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NUTRITIVE VALUE OF IRRADIATED TURKEY
II. VITAMIN LOSSES AFTER IRRADIATION AND COOKING

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NUTRITIVE VALUE OF IRRADIATED TURKEY[1]

by

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Food Preservation is accomplished primarily by heat, dehydration, freezing, and chemical preservatives. More recently, the sterilization of foods has been effected by the use of ionizing radiations.

Numerous investigations have been undertaken to determine the effect of ionizing radiation on the nutritive quality of food (1-6). This paper will report the thiamine, riboflavin, and niacin content of irradiated and non-irradiated turkey both before and after cooking.

PROCEDURE

Experiments were conducted to compare the effects of 0,2, 3 and 6 megarep radiation doses from gamma rays of spent fuel rods on the vitamin content of turkey. The samples used for this investigation have been described previously (7). A homogeneous mixture of raw turkey was hand packed into 307 by 409 tin cans and the cans sealed under 20 in. vacuum before freezing. Samples were irradiated in the frozen state and stored with non-irradiated samples at -20°F. until tested. On opening the cans, the characteristic acrid or "burnt" odor developed during irradiation was observed, being more pronounced with greater radiation dosage. Irradiated samples were distinctly more pink than non-irradiated samples and the ground particles were less cohesive.

For cooking, the ground raw turkey was divided into 3-lb. lots and formed into loaves of 2-in. thickness. In Experiment 1, the turkey was taken directly from refrigeration for roasting; samples were allowed to reach room temperature prior to roasting in Experiment 2. A thermometer was inserted into the center of each loaf and the loaf allowed to cook in an open pan until the internal temperature of the loaf reached 175°F. A post-oven rise in temperature of 8° to 10°F. was observed in all loaves.

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[2]With the technical assistance of Belle Rosler.

Weight losses on cooking were determined in all cases. The raw turkey was weighed before cooking started. At the end of the cooking period, the meat with its accumulated drippings was immediately weighed in the cooking pan to determine volatile losses. The turkey was then removed from the pan and the weight of the drippings determined. The sum of the volatile and dripping losses gave the total cooking losses. All turkey samples and the drippings from cooked samples of Experiment 2 were analyzed for moisture and fat as well as vitamin content.

Thiamine was determined by the thiochrome method; riboflavin by the fluorometric procedure and niacin by microbiologic assay (8). Moisture and fat content were determined by the Association of Official Agricultural Chemists (9) method and a modified A. O. A. C. method (10), respectively.

RESULTS AND DISCUSSION

The cooking losses were the same for irradiated and non-irradiated turkey though greater in Experiment 1 than Experiment 2 (Table 1). The greater cooking losses may be attributed to the longer cooking time required for the internal temperature of samples started at 32°F. to reach 175°F. In Experiment 2, cooking losses were greater in irradiated turkey than in non-irradiated turkey. As would be expected, volatile losses increased with cooking time. Although volatile losses were less in irradiated samples, dripping losses were greater. Since the ground particles of irradiated turkey were less cohesive than those of non-irradiated turkey, the rate of heat penetration into the loaves was increased, resulting in the shorter cooking period and the greater dripping loss.

The effect of radiation on the thiamine, riboflavin, and niacin content of turkey is shown in Table 2. As the radiation dose increased from 2×10^6 to 6×10^6 rep, thiamine retention decreased from 36 to 10 per cent. Retention of riboflavin was considerably greater. In samples treated with 2×10^6 rep, 94 per cent of the riboflavin was retained; increasing the dose to 6×10^6 rep resulted in 83 per cent retention. Niacin in turkey was unaffected by radiation doses up to 6×10^6 rep.

Although the thiamine losses obtained are of greater magnitude than reported for turkey by Proctor (11), a similar degree of radiosensitivity of thiamine in beef and pork has been reported by Tappel (12, 13). It should be pointed out that these data indicate results obtained using gamma irradiation from spent fuel rods, whereas Proctor's study reports results from high voltage cathode rays. The heat-labile properties of thiamine in food are affected not only by the amount and nature of the product, but the time and temperature of the "processing" operation. The literature reports (Table 2) that the retention of thiamine in meat products after heat-processing varies from 13 to 76 per cent. Therefore, it is likely that thiamine retention in separate studies might vary. On the other hand, the 94 per cent retention of riboflavin in turkey after treatment with 2×10^6 rep agrees favorably with the 96 per cent retention in turkey after treatment with 2.5×10^6 rep obtained by Proctor (11). That niacin is not affected by irradiation has been

reported by other workers (11-14). However, during heat-processing, the retention of niacin has been found to vary from 71-100 per cent (Table 2).

In general, the use of irradiation for sterilization was found to be similar to heat-processing in its effects upon thiamine, riboflavin, and niacin in meat products (15-18).

The vitamin content of raw and cooked turkey is shown in Tables 3 and 4. In Experiment 1, pan drippings collected from single loaves were insufficient to obtain analyses for moisture and fat in addition to vitamin analyses. However, sufficient sample for all analyses was provided by the twelve individual loaves per treatment used in Experiment 2. Vitamin retention in Experiment 2 has been calculated on the basis of the total sample. All data have been corrected to a dry, fat-free basis.

Cooking losses of thiamine in irradiated and non-irradiated turkey were greater in Experiment 1 than the corresponding sample in Experiment 2. The greater losses encountered in Experiment 1 may be attributed to the longer cooking period (Table 1) required by these samples to reach an internal temperature of 175°F. Although only 74 per cent retention of thiamine was obtained in non-irradiated turkey cooked for the longer period, 96 per cent retention was found in samples cooked for the shorter period. When irradiation doses of increasing intensity were compared, it was noted that thiamine loss during cooking increased with the radiation dose.

The amount of thiamine recovered in the drippings was the same for turkey treated with 3×10^6 rep as for the non-irradiated turkey and slightly less at the higher irradiation dose (Table 5). Only in the sample of non-irradiated turkey was the entire diminution in the thiamine content during cooking attributable to the pan drippings.

No appreciable difference was found in the retention of riboflavin during cooking of non-irradiated and irradiated turkey, regardless of the radiation dose. Analyses of pan drippings indicated that the leaching of the vitamin from the meat into the pan drippings accounted for all the apparent loss of riboflavin.

In Experiment 1, there was no difference in the retention of niacin during cooking of irradiated and non-irradiated turkey. In Experiment 2, losses of niacin were greater during cooking of irradiated turkey, and no additional loss was obtained by increasing the irradiation dose. However, for both irradiated and non-irradiated samples, the decrease in niacin content could be accounted for by the quantity recovered in the drippings.

SUMMARY

The thiamine, riboflavin, and niacin content of irradiated and non-irradiated turkey was determined both before and after cooking. Thiamine was severely affected by gamma irradiation doses of 2, 3, and 6×10^6 rep,

the destruction increasing from 65 to 90 per cent with the increase in dose. Riboflavin was more resistant to irradiation than thiamine. A loss of 6, 14, and 17 per cent riboflavin occurred after turkey was treated with 2, 3, and 6 megarep, respectively. Niacin was not affected by irradiation.

After cooking, the retention of thiamine in irradiated turkey was less than in non-irradiated turkey. The amount of thiamine in cooked turkey decreased with the intensity of the irradiation dose. There was no difference in the amount of riboflavin retained in either irradiated or non-irradiated turkey. Retention of niacin was slightly less in irradiated turkey.

Analyses of pan drippings indicated that only thiamine was destroyed by heat, as all loss of riboflavin and niacin in turkey was recovered in the drippings.

In general, the use of irradiation for sterilization was found to be similar to heat processing in its effects upon thiamine, riboflavin, and niacin in meat products.

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TABLE 1

SUMMARY OF COOKING DATA

TREATMENT of TURKEY	WEIGHT		TIME	COOKING LOSSES					
	Raw	Cooked		Volatile		Drippings		Total	
Experiment 1*									
	gm.	gm.	min./lb.	gm.	%	gm.	%	gm.	%
No irradiation	1362	980.6	26	324.4	24	57.0	4	381.4	28
Irradiated at 2×10^6 rep	1362	994.3	22	269.7	19	98.0	7	367.7	27
Experiment 2**									
No irradiation	1362	1289	19	34.9	2	38.1	3	73	5
Irradiated									
3×10^6 rep	1362	1233	18	26.2	2	102.8	8	129	9
6×10^6 rep	1362	1184	16	17.8	1	160.2	12	178	13

*Initial internal temperature of samples was approximately 32°F.

**Initial internal temperature of samples was approximate 78°F; values represent average of twelve loaves.

TABLE 2

EFFECT OF IRRADIATION AND HEAT-PROCESSING ON VITAMIN CONTENT OF VARIOUS MEAT PRODUCTS

FOOD	TREATMENT	THIAMINE RETENTION %	RIBOFLAVIN RETENTION %	NIACIN RETENTION %	SOURCE OF DATA
Turkey	irradiated				
	2×10^6 rep	36	94	100	this study
	3×10^6 rep	12	86	104	this study
	6×10^6 rep	10	83	98	this study
	2.5×10^6 rep	88	103	-	Proctor (11)
	heat-processed	88	96	-	Proctor (11)
Beef	irradiated				
	1×10^6 rep	76	90	100	Tappel (12,13)
	3×10^6 rep	21	-	70	Tappel (12,13)
	85 min. at 250°F.	13-24	171-278	-	Mayfield et al.(15)
	60 min. at 240°F.	35-37	213-280	-	Mayfield et al.(15)
Pork	irradiated				
	1×10^6 rep	84	-	93	Tappel (13)
	3×10^6 rep	12	52-79	78	Tappel (13)
Other meat products					
Luncheon meat	heat-processed	43-67	100	100	Rice et al. (16)
Luncheon meat	heat-processed	38-76	67-95	71-89	Greenwood et al.(17)
Luncheon meat	heat-processed	50	110	89	Brenner (18)
Chopped ham	heat-processed	68	90	94	Rice (16)
Beef and gravy	heat-processed	25	147	84	Brenner (18)
Pork sausage	heat-processed	40	133	88	Brenner (18)
Beef & pork loaf	heat-processed	40	106	89	Brenner (18)
Corned beef hash	heat-processed	50	140	92	Brenner (18)

TABLE 3

EFFECT OF COOKING ON VITAMIN CONTENT AND RETENTION OF IRRADIATED AND NON-IRRADIATED TURKEY (DRY FAT-FREE BASIS)

Experiment 1

Irradiation Dosage	THIAMINE			RIBOFLAVIN			NIACIN		
	Raw	Cooked	Retention	Raw	Cooked	Retention	Raw	Cooked	Retention
Mega-rep	mg./ 100 gm.	mg./ 100 gm.	%	mg./ 100 gm.	mg./ 100 gm.	%	mg./ 100 gm.	mg./ 100 gm.	%
0	0.264	0.196	74	0.690	0.656	95	32.9	28.4	86
2	0.094	0.060	64	0.650	0.668	103	33.0	27.4	83

TABLE 4

EFFECT OF COOKING ON VITAMIN CONTENT OF IRRADIATED AND NON-IRRADIATED TURKEY (DRY, FAT-FREE BASIS)

Experiment 2

Irradiation Dosage	THIAMINE			RIBOFLAVIN			NIACIN		
	Raw	Cooked	Drippings	Raw	Cooked	Dripping	Raw	Cooked	Drippings
On Basis of Milligrams per 100 Gm.									
0	0.224	0.228	0.760	0.600	0.602	1.75	25.8	25.6	68.9
3	0.026	0.021	0.033	0.518	0.565	1.33	26.8	24.6	66.2
6	0.022	0.014	0.008	0.499	0.518	0.972	25.4	23.3	67.0
On Basis of Milligrams per Total Loaf									
0	3.05	2.94	0.290	8.17	7.76	0.667	351.4	330.0	26.2
3	0.354	0.259	0.034	7.06	6.97	1.37	365.0	303.3	68.0
6	0.300	0.166	0.013	6.80	6.13	1.56	345.9	275.9	107.3

TABLE 5

VITAM RETENTION OF COOKED IRRADIATED AND NON-IRRADIATED TURKEY (DRY, FAT-FREE BASIS)

Irradiation Dosage	THIAMINE RETENTION			RIBOFLAVIN RETENTION			NIACIN RETENTION		
	Meat %	Drippings %	Total %	Meat %	Drippings %	Total %	Meat %	Drippings %	Total %
0	96	10	106	95	8	103	94	7	101
3	73	10	83	99	19	118	83	19	102
6	55	4	60	90	23	113	80	31	111