 samples of the fat phases of the drippings were taken. The exceptions were when there was not enough fat for 2 samples. With the first 6 animals, 2 samples of the aqueous phase of the drippings were taken; with the last 4 animals, 3 samples were taken. Test tubes containing the samples were weighed to determine weight of samples.

V. MEASURING RADIOACTIVITY

To determine the radioactivity of the samples scintillation well-type counters were used. Radioactivity of the sample in each tube was measured as counts per min per sample, and counts per min per g were calculated from the sample weights. About 14 or 15 tubes were counted for each cooking test, 5 containing raw meat, 5 containing cooked meat, 2 or 3 containing the aqueous phase of the drippings, and 1 or 2 containing the fat phase of the drippings.

VI. CALCULATING RETENTION OF RADIOACTIVITY

Total activity of the meat before cooking was calculated by multiplying weight of raw sample before cooking by the average counts per min per g of raw meat. Total activity of the cooked meat and drippings was determined in the same manner. The activity of the cooked meat and drippings was then calculated as per cent of the activity of the raw meat.

VII. ANALYSIS OF DATA

An analysis of variance was made on the data for the cooked loin roasts, round steaks, and stews and for the aqueous phase of the drippings from these meats. This gave a basis for determining if the radioactivity retained differed significantly with the 3 methods of cooking.

CHAPTER IV

RESULTS AND DISCUSSION

I. RESULTS

Roasts

Data on cesium-134 activity of the meat cooked by roasting are shown in Table I. The raw roasts had an average activity of 3.4×10^6 cpm.[a] After cooking the average cesium-134 activity of the roasts was 2.8×10^6 cpm. Thus on the average, about 82 per cent of the activity of the raw meat was retained in the cooked roasts.

Drippings from the roasts were separated into fat and aqueous phases. As indicated by the data in Table I most of the cesium-134 activity of the drippings was confined to the aqueous phase which contained 13 per cent of the activity of the raw roasts. The activity of the fat phase was negligible, being only 0.03 per cent of the original activity of the raw meat.

The average total activity recovered in the cooked meat and drippings was about 94 per cent (Table I). Thus about 6 per cent of the original activity was not recovered after cooking.

Steaks

Data on cesium-134 activity of the meat cooked by braising are shown in Table II. The raw steaks had an average activity of about

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[a]Counts per minute.

TABLE I

EFFECT OF OVEN ROASTING ON THE CESIUM-134 ACTIVITY OF BEEF LOIN

Sample Number	Cesium-134 Activity[a]								Per Cent of Activity of Raw Meat			
	Raw Roasts		Cooked Roasts		Aqueous Phase of Drippings		Fat Phase of Drippings		Retained in Cooked Meat	Transferred to Drippings		Total Recovered
	Counts per Gram	Total Counts	Counts per Gram	Total Counts	Counts per Gram	Total Counts	Counts per Gram	Total Counts		Aqueous Phase	Fat Phase	
Lot II												
Low K												
1	4.2	4296	4.0	3332	25.6	615	0.2	0.4	77.56	14.32	0.01	91.89
2	3.2	2992	3.0	2520	7.1	157	0.3	1.2	84.22	5.25	0.04	89.51
3	3.6	3284	3.8	2990	3.1	274	0.2	2.0	91.05	8.34	0.06	99.45
High K												
1	4.6	3198	4.3	2675	3.9	277	0.3	0.7	83.65	8.66	0.02	92.33
2	3.5	2926	3.4	2369	3.7	387	0.1	1.9	80.96	13.23	0.06	94.25
3	3.2	2869	3.0	2230	3.5	382	0.1	0.4	77.73	13.31	0.01	91.05
Lot III												
Low K												
1	3.3	3305	3.2	2702	4.6	557	0.2	1.0	81.75	16.85	0.03	98.63
High K												
1	3.0	2902	2.8	2339	3.9	463	0.2	1.2	80.60	15.95	0.04	96.59
2	3.7	4174	3.4	3108	5.1	894	0.2	1.1	74.46	21.42	0.03	95.91
3	3.4	4137	3.1	3321	4.5	538	0.5	1.6	80.28	13.00	0.04	93.32
Average	3.6	3408	3.4	2759	6.5	454	0.2	1.2	81.23	13.03	0.03	94.29

[a]Counts per minute. To determine actual count multiply by 10^3.

TABLE II

EFFECT OF SURFACE BRAISING ON CESIUM-134 ACTIVITY OF BEEF ROUND

Sample Number	Cesium-134 Activity[a]								Per Cent of Activity of Raw Meat			
	Raw Steaks		Cooked Steaks		Aqueous Phase of Drippings		Fat Phase of Drippings			Transferred to Drippings		
	Counts per Gram	Total Counts	Counts per Gram	Total Counts	Counts per Gram	Total Counts	Counts per Gram	Total Counts	Retained in Cooked Meat	Aqueous Phase	Fat Phase	Total Recovered
Lot II												
Low K												
1	5.1	4778	4.4	2406	12.7	2084	0.4	9.0	50.36	43.62	0.19	94.17
2	3.5	3926	3.3	2151	13.3	1341	5.8	69.2	54.79	34.16	1.76	90.71
3	4.2	5359	3.3	2444	7.6	2501	0.3	6.1	45.60	46.67	0.11	92.38
High K												
1	4.8	4885	5.0	2988	13.6	1156	0.1	2.9	61.17	23.66	0.06	84.89
2	4.2	2684	5.1	1866	8.8	678	1.0	15.4	69.52	25.26	0.57	95.35
3	3.7	3293	4.4	2274	10.9	848	0.1	3.8	69.06	25.75	0.12	94.93
Lot III												
Low K												
1	3.7	4235	3.3	2319	9.4	1408	0.4	11.0	54.76	33.25	0.26	88.27
High K												
1	3.3	3463	3.8	2317	9.2	689	0.1	2.2	66.91	19.90	0.06	86.87
2	4.2	4251	3.4	2038	10.0	1846	0.6	11.0	47.94	43.42	0.26	91.62
3	3.7	3799	3.2	2027	11.2	1536	0.1	2.2	53.36	40.43	0.06	93.85
Average	4.0	4067	3.9	2283	10.7	1409	0.9	13.3	57.35	33.61	0.34	91.30

[a]Counts per minute. To determine actual count multiply by 10^3.

4.1 X 10^6 cpm. After cooking the average activity of the steaks was 2.3 X 10^6 cpm, indicating that about 56 per cent of the activity of the raw meat was retained in the cooked steak.

As indicated in Table II the cesium-134 activity of the steak drippings also was concentrated in the aqueous phase, amounting to about 34 per cent of that in the raw meat. Only 0.34 per cent of the activity was recovered in the fat phase of the drippings.

The total activity retained by the cooked meat and drippings ranged from about 85 to 95 per cent and averaged 91 per cent. Nine per cent of the activity of the raw meat was not recovered after the steaks were braised.

Stews

Data for stewing showed more variation than was obtained by other methods of cookery. As indicated in Table III about one-half of the cesium-134 activity was leached out of the meat when stewed. The average activity of 1 lb of raw stew meat was 1.8 X 10^6 cpm. After cooking it was only 0.9 X 10^6 cpm.

With stewing, as much radioactivity was transferred to the drippings as was retained in the cooked meat (Table III). The activity of the aqueous phase of drippings averaged about 48 per cent and the fat phase, 0.10 per cent.

The total activity recovered in stew meat and drippings ranged from 89 to 101 per cent of the activity of raw meat and averaged about

TABLE III

EFFECT OF STEWING ON CESIUM-134 ACTIVITY OF BEEF ROUND

Sample Number	Cesium-134 Activity[a]								Per Cent of Activity of Raw Meat			
	Raw Stew		Cooked Stew		Aqueous Phase of Drippings		Fat Phase of Drippings		Retained in Cooked Meat	Transferred to Drippings		Total Recovered
	Counts per Gram	Total Counts	Counts per Gram	Total Counts	Counts per Gram	Total Counts	Counts per Gram	Total Counts		Aqueous Phase	Fat Phase	
Lot II												
Low K												
1	5.5	2493	3.3	956	5.8	1471	0.1	1.0	38.35	59.00	0.04	97.39
2	3.6	1630	3.2	932	7.5	514	b	b	57.18	31.53	b	88.71
3	4.3	1941	3.1	869	5.4	986	0.1	0.7	44.77	50.80	0.04	95.61
High K												
1	4.6	2100	3.2	895	4.7	1222	0.1	0.6	42.62	58.19	0.03	100.84
2	3.9	1787	3.2	875	4.9	878	0.3	2.8	48.96	49.13	0.16	98.25
3	4.0	1820	3.3	911	5.0	852	0.2	2.0	50.05	46.81	0.11	96.97
Lot III												
Low K												
1	3.5	1577	2.6	755	4.5	719	0.7	3.5	47.88	45.59	0.22	93.69
High K												
1	3.1	1456	2.2	616	c	c	0.4	2.6	42.31	c	0.18	c
2	4.4	1980	3.0	879	4.8	1090	0.2	1.8	44.39	55.05	0.09	99.53
3	3.9	1752	3.5	996	6.8	668	0.1	0.6	56.85	38.13	0.03	95.01
Average	4.1	1854	3.1	868	5.5	933	0.2	1.7	47.34	48.25	0.10	96.22

[a]Counts per minute. To determine actual count multiply by 10^3.
[b]Not enough fat obtained for sampling.
[c]Sample lost.

96 per cent (Table III). Thus only 4 per cent of the original activity was not recovered after stewing.

Cooking Losses

The cooking losses for roasts, steaks, and stews used in this study are shown in Table IV. No attempt was made to analyze these data. This table is included here as a matter of record.

II. DISCUSSION

The primary purpose of this study was to determine if increasing the surface area of meat and cooking with large amounts of water would decrease the radioactivity in beef obtained from steers that had been dosed with cesium-134.

This study should be considered exploratory in nature. There have been no known investigations concerning the effect of cooking meats having cesium-134 activity; therefore all procedures for cooking and sampling had to be developed for this study.

The data in Table V indicate that as the surface area of the meat and the amount of water were increased, the per cent of activity retained in the cooked meat decreased. The average activity retained in the cooked roasts was 81 per cent; in the steaks, 57 per cent; and in the stews, 47 per cent. When analyzed statistically, the activity retained in the braised steaks and stew meat was significantly less than the activity retained in the cooked roasts. Also, the activity

TABLE IV

COOKING LOSSES FOR ROASTS, STEAKS, AND STEWS[a]
(in per cent)

Sample Number	Roasts			Steaks			Stews		
	Volatile	Dripping	Total	Volatile	Dripping	Total	Volatile	Dripping	Total
Lot II									
Low K									
1	12.34	6.76	19.10	28.38	19.96	48.34	39.41	29.70	69.11
2	3.50	7.10	10.60	35.39	11.80	47.19	59.33	8.85	68.18
3	6.48	6.26	12.74	21.92	25.69	47.62	54.58	15.64	70.22
High K									
1	6.50	4.04	10.54	45.76	4.82	50.58	44.65	24.76	69.41
2	7.38	8.92	16.30	52.01	5.64	57.65	56.16	14.69	70.85
3	7.46	7.34	14.80	41.55	6.56	48.11	55.72	14.47	70.19
Lot III									
Low K									
1	7.20	8.48	15.70	34.38	10.49	44.87	56.36	12.82	69.18
High K									
1	7.66	7.87	15.53	41.88	5.35	47.23	49.03	21.01	70.04
2	7.95	11.92	19.87	33.69	13.63	47.32	46.32	21.86	68.18
3	5.07	6.57	11.64	34.00	11.25	45.25	60.97	8.54	69.51
Average	7.15	7.53	14.68	36.90	11.52	48.42	52.25	17.23	69.49

[a]Refer to glossary.

TABLE V

COMPARISON OF RETENTION OF CESIUM-134 IN BEEF COOKED BY THREE METHODS

Sample Number	Per Cent of Activity of Raw Meat Retained in Cooked Meat			Per Cent of Activity of Raw Meat Transferred to Aqueous Phase of Drippings			Per Cent of Activity of Raw Meat Transferred to Fat Phase of Drippings			Total Per Cent of Activity Recovered		
	Roasted Loin	Braised Round Steak	Stewed Round	Roasted Loin	Braised Round Steak	Stewed Round	Roasted Loin	Braised Round Steak	Stewed Round	Roasted Loin	Braised Round Steak	Stewed Round
Lot II												
Low K												
1	77.56	50.36	38.35	14.32	43.62	59.00	0.01	0.19	0.04	91.89	94.17	97.39
2	84.22	54.79	57.18	5.25	34.16	31.53	0.04	1.76	a	89.51	90.71	88.71
3	91.05	45.60	44.77	8.34	46.67	50.80	0.06	0.11	0.04	99.45	92.38	95.61
High K												
1	83.65	61.17	42.62	8.66	23.66	58.19	0.02	0.06	0.03	92.33	84.89	100.84
2	80.96	69.52	48.96	13.23	25.26	49.13	0.06	0.57	0.16	94.25	95.35	98.25
3	77.73	69.06	50.05	13.31	25.75	46.81	0.01	0.12	0.11	91.05	94.93	96.97
Lot III												
Low K												
1	81.75	54.76	47.88	16.85	33.25	45.59	0.03	0.26	0.22	98.63	88.27	93.69
High K												
1	80.60	66.91	42.31	15.95	19.90	b	0.04	0.06	0.18	96.59	86.87	b
2	74.46	47.94	44.39	21.42	43.42	55.05	0.03	0.26	0.09	95.91	91.62	99.53
3	80.28	53.36	56.85	13.00	40.43	38.13	0.04	0.06	0.03	93.32	93.85	95.01
Average	81.23	57.35*	47.34*	13.03	33.61*	48.25*	0.03	0.34	0.10	94.29	91.30	96.22

[a] Not enough fat obtained for sampling.
[b] Sample lost.
* Significant at the 1 per cent level.

retained in the stew meat was significantly less than that retained in the cooked steaks.

Most of the radioactivity lost from the muscle tissue was recovered in the aqueous phase of the drippings. Again the amount of activity recovered was proportional to the amount of water used. The average cesium-134 activity in the aqueous phase of the drippings from the roasts was 13 per cent; from the steaks, 34 per cent; and from the stews, 48 per cent. When analyzed statistically, there was significantly greater activity in the drippings from steaks and stews than from the roasts. The activity of the stew drippings was also significantly greater than that from the steaks. These data emphasize the water-soluble nature of cesium-134.

Even though the radioactivity of the meat was reduced when cooked, it was not considered safe to determine the effect of the cooking procedures on the palatability of the meat. Therefore the acceptability of the meat for human consumption is not known.

On the basis of these data the most important observation in this study was that radioactivity associated with a water-soluble radioisotope can be greatly reduced in muscle tissue by cooking procedures which expose a relatively large surface of the meat to large quantities of liquid. However, unless suitable procedures could be devised to make drippings usable by eliminating the radioactivity dissolved from the meats, the drippings would need to be discarded and the reduction in radioactivity of the muscle tissue would be at the

expense of water-soluble nutrients in the drippings usually consumed as "gravy".

Additional work is recommended in this field to determine whether it is possible to obtain greater reductions in the radioactivity of meats through cooking. Some suggestions for further work would be to study: the effect of increasing the surface area of the meat by grinding; the effect of freezing and thawing the meat; and the effect of using an acid liquid in which to cook the meat. The effect of cooking meat under pressure could warrant study. The possibility of eliminating the cesium-134 activity from the drippings by ion-exchange could merit investigation. If the activity in the drippings could be eliminated by this method then the drippings containing some of the water-soluble nutrients might possibly be used with the meat for human consumption. In connection with studies of the effects of cooking on the radioactivity of meats, investigations as to the effect of these factors on the nutritive value of the meat would be of interest and importance.

If meat to be used for human consumption should ever become contaminated with radioactivity, then information concerning various cooking procedures would be most helpful.

CHAPTER V

SUMMARY

In this study the effect of cooking on the cesium-134 content of beef from orally dosed steers was investigated. The chief purpose of the investigation was to determine if radioactivity of beef muscle tissue could be reduced by appropriate cooking procedures. Three commonly used methods of cooking meat were compared. Loin roast representing small surface area in proportion to weight of meat was cooked without added moisture. Round steak with increased surface area was braised in a small amount of water. Cubed beef from round representing a relatively large surface area was stewed with a large amount of water.

I. PRINCIPAL FINDINGS

After cooking, the cesium-134 activity retained by the stew meat was about 47 per cent which was significantly less than that retained by either the roasts (81 per cent) or the steaks (57 per cent). The braised steaks also had significantly less activity than the roasts. Most of the activity lost from the cooked meat was recovered in the aqueous phase of the drippings. The cesium-134 activity of the drippings from the stew (48 per cent) was significantly greater than that from the roast (13 per cent) or steak (34 per cent). The activity in the drippings from the steak was significantly greater than the activity in the roast drippings.

II. CONCLUSION

Based on the data obtained from this study, it could be concluded that the cesium-134 content of beef muscle tissue can be significantly reduced by cooking procedures which expose a large surface of the meat to a large quantity of water and then discarding the radioactive drippings. More work with meat containing cesium-134 is necessary to determine other factors which could alter the cesium-134 activity in meat. It is felt that further work is desirable so that some recommendations concerning the possible use of meat contaminated with cesium-134 could be made if the need becomes apparent.

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APPENDIX

GLOSSARY

I. Volatile Cooking Losses

A. Roasts. Loss due to evaporation from meat.

$$\text{Per cent volatile loss} = \frac{B_2}{A_2} \times 100, \text{ where}$$

A_2 = Weight of meat

B_2 = Weight lost due to evaporation

B. Steaks and Stews. Loss due to evaporation from the meat and added water.

$$\text{Per cent volatile loss} = \frac{A_4 - B_1}{A_2 + A_3} \times 100, \text{ where}$$

A_2 = Weight of meat before cooking

A_3 = Weight of water before cooking

A_4 = Weight of pan, meat, and water before cooking

B_1 = Weight of pan, meat, and drippings after cooking

II. Drippings Losses

A. Roasts. Extracted meat juices remaining after cooking.

$$\text{Per cent drippings loss} = \frac{B_5}{A_2} \times 100, \text{ where}$$

A_2 = Weight of meat

B_5 = Weight of drippings

B. Steaks and Stews. Extracted meat juices dissolved in water remaining after cooking.

$$\text{Per cent drippings loss} = \frac{B_3 - B_4}{A_2 + A_3} \times 100, \text{ where}$$

A_2 = Weight of meat before cooking

A_3 = Weight of water before cooking

B_3 = Weight of pan and drippings

B_4 = Weight of pan

III. Total Cooking Loss

Roasts, Steaks, and Stews. Total cooking loss is the sum of the volatile loss and the drippings loss.

DATA ON COOKING AND COOKING LOSSES OF MEAT FOR CESIUM-134 DETERMINATIONS

U.T.-A.E.C. IDENTIFICATION:	DATE:		
Method of Cooking:			
Home Economics Sample Number:			
A. Before Cooking 1. Wt. of pan			
2. Wt. of meat			
3. Wt. of water			
4. Total wt. before cooking			
B. After Cooking 1. Wt. of pan, meat, and drippings			
2. Wt. loss due to evaporation			
3. Wt. of pan and drippings			
4. Wt. of pan			
5. Wt. of drippings			
C. Cooking Data 1. Time began cooking			
2. Time finished cooking			
3. Total cooking time			
4. Time per pound			

DATA ON MEAT DRIPPINGS AFTER SEPARATION FOR COUNTING

U.T.-A.E.C. IDENTIFICATION:	DATE:		
Method of Cooking:			
Home Economics Sample Number:			
A. Water Phase 1. Wt. beaker and water phase			
2. Wt. beaker			
3. Wt. water phase			
B. Fat Phase 1. Wt. beaker and fat phase			
2. Wt. beaker			
3. Wt. fat phase			

CUMULATIVE DATA SHEET

Tube Identification	Scale___ Total Counts	Length of counts (min.)	bkg[a]	cpm[b]	cpm-bkg	Time	Date

[a]Background count.

[b]Counts per minute.