AD

TECHNICAL REPORT
FD-5

DEVELOPMENT OF READY-TO-EAT RATION TYPE BEEF ITEMS

by

F. L. Kauffman J. W. Harlan

SWIFT & COMPANY
Research Laboratories
Chicago 9, Illinois

Contract No. DA19-129-QM-1897

February 1965

U. S. Army Materiel Command
U. S. ARMY NATICK LABORATORIES
Natick, Massachusetts

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7-84-01-002

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FOREWORD

The availability of shelf-stable, highly acceptable meat items for use in military feeding systems is considered a necessity. The currently available thermally processed items do not fully meet requirements because of their limited utility, stability and acceptability. Radiation processing, or "cold" sterilization as it is frequently called, has the potentiality of yielding products that have good military utility, good storage stability, and good acceptability. Therefore, research to develop process criteria that can be used to produce irradiation sterilized meats is under way.

The work covered in this report was performed by Swift & Company Research Laboratories under Contract DA19-129-QM-1897 during the period from September 1961 to September 1963. It represents an investigation of the effects of a variety of pre-irradiation process variables on the acceptability and storage stability of radiation sterilized beef. These variables include such factors as type and quality of the raw material, enzyme inactivation techniques, and the use of selected additives such as spices and seasonings.

Dr. F. L. Kauffman was the Project Officer and official investigator and Dr. J. W. Harlan the collaborator in the research work for Swift & Company Research Laboratories. The U. S. Army Natick Laboratories' Project Officer was Dr. F. Heiligman and the Alternate Project Officer was Mr. M. Simon, both of the Food Division.

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ABSTRACT

Beef cooked in barbecue sauce, beef sauce or mushroom sauce had reduced irradiation flavor compared to untreated controls and had a fair acceptability in consumer tests. Some spices added to beef resulted in a product having a lower over-all irradiation flavor, but no spice was found that was satisfactory. Protein hydrolysates pumped into the beef before slicing also lowered ultimate irradiation flavor.

Beef must be enzyme-inactivated in order to make it shelf-stable. This enzyme inactivation has been done by heating to 77°C and results in a partially cooked product. When it is reheated prior to serving it has a "warmed over" flavor that is not desirable. To improve this aspect of beef steak quality we have evaluated steak preparation methods based on lower temperatures for longer times. It was found that steaks heat-enzyme-inactivated at 65°C and 50% relative humidity for 15 minutes, or at 57°C and 90% relative humidity for 60 minutes, had a greatly reduced "warmed over" flavor.

INTRODUCTION

The objective of this project was to develop and prepare shelf-stable irradiation sterilized beef and beef products, with emphasis placed on items which can be eaten directly from their container and/or could be prepared for consumption with limited facilities. Beef products when given sterilizing doses of irradiation have an odor and flavor that is objectionable to many people. The reduction or masking of this odor and flavor was a primary purpose of this research. Many additives and numerous variables and techniques were evaluated.

In order to have a shelf-stable product, the natural enzymes in beef must be inactivated. The customary method of inactivation is to heat the product to approximately 75°C. for a short time. This results in a product that is substantially cooked to a well done condition. Methods of enzyme inactivation using established time-temperature relationships were evaluated to develop a partially cooked product which could then be cooked to individual preference before serving.

Four different scales were used for product evaluation. For expert panel evaluation, a 1 to 6 scale was used for amount of irradiation flavor:

6 Very much
5 Much
4 Moderate
3 Little
2 Very little
1 None

Usually a panel of 8 experts were used. Consumer panel ratings were made on a 1 to 7, 1 to 9 or a 1 to 10 hedonic scale where 1 represents dislike very much and the top of the scale like very much.

RESULTS AND DISCUSSION

Sauces

In one series of experiments boneless sirloin strip steaks were cut into 1.75 oz. portions, drenched in an 80% hard wheat flour, 20% salt mixture, french fried for one minute in a 190°C. french fryer, heated in a sauce for 15-20 minutes at 95-100°C. and the meat was removed. Some of the same sauce was placed in the bottom of the can. Two pieces of meat were then placed in the can and the can filled with sauce, vacuum sealed and irradiated at ambient temperature with 4.5 megarads. Three sauces were used; - barbecue sauce, beef sauce and mushroom sauce. The formulae for these sauces are shown in Tables I, II, III respectively. Panel scores initially and after storage at 21°C.

and 32°C. for periods up to 3 months are given in Table IV. Results of consumer tests are shown in Tables V and VI. All samples had very little to little irradiation flavor. Consumer acceptance tests showed that the irradiated samples were less acceptable than the control. It was found that the use of dehydrated potatoes in place of corn starch in an original formula, was necessary from a consistency standpoint. The sauces containing dehydrated potatoes had a much better consistency after irradiation than those containing starch. The consistency of all the sauces prior to irradiation was normal.

Protein Hydrolysates

Pieces of choice grade rib-eye beef were stitch pumped 10% by weight with various concentrations of a liquid protein hydrolysis, (sauce LBH manufactured by Keratene Company, Inc. Winsted, Connecticut). Air at 30 pounds pressure was used as the propellent. The pumped beef was then sliced into 2.5 oz. steaks, fried in an electric frying pan until the temperature reached 165°F. and then packed three steaks per 300 X 200 can and sealed under 25 inches (gauge) of vacuum. Half of the cans contained added liquid beef gravy and half did not. A composition of the gravy is given in Table VII. The resulting steaks were graded by an expert panel. A statistical analysis of the individual scores on the amount of irradiation flavor indicated that there was a significant effect of the protein hydrolysate in the irradiated steaks on the amount of irradiation flavor noted. This was a linear effect to the decreasing amount of irradiation with increasing percentage of protein hydrolysate. There was a significant difference ($p > 0.95$) in the amount of irradiation flavor between 0 and 5% and 0 and 10%. The mean scores for the amount of irradiation flavor noted are shown in Table VIII.

In addition to the above, samples of sliced cow grade rib-eye beef were packed with Swift's liquid beef gravy containing 5% added 4BE protein hydrolysate (manufactured by the Nestle Company, Inc., White Plains, New York). The samples were previously roasted in ovens to an internal temperature 165°F., sliced, mixed with hot gravy and canned under a vacuum. Half of the samples were irradiated at the 4.5 megarad level and the other half held as non-irradiated controls. The samples were reheated and served hot to 100 male laboratory personnel. In the first test, 50 people evaluated a single sample of irradiated beef and 50 people evaluated the non-irradiated beef. In the second, the two groups of people evaluated the opposite sample. The products were scored for over-all acceptability using 9 point hedonic scale (1 = dislike extremely; 9 = like extremely). The non-irradiated sample had an average score of 6.7 and the irradiated sample 5.4. A statistical analysis of the data showed a significantly higher acceptance of the non-irradiated beef over the irradiated beef ($p > 0.95$).

Thickeners

Some tests were conducted in an attempt to develop a beef and gravy product with a gravy that would withstand irradiation without breaking down to a watery condition. There is evidence that the starch portion of the gravy is broken down during the irradiation. Beef stock for the gravy was made by grinding 10 lbs. of beef through a 3/16 inch plate, adding 0.05 lbs. of salt and 40 lbs. of water. After simmering for two hours, the meat and fat were drawn off, 27 grams caramel color added and the broth brought up to 40 lbs. with water. The various thickeners were added to the base stock. Three series of thickeners were tried. The formulations are shown in Table IX. Beef steaks that had been enzyme inactivated were placed in cans and filled with gravy at 90°C., vacuumized, chilled and irradiated with 4.5 megarads. The results of the tests showed that most of the gravies were watery, as compared with the controls. After irradiation and heating, only the sauce with waxy maize retained the gravy consistency.

Spices and Other Additives

A series of ground meat with spices added was prepared using a large variety of spices, individually or in combination. These samples were irradiated and then the flavor of the irradiated sample compared with the non-irradiated control. In most instances, the irradiation damaged the spice flavor, as well as adding an irradiation flavor. In Table IX is a list of the spices tried. Garlic, rosemary, cloves, mustard and thyme showed some promise, but no one spice or combination of spices tried was judged to be satisfactory.

Other additives tried included smoke flavor, imitation smoked bacon flavor, imitation barbecue spice, and various combinations. The results of these tests are shown in Table XI and XII.

Thermal Enzyme Inactivation

The general level of acceptability of irradiated beef steaks is reduced, because of the fact that the meat must be partially cooked in order to inactivate the naturally occurring enzymes, and reheated before serving. Even with beef which was not irradiated, the general level of acceptability was lower than that of fresh beef steaks. This condition can be compared to an over cooked, steam table or warmed-over piece of beef. To improve this aspect of beef steak quality we have evaluated steak preparation methods based on achieving enzyme inactivation at lower temperatures using longer holding times under controlled humidity. This process leaves the meat rare until the final cooking just before serving. As a guide to the proper time-temperature requirements for enzyme inactivation, we have used the data in "A Time-Temperature Relationship for Heat-Enzyme Inactivation of Radiation Sterilized Beef and Pork" by Charles James Chiambalero, et al., Ag. and Food Chem. 7 No. 11, p. 782 (1959). According to this report, the holding time required for enzyme inactivation varies from an extrapolated value 60 minutes at 57°C. to 6 minutes at 65°C. and 0.3 minutes at 77°C. A steak quality panel was set up and trained for

product evaluation using a 10-point hedonic scale for each of the qualities: flavor, tenderness, juiciness and texture. Freshly broiled choice round steaks were used as reference standards.

From the processing standpoint, the most practical way of obtaining low temperature enzyme inactivation would be to enzyme inactivate large pieces of meat (roast), slice, can and irradiate. The final cooking could then be done by broiling the slices before serving. Taste panel evaluations of "steaks" prepared from roasts enzyme inactivated at 60°C. for 30 minutes (at 61% relative humidity) are shown in Table XIII.

These results indicate that the steaks from the seared roast were less juicy but were otherwise better than the unseared product, and nearly as good as the control except for flavor and juiciness. However, the most important observation is the presence of "warmed over" or roast beef flavor rather than typical steak flavor. This method of processing, therefore, is not suitable for producing a product acceptable as a steak.

Experimentation indicated that a searing or surface broiling step was required prior to the enzyme inactivation step in order to produce a typical steak flavor in the meat. This surface searing was accomplished satisfactorily by inserting frozen steaks (5/8" to 1" thick) in a muffle furnace held at approximately 700°C. for 30 to 60 seconds. Under these conditions, the surface layer of 1 to 2 mm was broiled to a good appearance while the interior of the steak remained frozen. Higher furnace temperatures produced charring of the fat.

An inside round of U. S. Choice beef was sliced and trimmed into 5/8" thick steaks. Two-thirds of the steaks were charred by the method above and then enzyme inactivated by holding at 50% relative humidity in an oven. Set A was brought to an internal temperature of 57°C. and held 60 minutes, while set B was brought to an internal temperature of 65°C. and held for 15 minutes. These samples were then vacuum canned in 300 X 200 cans and frozen in liquid N_2. The remaining one-third of the steaks were broiled in an electric broiler to 77°C. internal temperature, vacuum canned, and then frozen in liquid N_2.

Samples enzyme inactivated by each of the three methods were then cooked, using two different methods, to a medium done condition for evaluation by the Steak Quality panel. One cooking method utilized a "Radar Range" and the other was standard oven broiling. Freshly broiled steaks were used as panel reference standards. Panel scores with their 95% confidence intervals are shown in Table XIV.

This data was analyzed as a 2 by 3 factorial experiment with four replications (panel sessions). The analysis of variance showed the following:

(1) Method of Cooking for Panel.

Regular broiling gave significantly (above 90% probability level) better scores than the Radar Range cooking in tenderness, texture and juiciness, while flavor scores were the same.

(2) Differences in Enzyme Inactivation Treatments.

No significant differences due to treatments were found in flavor or texture scores. Steaks enzyme inactivated at 57°C. were more tender (at the 90% confidence level) than the others, while steaks enzyme inactivated at 65°C. were significantly (+ 90% level) juicier than the others.

In terms of developing methodology for overcoming dryness in low temperature irradiated steaks, the superior juiciness of the 65°C. treatment becomes important and a survey of the scores in Table V suggests the conclusion that enzyme inactivation at 65°C. may give a superior product.

It should be noted that "roast beef" or "reheated" flavor was not observed in any of these samples.

Panel evaluations of seared, low temperature inactivated canned and reheated steaks inactivated at 57°C. and at 65°C. at both 50% and 90% relative humidity (Table XV) showed that relative humidity in this range had no significant effect on tenderness, texture, flavor or juiciness at 57°C. but the higher humidity produced a significant lowering of flavor scores and possibly reduced ($p > .50$) juiciness and tenderness scores at 65°C.

Steak thickness was shown to be an important factor in acceptability of steaks processed in the above manner, especially at the 65°C. inactivation temperature. The data in Table XVI show that tenderness, texture and juiciness of 65°C. inactivated (50% relative humidity) were significantly ($p > .95$) increased in going from 5/8" to 1" steaks. The same improvement was seen in fresh frozen steaks but the 57°C. (50% relative humidity) inactivated steaks were insensitive to steak thickness.

In summarizing the results of this study of steak preparation and enzyme inactivation variables we may conclude that thin steaks should be enzyme inactivated at 57°C. and 90% relative humidity after a preliminary surface searing and then reheated for serving in an oven broiler, while thick steaks should be processed at 65°C. and 50% relative humidity after surface searing and reheated for serving in an oven broiler.

Steaks prepared by either of these methods may be expected to be almost as good as broiled fresh frozen steaks in texture, tenderness, juiciness and flavor, and to be free of "roast beef" or "reheated" flavor.

LIST OF TABLES

TABLE I

BARBECUE SAUCE FORMULA

	%
Onions, dehydrated	0.15
Garlic paste (10% salt)	0.10
Vinegar (cider 40 grains)	3.52
Brown sugar	1.16
Mustard (dry)	0.15
Granulated sugar	1.75
Red pepper seeds	0.02
Bay leaf	0.01
Salt	1.55
Black pepper	0.02
Paprika	0.29
Worchestershire sauce	3.52
Tomato puree	30.19
Soft wheat flour	0.78
Corn starch	0.39
Smoke flavor - Charsol*	0.15
Water	56.26
	100.0%

*Red Arrow Company, Milwaukee, Wisconsin

The sauce is cooked to yield about 60% of formula weight.

TABLE II

BEEF SAUCE FORMULA

	%
Onions	0.29
Pearl onions	2.20
Garlic	0.15
Bay leaf	0.01
Salt	0.88
Black pepper	0.06
Beef extract	0.44
Potato flour	1.91
Flour	1.91
Color	0.04
Burgandy flavor*	0.59
Water	91.52
	100.00

*Vie-Del Grape Products Company, Fresno, California

The sauce is cooked to yield about 60% of formula weight.

TABLE III

MUSHROOM SAUCE FORMULA

	%
Onions, dehydrated	0.30
Pearl onions	2.25
Garlic	0.15
Bay leaf	0.01
Salt	0.90
Tomato paste	4.36
Black pepper	0.06
Mushrooms	6.76
Potato flour	4.21
Color	1.08
Burgandy flavor*	0.60
Water	79.32
	100.00

*Vie-Del Grape Products Company, Fresno, California

The sauce is cooked to yield about 60% of formula weight.

TABLE IV

IRRADIATION FLOUR INTENSITY SCORES ON IRRADIATED BEEF WITH VARIOUS SAUCES - ORIGINALLY AND AFTER STORAGE - 1 TO 6 SCALE (MEANS OF REPLICATE PANELS)

Storage		Sauce		
Time	Temperature °C.	Barbecue	Mushroom	Beef
Initial	21	2.1	2.3	2.1
	32	2.1	2.3	2.1
1 Week	21	1.8	2.1	2.6
	32	2.4	2.1	2.5
1 Month	21	2.9	2.6	2.3
	32	2.5	2.4	2.5
2 Months	21	2.7	2.3	2.5
	32	3.2	1.9	2.9
3 Months	21	2.1	2.1	2.6
	32	1.8	2.1	2.5
Average		2.36	2.22	2.46

TABLE V

CONSUMER ACCEPTANCE SCORES FOR 33 TESTERS ON IRRADIATED BEEF WITH VARIOUS SAUCES - 7-POINT HEDONIC SCALE

Sauce	Non-irradiated	Irradiated	95% Confidence Limit
Barbecue	5.56	4.41	± 0.30
Beef	5.58	4.29	± 0.30
Mushroom	5.09	4.79	± 0.30

TABLE VI

CONSUMER ACCEPTANCE SCORES FOR 16 TESTERS ON IRRADIATED BEEF WITH VARIOUS SAUCES - 9-POINT HEDONIC SCALE

Sauce	Non-irradiated	Irradiated
Barbecue	7.3	5.5
Beef	6.8	4.8
Mushroom	6.7	4.8

TABLE VII

FORMULA FOR GRAVY USED AROUND PUMPED STEAKS

	%
Primal beef plates	10.0
Fresh celery	.8
Fresh carrots	1.3
Waxy maize	3.0
Potato flour	1.3
Salt	1.2
4 BE* protein hydrolysate	1.2
Dry caramel	.15
Onion powder	.4
Worcestershire sauce	.1
Ground white pepper	.01
Water	81.54

*Produced by the Nestle Company, Inc., White Plains, N.Y.

TABLE VIII

MEAN SCORES FOR AMOUNT OF IRRADIATION FLAVOR OF STEAKS PUMPED 10% WITH A PROTEIN HYDROLYSATE PRIOR TO IRRADIATION

% Hydrolysate in Solution	Flavor Score	
	Without Gravy	With Gravy Added
0%	4.2	4.1
2	3.7	3.4
5	3.4	2.8
10	2.9	2.8

TABLE IX

THICKENERS USED WITH BEEF BASE STOCK

Thickeners	Concentration in Base Stock(%)
Corn Starch - American Maize	4
Corn Starch - American Maize	8
Soya Flour - A. E. Staley and Company	4
Gelatin - Swift & Company	4
Gwar Gum - General Mills	2
Methyl Cellulose - Dow Chemical Company	2
Hydroxy Cellulose QP 440V - Dow Chemical Company	4
Col Flo #67 - National Chemical Starch	4
Instant Clear Gel - National Chemical Stock	4
Purity Starch - National Chemical Starch	10
Corn Starch, Waxy Maize - American Maize Company	6
Corn Starch, Waxy Maize - American Maize Company	9
Corn Starch, Waxy Maize - American Maize Company	15

TABLE X

SPICES USED TO REDUCE IRRADIATION FLAVOR

	%
Allspice	0.08
Annis	0.08
Sweet basil	0.10
Black pepper	0.125
Caraway seed	0.16
Celery seed	0.125
Chili powder	0.125
Cloves	0.06
Cumin	0.125
Coriander	0.125
Curry powder	0.125
Dill seed	0.125
Fennel seed	0.08
Garlic powder	0.125
Mint leaves	0.25
Mustard powder	0.125
Onion powder	0.125
Oregano	0.125
Paprika	0.25
Rosemary	0.25
Sage	0.125
Savoy	0.25
Thyme	0.08

%		%		%		%
Cloves 0.06,	paprika	0.50				
Cloves 0.06,	paprika	0.50,	rosemary	0.25		
Cloves 0.06,	paprika	0.50,	rosemary	0.25,	celery seed	0.25
Paprika 0.50,	rosemary	0.25				
Paprika 0.50,	rosemary	0.25,	celery seed	0.25		
Paprika 0.50,	rosemary	0.25,	celery seed	0.25,	mustard	0.50
Rosemary 0.25,	celery seed	0.25				
Rosemary 0.25,	celery seed	0.25,	mustard	1.50		

TABLE XI

IRRADIATION FLAVOR INTENSITY SCORES OF GROUND BEEF WITH VARIOUS ADDITIVES - IRRADIATED AT 45 MEGARADS - 1 TO 6 POINT SCALE

	Irradiation Flavor Intensity Score (Mean of 4 panels) with 95% Confidence Level
3% Natural Smoke Flavor #V12.125	2.31 ± 0.40
1% Imitation Smoked Bacon Flavor #2306B	2.75 ± 0.40
0.125% Imitation Spice Flavor #V15.011	3.00 ± 0.40
1% Barbecue Spice Flavor #V9260	1.16 ± 0.40
No additive	2.81 ± 0.40

*International Flavors and Fragrances, Inc., Teterboro, New Jersey

TABLE XII

MEAN ACCEPTANCE VALUES OF CONSUMER TESTS ON GROUND BEEF WITH VARIOUS ADDITIVES - 7 POINT HEDONIC SCALE

	Score and 95% Confidence Level		
Additive*	4.5 Megarads	Non-irradiated	No. of Panel Members
3% Natural Smoke Flavor #V12.125	3.10 ± 0.34	5.12 ± 0.34	45
1% Imitation Smoked Bacon Flavor #2306B	2.77 ± 0.32	4.56 ± 0.32	54
0.125% Imitation Spice Flavor #V15.011	3.31 ± 0.34	5.12 ± 0.34	49
1% Barbecue Spice Flavor #V9260	3.31 ± 0.34	3.87 ± 0.34	50

*International Flavors and Fragrances, Inc., Teterboro, New Jersey

TABLE XIII

EVALUATION OF LOW TEMPERATURE PROCESSED STEAK PRODUCED FROM ENZYME INACTIVATED ROASTS

Evaluation Criteria	Mean Preference Scores (10 point scale) Seared	Not Seared	Control (freshly broiled)	95% Confidence Interval
Flavor	6.0	6.0	6.9	± 0.17
Juiciness	5.3	5.5	7.1	± 0.18
Tenderness	7.4	6.6	7.9	± 0.18
Texture	7.8	7.2	7.9	± 0.16
Comments	"warmed over" "roast beef"	"warmed over" "roast beef"		

TABLE XIV

EVALUATION OF LOW TEMPERATURE ENZYME INACTIVATED STEAKS REHEATED BY TWO METHODS (10-POINT HEDONIC SCALE)

Reheating Method	Panel Scores and 95% Confidence Interval			
	Broiled	Sear and 57°C	Sear and 65°C	95% C. I.
-Flavor				
Radar Range	6.4	6.3	6.6	) ± 0.20
Broiler	6.5	6.7	6.8	)
Juiciness				
Radar Range	5.3	4.5	5.2	) ± 0.26
Broiler	6.1	5.6	6.4	)
Tenderness				
Radar Range	5.7	6.0	5.8	) ± 0.22
Broiler	6.5	7.6	6.5	)
-Texture				
Radar Range	7.4	7.0	7.8	) ± 0.20
Broiler	7.9	8.1	7.8	)

TABLE XV

THE EFFECT OF RELATIVE HUMIDITY ON QUALITY OF STEAKS ENZYME INACTIVATED AT 57°C AND 65°C
(MEAN PANEL SCORES BASED ON A 10-POINT HEDONIC SCALE)

	Processing Conditions			
	Fresh Frozen	% Humidity	Deactivation Temperature	
			57°C	65°C
Tenderness	6.8	50	7.8	7.5
		90	8.1	7.0
	95% Confidence limits = ± .5			
Texture	9.0	50	8.8	8.4
		90	8.9	8.6
	95% Confidence limits = ± .4			
Flavor	8.2	50	6.7	6.9
		90	6.8	6.0
	95% Confidence limits = ± .4			
Juiciness	8.0	50	6.3	6.4
		90	6.8	5.9
	95% Confidence limits = ± .3			

TABLE XVI

THE EFFECT OF STEAK THICKNESS ON QUALITY OF LOW TEMPERATURE ENZYME INACTIVATED STEAKS
(MEAN PANEL SCORES USING A 10 POINT HEDONIC SCALE)

	Thickness	Fresh Frozen	Enzyme Inactivation Temperature	
			57°C	65°C
Tenderness	5/8"	5.6	6.1	5.5
	1"	6.7	6.5	6.8
	95% Confidence limits = ± 0.7			
Texture	5/8"	8.1	8.8	7.8
	1"	8.7	8.8	8.6
	95% Confidence limits = ± 0.6.			
Flavor	5/8"	6.9	6.8	6.4
	1"	8.7	6.0	6.7
	95% Confidence limits = ± 0.6			
Juiciness	5/8"	6.7	6.1	6.2
	1"	7.5	6.2	7.1
	95% Confidence limits = ± 0.6			

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*

U. S. Army Natick Laboratories

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b GROUP

3. REPORT TITLE

DEVELOPMENT OF READY-TO-EAT RATION TYPE BEEF ITEMS

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

5. AUTHOR(S) *(Last name, first name, initial)*

KAUFFMAN, F. L.
HARLAN, J. W.
SWIFT & COMPANY RESEARCH LABORATORIES

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
February 1965	21	0

8a. CONTRACT OR GRANT NO. DA19-129-QM-1897	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 7-84-01-002	FD-5
c.	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
d.	

10. AVAILABILITY/LIMITATION NOTICES

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Irradiated Food Products Branch, Food Division, U. S. Army Natick Laboratories, Natick, Massachusetts 01762

13. ABSTRACT

Beef cooked in barbecue sauce, beef sauce or mushroom sauce had reduced irradiation flavor compared to untreated controls and had a fair acceptability in consumer tests. Some spices added to beef resulted in a product having a lower over-all irradiation flavor, but no spice was found that was satisfactory. Protein hydrolysates pumped into the beef before slicing also lowered ultimate irradiation flavor.

Beef must be enzyme-inactivated in order to make it shelf-stable. This enzyme inactivation has been done by heating to 77°C and results in a partially cooked product. When it is reheated prior to serving it has a "warmed over" flavor that is not desirable. To improve this aspect of beef steak quality we have evaluated steak preparation methods based on lower temperatures for longer times. It was found that steaks heat-enzyme-inactivated at 65°C and 50% relative humidity for 15 minutes, or at 57°C and 90% relative humidity for 60 minutes, had a greatly reduced "warmed over" flavor.

DD FORM 1 JAN 64 1473

Unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Enzyme inactivation	8					
Beef	1		9			
Radiation sterilization	10					
Containers	5					
Storage stability	4					
Taste tests			8			
Food additives			5			
Irradiation flavor			3			

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