

## Loss of Carbohydrate Metabolism Factor During Boiling of Vegetables.\*

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Abnormally high respiratory quotients during carbohydrate assimilation are given by rats that have been maintained for a number of months on a fat-deficient diet.<sup>1,2</sup> These high quotients, a large proportion of them above 1, have been attributed to a lack, in the fat-deficient diet, of an accessory factor that is necessary for normal carbohydrate metabolism.<sup>1,2</sup>

In the present paper it will be shown that rats maintained for 3 months or longer on a diet of boiled vegetables give carbohydrate RQ's that are abnormally high as compared with animals on a stock diet. This is interpreted as indicating that the boiled vegetable diet is likewise deficient in this carbohydrate metabolism factor. As it has previously been shown<sup>1,†</sup> that raw vegetables and fruits apparently possess a high content of this factor, it now becomes evident that a loss of this factor takes place during the boiling of vegetables. That this is the case is confirmed by feeding rats that show the abnormal carbohydrate metabolism the same vegetable diet, but autoclaved instead of boiled. The effect of the autoclaved diet on these rats will be shown to be similar to that obtained by feeding the ether-soluble substances extracted from raw vegetables and animal fats in previous investigations.<sup>1,2,†</sup> namely, the restoration of the carbohydrate assimilatory RQ's to nearly normal.

*Diets. Boiled vegetable diet.* A minced mixture of 2 parts by weight of potatoes, 1 part of carrots, and 1 part of string beans, to which was added 0.25% NaCl and a surplus of tap water, was

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<sup>1</sup> Wesson, L. G., *J. Biol. Chem.*, 1927, **73**, 507.

<sup>2</sup> Wesson, L. G., and Burr, G. O., *J. Biol. Chem.*, 1931, **91**, 525; Wesson, L. G., *J. Biol. Chem.*, 1933, **100**, 365; Wesson, L. G., and Murrell, F. C., *J. Biol. Chem.*, 1933, **102**, 303; *PROC. SOC. EXP. BIOL. AND MED.*, 1934, **31**, 1118.

† Previously unpublished data supporting this statement: Using a group of 4 rats in each case, the average maximum carbohydrate assimilatory RQ before dosing with approximately 0.3 g of the ether-soluble substances of raw potato was 1.08, after dosing it was 0.97; of raw carrot, 1.05 before dosing, and 0.89 after dosing; of raw apple, 1.05 before, and 1.01 after dosing.

actively boiled, with frequent stirring, for 8 hr in an open saucepan. At the end of that time, the mixture was of a pasty consistency, and of somewhat less than the original volume. Before the mixture cooled, 10 ml of an aqueous 5% solution of Na benzoate per 500 ml (0.1%) was stirred into it. It was then refrigerated until fed to the rats. In addition to the boiled vegetable mixture *ad libitum*, approximately 0.5 g of ether-extracted brewers' yeast per rat was fed daily during most of the work.

*Autoclaved vegetable diet.* The same vegetable mixture that was used in the preparation of the boiled vegetable diet, without the addition of water, was heated in sealed jars for 4 hr at 15 lb steam pressure.

*Procedures.* The respiratory exchange was determined by the use of a closed-circuit calorimeter of the type previously employed for this purpose.<sup>3</sup> The dextrin test meal following 18 to 20 hr of fasting was the same as that described in previous papers on this subject.<sup>2,3</sup>

*Results.* Six male and 5 female rats, 6 months old, were used. Approximately 3 months' feeding of the boiled vegetable diet was required before the first indication of abnormality in the carbohydrate metabolism was observed. This abnormality is shown in Table I by a significant difference between the carbohydrate assimilatory RQ's of these 11 rats and the corresponding RQ's of rats on a stock diet. The high RQ's are distinctly abnormal and are similar to those of rats on a fat-deficient, purified diet.<sup>2</sup>

In Table II are given the average carbohydrate RQ's of 6 of the abnormal rats before and after 7 days' feeding of the autoclaved diet. These values show that a marked lowering of the RQ's is

TABLE I.  
RQ's Following Dextrin Test Meals with Rats on a Stock Ration and on a Boiled Vegetable Diet.

Time after test meal hr	Stock ration <sup>3</sup> 10 runs on 10 rats			Boiled vegetable diet 82 runs on 11 rats		
	Mean RQ	RQ's > 1.00 No.	Max.	Mean RQ	RQ's > 1.00 No.	Max.
1.5	.90 ± .06*	0	1.00	1.00 ± .005	31	1.09
2.5	.91 ± .02	0	1.00	1.01 ± .004	50	1.09
3.5	.89 ± .02	0	0.99	1.03 ± .005	59	1.11
4.5	.88 ± .02	0	1.00	1.01 ± .007	58	1.11
5.5	.85 ± .02	0	1.00	0.94 ± .009	17	1.04

\*Standard deviation of the mean.

<sup>3</sup> Wesson, L. G., *J. Nutr.*, 1931, **3**, 503.

TABLE II.  
Lowering of Abnormal Dextrin RQ's of 6 Rats on a Boiled Vegetable Diet, Followed by 7 Days' Feeding of the Autoclaved Diet.

Time after test meal hr	Boiled vegetable diet 6 runs on 6 rats			Autoclaved vegetable diet 6 runs on 6 rats		
	Mean RQ	RQ's > 1.00 No. Max.		Mean RQ	RQ's > 1.00 No. Max.	
1.5	1.02 ± .02	3	1.08	.93 ± .02	1	1.01
2.5	1.02 ± .01	5	1.07	.94 ± .02	0	0.98
3.5	1.07 ± .01	6	1.11	.95 ± .01	0	0.98
4.5	1.01 ± .02	5	1.04	.97 ± .02	1	1.01
5.5	0.90 ± .02	0	0.99	.94 ± .01	0	0.98

produced by the autoclaved diet, similar to the effect of animal fats and of the ether-soluble substances of raw vegetables and fruit.<sup>1, 2, †</sup>

*Conclusions.* A loss of the carbohydrate metabolism factor takes place during the boiling of vegetables in an open vessel. This makes plausible the possibility that some deficiency of this factor occurs in many human dietaries. Since its lack causes abnormal fat formation and a disturbance of the carbohydrate metabolism of rats, it seems reasonable to consider a possible dietary deficiency of this factor in the study of prediabetic obesity.

*Summary.* Abnormally high respiratory quotients during carbohydrate assimilation are given by rats that have been maintained on a diet of boiled vegetables. This indicates a loss of an appreciable part of the carbohydrate metabolism factor which the vegetables contain in the unboiled condition.

The question is raised as to a possible causative connection of a dietary deficiency of this factor with prediabetic obesity.