appearance. Control rabbits were fed with steamed pressed cabbage cake from the same lot of cabbage without drying.

The principal data are given in Table I.

TABLE I.

| Sex | Weight at Beginning | Preparation Number | Amount Fed per day gm. | No. days Fed | Weight at End | Condition of Thyroid |
|---|---|---|---|---|---|---|
| M | 1200 | 1 | 41* | 26 | 1365 | Normal |
| F | 1128 | 1 | 38* | 26 | 1227 | Normal |
| M | 2260 | 2 | 53* | 21 | 2206 | Normal |
| F | 2300 | 2 | 53* | 21 | 2351 | Normal |
| F | 1845 | Control | 214* Pressed cake | 18 | 1703 | Moderate hyperplasia |
| F | 2290 | Control | 266* Pressed cake | 18 | 2175 | Moderate hyperplasia |

* Supplementary diet of 17 gm. oats and 20 gm. alfalfa hay twice weekly.

These experiments indicate that cabbage loses its goitrogenic quality when dried by the methods indicated.

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## Effect of Acid and Alkaline Hydrolysis on the Goitrogenic Substance Contained in Cabbage.

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Further studies have been carried out in an effort to determine the nature of the goiter-producing substance contained in cabbage and other vegetables.[1, 2]

It was first considered advisable to attempt to find out whether or not this goiter-producing factor was soluble in water. Cabbage was steamed for 30 minutes, hashed and pressed until 50% of the total weight had been removed. The residue thus obtained had previously been shown[2] to contain a considerable proportion of the goiter-producing substance. Samples of this residue were washed with one and two volumes of water respectively, at room temperature and the water removed by pressing. As shown in the accom-

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[1] Webster, Bruce, and Chesney, A. M., *Am. J. Path.*, 1930, vi, 275.

[2] Marine, D., Baumann, E. J., and Cipra, Anna, PROC. SOC. EXP. BIOL. AND MED., 1929, xxvi, 822.

panying table, no marked change in the goiter-producing power occurred in either instance. Similarly, boiling the above residue for 15 minutes in 2 volumes of water, and pressing to its original weight did not materially alter its goitrogenic power.

Studies were then made of the effect on the goitrogenic power of cabbage of extracting with water at various hydrogen ion concentrations. The fraction which remained, after removal of 50% of the total weight as juice, from steamed hashed cabbage, was allowed to stand for 15 minutes at room temperature in 2 volumes of water to which sufficient hydrochloric acid had been added to bring the pH of the mixture to 3.0. The water was then pressed

TABLE I.

| Rabbit No. and Sex | Cabbage Lot No. | Method of Treatment of Cabbage Cake | Duration of Feeding in Days | Condition of Thyroid Gland at Termination |
|---|---|---|---|---|
| 847 F | 21 | Extracted for 15 minutes | 23 | Moderate hyperplasia |
| 848 F | 21 | at room temperature with 2 vol. water. Pressed to original weight. | 23 | " " |
| 865 M | 21 | Boiled for 15 minutes | 21 | " " |
| 866 F | 21 | with 2 vol. water. Pressed | 21 | " " |
| 863 M | 22 | to original weight. | 21 | " " |
| 902 M | 22 | " | 21 | " " |
| 759 F | 9 | Extracted with 2 vol. | 18 | Marked " |
| 791 F | 9 | water at pH 3.0 at room | 23 | " " |
| 826 M | 9 | temp. for 15 minutes. Pressed to original wgt. | 23 | Moderate " |
| 849 F | 21 | Boiled with 2 vol. water | 23 | Marked " |
| 850 F | 21 | at pH 3.0 for 15 minutes. | 23 | " " |
| 869 M | 21 | Pressed to original wgt. | 21 | " " |
| 870 F | 21 | " | 21 | " " |
| 847 F | 23 | " | 19 | " " |
| 903 M | 23 | " | 19 | Moderate " |
| 871 M | 21 | Boiled with 2 vol. water | 21 | Marked " |
| 872 F | 21 | at pH 3.0 for 30 minutes. Pressed to original wgt. | 21 | " " |
| 873 M | 21 | Boiled with 2 vol. water | 21 | Moderate " |
| 874 F | 21 | at pH 3.0 for 60 minutes. | 21 | |
| 773 M | 21 | Pressed to original wgt. | 21 | " " |
| 885 M | 21 | " | 21 | " " |
| 851 F | 21 | Extracted with 2 vol. | 23 | Slight " |
| 852 F | 21 | water at pH 9.0 at room temp. for 15 minutes. Pressed to original wgt. | 23 | " " |
| 867 M | 21 | Boiled with 2 vol. water | 21 | Moderate " |
| 868 F | 21 | pH 9.0 for 15 minutes. Pressed to original wgt. | 21 | Slight " |
| 853 F | 21 | Control. Untreated cab- | 21 | Moderate " |
| 854 F | 21 | bage cake. | 21 | " " |
| 861 M | 22 | " | 21 | " " |
| 901 M | 22 | " | 21 | Slight " |

All animals in this experiment were given a supplementary diet of 17 gm. oats and 20 gm. alfalfa hay twice weekly.

out and the residue fed to rabbits. Such a procedure invariably produced a definite increase in the goiter-producing power of the cabbage. Boiling the cabbage in 2 volumes of water at pH 3.0 for 15 minutes further increased its goitrogenic power. Boiling at pH 3.0 for 30 minutes gave no detectable improvement over boiling for 15 minutes. Boiling for one hour, on the other hand, tended to decrease, but not to destroy entirely, its ability to produce thyroid hyperplasia. The results of the above experiments are summarized in the accompanying table. The feeding of equivalent amounts of hydrochloric acid to control animals did not produce goiter.

Attempts were made to study the effect of extracting the cabbage at pH 9.0. Since it has been shown[3] that the feeding of excessive amounts of alkali will, in itself, produce thyroid hyperplasia in animals, the results of our experiment are difficult to interpret. However, it appeared that extraction of the cabbage at pH 9.0 tended to lessen its goitrogenic power.

The results of these experiments would suggest that the goiter-producing substance contained in cabbage and other vegetables is not readily soluble in water, either at room temperature or at 100°C. Further, mild acid hydrolysis does not extract this substance. Prolonged acid hydrolysis at high temperatures may extract or destroy it to a slight degree. Alkaline hydrolysis appears to extract or destroy the goiter-producing factor.

The apparent increase in goitrogenic activity after contact with acid, may be due to a preservation of the goitrogenic substance, or on the other hand, it may be due to the destruction or extraction of anti-goitrogenic agents.[4] Further experiments along these lines are in progress.

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[3] Marine, D., unpublished data.

[4] Marine, D., Baumann, E. J., and Webster, B., PROC. SOC. EXP. BIOL. AND MED., 1930, xxvii, 1029.