

eral components of these respective materials are the same, our experiments would suggest a better utilization of the finely divided (pureed) material by the animal.

We wish to acknowledge the kindness of Dr. G. A. Fisher of the Van Camp Packing Company in supplying the spinach and apricots for this investigation. All material was sealed in lacquered tin cans. No evidence of corrosion could be detected nor was it indicated by the following analysis:

June 23, 1931, Canned Pureed Spinach	Fe = 0.001820%
Feb. 20, 1932, Canned Leaf Spinach	Fe = 0.001852%
Feb. 20, 1932, Above Spinach Hand Pureed	Fe = 0.001829%
Oct. 4, 1931, Canned Pureed Spinach	Cu = 0.000250%
Feb. 25, 1932, Canned Leaf Spinach	Cu = 0.000236%
Feb. 25, 1932, Above Spinach Hand Pureed	Cu = 0.000246%

All material was from the same original factory batch.

## 6072

### Nutritional Value of Proteins as Influenced by Exposure to Ultra-violet Irradiation.\*

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The experiments described below include (A) *in vitro* digestion experiments on irradiated and non-irradiated proteins with pepsin and trypsin respectively and (B) growth and metabolism studies on rats kept on low protein diets where the protein was either irradiated or non-irradiated.

#### A. *In vitro* Digestion Experiments on Irradiated and Non-irradiated Purified Proteins with Pepsin and Trypsin, Respectively.

1. Tryptic Digestion of Casein. The irradiated product was prepared by exposing dry casein (Merck according to Hammarsten) for 2½ hours at a distance of 18 inches to the mercury quartz lamp in a current of air. The digestion experiments with irradiated and non-irradiated casein were carried out as described by Helmer.<sup>1</sup> At the end of the digestion period the undigested protein was precipitated and the refractive indices of the filtrates read.

\* These researches were supported in part by the Quaker Oats Company.

<sup>1</sup> Helmer, Oscar, Doctor of Philosophy Dissertation, September, 1927, 10, University of Chicago.

As shown in Table I, the non-irradiated casein is somewhat better digested than the irradiated. The refractive index readings were confirmed by actual determination of nitrogen in the filtrates.

TABLE I.  
Tryptic Digestion of Irradiated and Non-irradiated Casein as Measured by Changes in Refractive Index and Soluble Nitrogen on Isoelectric Acetic Acid Filtrates.

Mgm. U.S.P. Pancreatin	Refractive Index Readings				Changes in Refractive Index				Mgm. N in 10 cc. filtrate			
	Irrad. 2½ hr.		Non-irrad.		Observed		After cor. for blank		Irradiated		Non-irrad.	
	0 hr.	4 hr.	0 hr.	4 hr.	Irrad.	Non Irrad.	Irrad.	Non	Cor.	Cor.	Cor.	Cor.
	Experiment IV											
0	16.49	16.55	16.52	16.8	0.06	0.28			0.31			0.41
4	16.5	18.57	16.52	19.0	2.07	2.48	2.01	2.20	1.39	1.08	1.68	1.27
8	16.5	20.6	16.52	21.1	4.1	4.58	4.04	4.3	2.22	1.91	2.74	2.33

2. Peptic Digestion of Egg-White. Dried egg-albumin was prepared and digestion experiments carried out according to the method described by McMeekin and Freeland.<sup>2</sup> A portion of the dried, powdered material was irradiated for 4 hours in a current of air; the longer irradiation period being used because of the coarse physical state of the protein. Here again the amount of digestion was slightly greater for the non-irradiated protein than for the irradiated (Table II).

TABLE II.  
Peptic Digestion of Irradiated and Non-irradiated Coagulated Egg White as Measured by Changes in Refractive Index and Soluble Nitrogen on the Acid Solution.

1:3000 U.S.P. Pepsin	Refractive Index Readings				Changes in Refractive Index				Mgm. N in 10 cc. filtrate			
	Irradiated		Non-irrad.		Corrected		Irradiated		Non-irrad.		Cor.	
	2 hr. dig.	4 hr. dig.	2 hr. dig.	4 hr. dig.	Irrad.	Non-irrad.	Irrad.	Non-irrad.	Cor.	Cor.	Cor.	Cor.
0		15.24		15.15					0.3			0.21
1 mgm.		15.95		15.85	0.71	0.7	3.5	3.2	4.0	3.79		
3 mgm.		16.88		16.93	1.64	1.78	8.6	8.3	10.1	9.89		
0	15.05		14.87				0.21		0.13			
1 mgm.	15.35		15.48		0.3	0.61	1.65	1.44	1.93	1.8		
3 mgm.	15.6		16.1		0.55	1.23	4.32	4.11	5.13	5.0		

## B. Growth and Metabolism Studies on Rats Kept on Diets Low in Irradiated and Non-irradiated Proteins.

1. Group Experiments. In spite of the very slight differences in digestibility between the irradiated and non-irradiated proteins, the

<sup>2</sup> Freeland, Milnor, Doctor of Philosophy Dissertation, March, 1931, 9. T. L. McMeekin, unpublished data.

final test of actual feeding experiments was obviously the next step. In the usual laboratory diet the protein was reduced to 9% in the hope that at this minimal protein level, slight variations in growth curves could be demonstrated. Four animals, all litter-mates, were given the irradiated casein diet and 4 the non-irradiated. The animals receiving irradiated protein maintained an average weight-curve distinctly superior to those on the non-irradiated casein. Moreover, when the diets were cross-substituted, the growth curves after a short lag, also crossed.

TABLE III.

Tabulation of Results on Metabolism Studies Involving the Feeding of Irradiated and Non-irradiated Casein.

Four rats were studied independently at the same time on each diet. The figures given in this table are the average values. The diets consisted of irradiated or non-irradiated casein 9%, lard 10%, butter fat 15%, salt mixture 4%, dried yeast 5%, corn starch 57%. The casein was irradiated for 2 hours by a Cooper-Hewitt quartz mercury arc lamp at a distance of 40 cm. in a current of air.

Week	Average Gain in weight		Gm. Food Eaten per gm. Gain		Mgm. N Elim- inated per gm. Body Wt.		Mgm. N Elim- inated per gm. Food Eaten	
	Irrad.	Non-irrad.	Irrad.	Non-irrad.	Irrad.	Non-irrad.	Irrad.	Non-irrad.
First	8.5	7.25	4	5.7	2.07	1.9	3.02	2.52
Second	6.75	4.25	5.4	6.9	3.02	2.64	4.66	4.61
Third	5.5	4.75	5.7	6.0	3.61	3.6	7.21	6.6
Fourth	7	5	4.9	5.6	4.0	3.9	8.07	8.3

2. Individual Metabolism Studies. Finally, to determine whether the improved weight-gain resulting from irradiation of the protein was a result of better nitrogen-retention, metabolism experiments were carried out on individual rats. Four male rats were used for each diet and placed in individual cages. With slight modifications the method of Still and Koch<sup>3</sup> was used for weighing the food and collection of urine and feces. The results are tabulated in Table III.

Average data for the group are given. During the 4 weeks of experiment beginning with the second day after weaning, the gain in weight for the rats receiving irradiated casein was from 0.75 to 2 gm. greater than for those receiving the non-irradiated protein, and at the same time the average food consumption per gm. gain in weight was from 0.3 to 1.7 gm. less on irradiated casein than on non-irradiated. There was no corresponding greater retention of nitrogen, however. The improved weight-gain, therefore, cannot be ascribed to a more economical utilization of the nitrogen.

The limited number of experiments run seems to warrant the fol-

<sup>3</sup> Still, E. U., and Koch, F. C., *Am. J. Physiol.*, 1928, **87**, 225.

lowing tentative conclusions: Irradiation of 2 proteins, casein, and egg-white, in the dry, solid state changes them so that digestion *in vitro* by pepsin and trypsin are slightly inhibited. Metabolism experiments on young male rats, on the other hand, demonstrate a slightly higher body-weight when the protein fraction is irradiated. Since the nitrogen-retention on the low protein diet is slightly less for the irradiated than for the non-irradiated protein, the improvement of the body-weight curve appears to be due to something other than improved utilization of the protein. Vitamin D as an antirachitic agent is ruled out since the diet contains an ample supply for that purpose. Some other factor, stimulating in character is suggested.

## 6073

**Further Studies on Etiology of Goiter with Particular Reference to the Action of Cyanides\***

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The *immediate* cause of thyroid hyperplasia in all probability is a *relative* or an *absolute* deficiency of iodine.<sup>1</sup> The fundamental or essential cause of goiter is unknown, but the search for the essential cause, as we have often suggested, appears to resolve itself into determining the cause or causes of the iodine deficiency. As most iodine deficiencies are relative rather than absolute, the search further limits itself largely to determining the factors which create the increased needs of the organism for the iodine containing hormone. The simplest way of increasing the need of the thyroid for iodine would be by depressing the utilization of oxygen in the tissues, and the discovery by Chesney and Webster<sup>2</sup> that the prolonged feeding of cabbage caused thyroid hyperplasia in rabbits appeared to offer a practical means of testing this hypothesis.

It has been shown that there are great seasonal and climatic variations in the goitrogenic activity of cabbage,<sup>3</sup> that drying in a current

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\* Aided by a grant from the Ella Sachs Plotz Foundation.

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<sup>1</sup> Marine, D., *Arch. Int. Med.*, 1923, **32**, 811.

<sup>2</sup> Chesney, A. M., Clawson, T. A., and Webster, B., *Bull. Johns Hopkins Hosp.*, 1928, **43**, 261.

<sup>3</sup> Webster, B., Marine, D., and Cipra, A., *J. Exp. Med.*, 1931, **53**, 81.