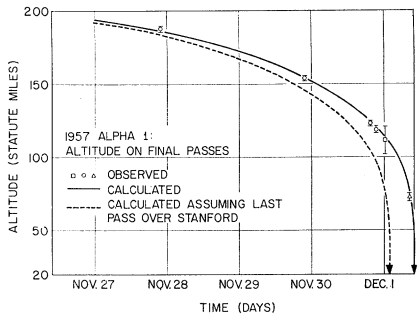

Fig. 2. Comparison of observed and calculated altitudes during the final days of satellite 1957 Alpha 1: ○, Lincoln Laboratory; □, Stanford Research Institute; △, Royal Radar Establishment (Malvern, England). The solid curve indicates the calculated altitudes. The dashed curve represents the calculated altitudes on the assumption that the satellite fell during its last pass over the United States.

to an uncertainty of ± 15°, corresponding to an assumed variation in the drag coefficient by a factor of 2. The combined uncertainty is shown by the heavy line in Fig. 1, as mentioned above.

In the final phase of the reentry the rocket probably disintegrated into elements of differing drag coefficient, whose impacts would be strewn over an arc length of the satellite trajectory approximately equal to the uncertainty in impact shown in Fig. 1.

R. JASTROW
I. HARRIS

U. S. Naval Research Laboratory, Washington, D.C.

References and Notes

1. See *Science* **126**, 1334 (27 Dec. 1957).
2. G. H. Pettengill, private communication.
3. A. M. Peterson and W. E. Jaye, private communication.
4. J. S. Hey and V. A. Hughes, private communication.

11 June 1958

B-Complex Vitamins in Certain Brown and Red Algae

With the world population continually expanding at a rapid rate, it has been predicted that future generations may have to depend more and more, for food, upon products from the sea (*1*). Such products include the algae, which are found in great abundance in many areas and about the nutritional value of which with respect to B vitamins, except for a small number of reports on some of the water-soluble factors in certain species (*2*) comparatively little is known. In this report (*3*) are presented the results of an investigation of the B-vitamin content of certain red and brown algae.

The plants analyzed were *Fucus spiralis, Ascophyllum nodosum, Laminaria agardhi,* and *Chondrus crispus.* They were taken from the coast line of New Hampshire and of York, Maine, through the months of October and November 1956. The algae were dried in a large, forced-hot-air dryer, at not over 85°C, and were then ground in a Wiley mill before analysis.

Analyses for the various vitamins were carried out by microbiological procedures (*4*); *Lactobacillus arabinosus* 17-5 (ATCC 8014) was used for niacin, pantothenic acid, and biotin; *Lactobacillus casei* (ATCC 7469), for riboflavin; *Streptococcus fecalis* (ATCC 8043), for folic acid; *Lactobacillus fermenti* 36 (ATCC 9833), for thiamine; and *Lactobacillus leichmannii* (ATCC 7830), for vitamin B_{12}.

The average results of the vitamin-content analyses are presented in Table 1. The four algae gave rather high results for niacin content when compared to many vegetables, fruits, and animal feeds. However, even the species containing the greatest amount of niacin, *Chondrus crispus,* contains considerably less than the 60 or more micrograms per gram found in barley and wheat. It can be concluded that these algae are a moderately good source of niacin. While all four of the algae studied are rich sources of pantothenic acid, the red alga *C. crispus* contains much more of the vitamin than do the three brown algae. This same relationship holds also for riboflavin and, to a lesser extent, for thiamine and vitamin B_{12}, indicating perhaps that in general the red algae are superior to the brown as a source of B vitamins.

In addition to being a good source of niacin and pantothenic acid, the algae are apparently a relatively good source of riboflavin and folic acid and a fair source of biotin and vitamin B_{12}. They are comparable with many fruits and vegetables as a source of thiamine.

It may be concluded, therefore, that the algae constitute an important potential source of certain water-soluble vitamins for animal, or human, consumption. Of the species studied, this is particularly true for the red alga *Chondrus crispus.*

A. E. TEERI
R. E. BIEBER

Department of Biochemistry, University of New Hampshire, Durham

Table 1. Average vitamin content (in micrograms per gram) of various species of algae. The average results were figured from three to seven determinations.

Vitamin	*Fucus spiralis*	*Ascophyllum nodosum*	*Laminaria agardhi*	*Chondrus crispus*
Niacin	22.8	14.6	30.2	31.8
Pantothenic acid	23.0	49.4	33.0	150.0
Biotin	0.063	0.021	0.042	0.032
Riboflavin	10.0	3.50	12.6	25.0
Folic acid	1.91	1.50	10.00	9.50
Thiamine	0.40	0.23	0.46	0.83
Vitamin B_{12}	0.080	0.096	0.052	0.312

References and Notes

1. H. G. Mautner, *Econ. Botany* 8, 174 (1954).
2. G. E. Fogg, *The Metabolism of Algae* (Wiley, New York, 1953); Y. Ishihara, S. Umemoto, Y. Matsubara, *Hokkaidô Daigaku Nôgakubu Kiyô* 1, 83 (1951); M. Tsujimura, K. Tabei, T. Wada, *Nippon Nôgei-kagaku Kaishi* 26, 11 (1952); L. E. Ericson *et al., Arkiv Kemi* 6, 427, 511 (1953); L. E. Ericson and Z. G. Banhidi, *Acta Chem. Scand.* 7, 167 (1953); B. A. Southcott and H. L. A. Tarr, *Fisheries Research Board Can. Progr. Repts. Pacific Coast Stas. No. 95* (1953), p. 45.
3. This report is published with the approval of the director of the New Hampshire Agricultural Experiment Station as scientific contribution No. 219.
4. E. C. Barton-Wright, *The Microbiological Assay of the Vitamin B Complex and Amino Acids* (Pitman, New York, 1952); *Difco Manual for Microbiological and Clinical Laboratory Procedures* (Difco Laboratories, Detroit, Mich., ed. 9, 1953).

10 February 1958

Chemical Induction of Male Sterility in Inbred Maize by Use of Gibberellins

The effects of gibberellin on flowering of inbred maize were studied during the winter of 1957. Unexpectedly, plants sprayed with relatively high concentrations (500 to 1000 parts per million) of gibberellic acid developed sterile or partially sterile tassels. Possibilities of chemical induction of male sterility in maize by means of gibberellin were thus suggested.

The following summer this phenomenon was further investigated under field conditions. A relatively early-flowering inbred line, R53, was planted on 1 June and 1 July, and a relatively late-flowering inbred line, OH51, was planted on 1 June and 8 July. Potassium gibberellate (*1*) in concentrations of 100, 1000, 2000, and 2500 parts per million, and a wetting agent (Tween 20 at 0.1 percent) were used as a foliar spray. The estimated amount of gibberellin per plant ranged from 1.0 to 10 mg for the 1 June plantings and from 12 to 35 mg for the two later plantings. Approximately 40, 55, and 90 plants per treatment were sprayed and scored for the 1 June, 8 July, and 1 July plantings, respectively.

The critical stage of plant development for the most effective chemical induction of male sterility appeared to be when the immature male inflorescence (immature tassel) was approximately 1 in. in length. Plants were defoliated (with

a razor blade) to expose the immature tassel for measurement. Test plants from each planting were used to estimate the stage of plant maturity for the remaining plants.

Gibberellin-induced male sterility, ranging from tassels barren of all floral parts to tassels which approached normal pollen shedding, was found. Most sterile tassels developed all floral parts except stamens (pollen and pollen sacs). On partially fertile tassels the upper portion of the central spike or the terminal portions of the lateral spikes, or both, developed staminate spikelets and shed pollen. The number of anthers extruding from staminate spikelets during flowering was recorded as trace, light, moderate, and normal as a measure of relative fertility of the tassel. Silks were functional, and open-pollinated seed from male-sterile plants produced plants with fertile staminate flowers.

The early flowering line planted 1 June showed no gibberellin-induced male sterility in any of the treatments, and the data are not presented. The immature tassels of this earlier flowering line, being considerably more than 1 in. in length when treated, had apparently passed the stage of development for chemical induction of male sterility.

Data from field experiments are presented in Table 1. The late-flowering line planted 1 June showed sterility in varying percentages of tassels, depending on the time of application and the concentration of gibberellin applied. Application of both concentrations (500 and 1000 parts per million) of gibberellin 56 days after planting induced fewer sterile tassels on the main stalk, but it was observed that there were more sterile tassels on the "suckers" (lateral shoots) than when the same concentrations were applied 48 days after planting. Data for the "suckers" are not included in the percentages in Table 1. Gibberellin in concentrations of 100 parts per million at both times of spraying induced only an occasional partially sterile tassel, and no data were recorded.

Applying the gibberellin near the suggested critical stage of plant development and increasing the concentration of gibberellin 2½ times induced male sterility in the early flowering line planted 1 July. Both treatments resulted in sterility in 87 percent of the tassels. Similar treatments on the late flowering line in the 8 July planting induced sterility in 100 percent of the tassels.

In the two later plantings, flowering occurred in early September, when temperature and day length were less favorable for optimum pollen development and shedding. It is impossible to separate environmental effects present during the late plantings from the effect of increased concentrations.

Moore (*2*) and Naylor (*3*) reported chemical induction of male sterility when young maize plants were sprayed with maleic hydrazide. Wittwer (*4*) used maleic hydrazide effectively to induce male sterility in cucurbits. In this study, gibberellin effectively induced male sterility in two maize inbreds. This effect has not been reported in previous papers on gibberellin-treated maize.

Further investigations are needed to determine the reliability of this chemical (gibberellin) "sterilization" and its large-scale application in the production of maize hybrids. If consistently effective, chemical induction of male sterility would be a valuable method for reducing or eliminating detasseling of seed fields. (*5*)

Table 1. Chemical induction of male sterility in two inbred lines of maize by foliar applications of gibberellin.

Time of spraying (days after planting)	Gibberellin (ppm)	Male sterile tassels (%)	Partially fertile tassels			Normal tassels (%)
			Trace†	Light‡	Moderate§	
Late flowering line planted 1 June						
	0	0	0	0	0	100
48*	500	32	13	32	23	0
48*	1000	46	18	15	21	0
56	500	15	10	20	10	45
56	1000	25	3	7	15	50
Early flowering line planted 1 July						
	0	0	0	0	0	100
39* and 46	1000 each	87	5	6	2	0
39*	2500	87	10	3	0	0
Late flowering line planted 8 July						
	0	0	0	0	0	100
36* and 43	1000 each	100	0	0	0	0
36*	2000	100	0	0	0	0
43	1000	33	13	35	19	0

* Immature tassels were approximately 1 in. in length.
† Trace: from one extruded anther to 1 in. of extruded anthers on any part of the central spike or one lateral spike.
‡ Light: more than 1 in. of extruded anthers on any part of the central spike or one lateral spike, or a trace on two or more spikes, central or lateral.
§ Moderate: more than 1 in. of extruded anthers on two or more spikes, central or lateral.

P. M. Nelson
E. C. Rossman
Department of Farm Crops, Michigan State University, East Lansing

References and Notes

1. Potassium gibberellate was supplied by Merck & Co., Inc., Research Laboratories, Rahway, N.J.
2. R. H. Moore, *Science* 112, 52 (1950).
3. A. W. Naylor, *Proc. Natl. Acad. Sci. U.S.* 36, 230 (1950).
4. S. H. Wittwer, *Science* 120, 893 (1954).
5. The suggestions and advice of Dr. S. H. Wittwer in connection with this study are appreciated.

27 December 1957

Electrophoresis of Free Sugars in Blood

A convenient method, described in this report, for the qualitative identification of free sugars in blood provides a useful complement to data obtained from nonspecific oxidation methods. Thus, in the development of a micromethod for the quantitative determination of galactose, in which a Somogyi oxidant was used (*1*), definite confirmation of the presence of galactose was required as proof that the reduction was not due to other sugars or to nonsugar reducing substances.

A method for determining this, based on the electrophoretic behavior of the sugar-borate complexes (*2, 3*), is easy to perform and is more rapid than chromatographic methods. In developing it we used a Spinco model R apparatus, although, with suitable adjustment of voltages and times, any strip-type electrophoresis apparatus may be used.

Differentiation of glucose, galactose, fructose, and lactose in deproteinized human blood is facilitated by the use of borate solutions at two different *p*H's—an extension of the techniques of Consden and Stanier (*2*). The method will indicate concentrations as low as 4 mg per 100 ml of any one of these sugars in blood, equivalent to less than 4 μg per spot (*4*). It is satisfactory up to a total sugar concentration of about 125 mg per 100 ml; above this concentration the sample should be diluted to prevent streaking.

Reagents. Buffer A (*p*H 9.2) consists of a 2 percent aqueous borax ($Na_2B_4O_7 \cdot 10\ H_2O$) solution. Buffer B (*p*H 7) consists of 24.8 g of boric acid (H_3BO_4) and 5.8 g of sodium chloride, dissolved in water and diluted to about 700 ml. Borax solution (0.05*M*) is added, with stirring, until the *p*H reads 7.0. The solution is then diluted to 1 liter with water (*2*). Standard sugar solutions consisting of 1