A NOTE ON THE CHEMICAL COMPOSITION OF CHARA FROM GREEN LAKE, WISCONSIN

HENRY A. SCHUETTE AND HUGO ALDER

Contribution from the Department of Chemistry, University of Wisconsin, and the Biological Laboratory of the Wisconsin Geological and Natural History Survey. XXXIII.

Little published information on the chemical composition of *Chara* seems to be available except a statement from botanical sources[1] that a species of stone-wort, *Chara foetida,* was found to contain potash, soda, lime, and silica in the amounts of 0.2, 0.1, 54.8, and 0.3 per cent, respectively. In view of the incomplete state of these data we have been prompted to fill the existing gaps by reporting the results of a chemical analysis which we made of a typical member of this order.

An opportunity of securing representative samples of *Chara* from Green Lake, Wisconsin, presented itself through the activities of Rickett[2] who made a survey of the annual crop of higher plants of this body of water in 1921. He observed that it is the dominant plant in the vegetation of this lake and reported that it may be found growing almost everywhere, sometimes mixed with other plants, and often standing alone in such dense masses that no other form has been able to obtain a foothold. This condition stands in marked contrast to that which obtains in Lake Mendota, it is stated, for here *Chara* plays but a minor rôle in the attached flora. Rickett advances the opinion that this situation may be traced not only to differences in the character of the respective lake floors, but also to differences in the transparency and temperatures of the waters in question. The waters of Lake Mendota are warmer and less transparent than those of Green Lake. The floor of the latter is covered with a fine marl in contrast to a mud which is characteristic of Mendota's bottom. Differences in the chemical composition of the waters of these lakes are

not such as to be conspicuous, hence this condition is probably outside the scope of the discussion.

Description of the Plant

Members of the genus *Chara* are popularly known as the stoneworts because they are incrusted with a calcareous deposit which, it is believed, serves them as a defensive armor. They are brittle and rough to the touch.

The most common species of this group is *Chara fragilis*[3]. It is wide spread in its distribution. The plant is about twelve inches high and consists of an axis with whorled, long, spiny, leaf-like structures at the nodes.

It reproduces vegetatively by outgrowths or sexually by the formation of motile sperm cells. The sexual structures are borne on the whorled branches at the nodes. Here are found oögonia, each containing a large egg cell which is visible to the eye because of its orange-red color. Beneath the oögonia at the same nodes are found antheridia which produce a large number of motile sperm cells. These enter the oögonia through an opening at the top and after fertilization a resting spore (oöspore) is produced.

It is probably not incorrect to state that these plants have never been used for any practical purposes, yet very good reasons suggest themselves for their use in correcting the acidity of sour soils.

Others, however, of the so-called worts have had at one time an economic importance. It may be pertinent to recall, in this connection, that it was to the members of the genus *Salsola* or saltworts that soap makers of early days in Spain turned as a source of alkalies long before the development in France of the well-known Le Blanc process for producing soda from common salt. The saltwort was here burned for its ash because the latter is relatively high in soda. This ash, which was known as "barilla", was then lixiviated with burnt lime whereby a solution of caustic alkali was obtained.

Chemical Analysis

The material which was made available for analysis represented the harvest from 38 collecting stations which were

variously located in the zones of plant growth—an area comprising here some 8,570 square kilometers—over which the depth of water ranged from zero to eight meters. It had been air dried and then further dehydrated in an oven maintained at a temperature of 60°C. During the five-year interval which had elapsed between collection and chemical analysis, it had been stored in closed containers. Extraneous matter, such as shells, stones, sand, etc., was removed by hand after which the dried plant was comminuted in a drug mill to pass through a sixty-mesh sieve. Iron introduced during the process of milling was removed with an electro-magnet.

The analytical procedures of the Association of Official Agricultural Chemists[4] for the determination of organic and inorganic plant constituents and that of carbon dioxide in baking powder were followed with one exception, and that was the method of separating the alkali metals. The perchlorate method of Schlössing-Wense[5] was substituted for the official platinic chloride procedure. They are standard methods which require no description here.

Sand was found to be present to the extent of 0.89 per cent. In as much as this may very well be considered an impurity, analytical data subsequently obtained were corrected to a sand-free basis. They are reported on "as received" or air dry basis under conditions which have been outlined in preceding paragraphs. They are recorded in the following tables.

TABLE 1. *Proximate composition of Chara.*

Constituent	Percentage Sand-free air dry basis
Ash	41.22
Crude protein (N x 6.25)	4.50
Ether extract	0.76
Crude fiber	9.32
Pentosans	4.70
Nitrogen-free extract	39.50

TABLE 2. *Inorganic constituents of Chara.*

Constituent	Percentage Sand-free air dry basis
Silica (SiO_2)	0.83
Ferric oxide (Fe_2O_3)	0.06
Aluminum oxide (Al_2O_3)	0.81
Manganomanganic oxide (Mn_3O_4)	0.08
Calcium oxide (CaO)	37.82
Magnesium oxide (MgO)	1.19
Sodium oxide (Na_2O)	0.35
Potassium oxide (K_2O)	0.58
Chloride (Cl)	0.29
Carbonate (CO_3)	39.00
Total sulfur (S)	0.27
Total phosphorus (P)	0.06

It is generally accepted that the nature of the mineral salts in a water, in a plant or its products is to a certain extent a matter of conjecture since the salts found by analysis of the ash of the material in question are not exactly the same as those present in the uncalcined sample. These limitations make impractical the assignment to hypothetical combination of the acidic and basic oxides which are recorded in the foregoing tables. These data, however, admit of certain gross generalizations of which the following appear worthy of comment.

That the name stonewort which popular usage associates with this plant is well taken becomes apparent upon analysis of the data in tables 1 and 2 and by comparison with that obtained in the study of other forms of aquatic vegetation [6, 7] from Lake Mendota. *Chara* contains less nitrogenous matter, less cellulosic material and a lower carbohydrate content, referable to crude fiber and pentosans, respectively, than do *Vallisneria, Potamogeton, Myriophyllum* and *Cladophora.*

The fact that *Chara* contains, with some exceptions, a lower content of silica, iron, aluminum, maganese, magnesium, sodium, potassium, sulfur, phosphorus, and chloride than do the other vegetative forms in question is not so striking as that calcium oxide constitutes approximately 92 per cent of its ash. The value obtained, 37.82 per cent, is not in agreement with that reported from other sources[1], yet this apparent discrepancy has no particular significance

of itself since the history of the material in question and the conditions under which it was grown, gathered, and analyzed are obscure.

Parallel with a high content of calcium oxide lies the quantity of carbon dioxide which the dried plant yields on treatment with acids. If one assumes that all of the carbonate in this plant exists here in chemical union with calcium and translates the quantity of carbon dioxide found into terms of calcium carbonate, there is obtained a value for the latter of 65 per cent. That this assumption, whereby is established the order of magnitude if not the exact quantity of the calcium carbonate content of *Chara,* is not seriously in error is established by the fact that the actual amount of calcium oxide found by analysis is approximately equal to that required by theory. On deducting the calcium oxide content of the ash from that required by the calcium carbonate of the incrusted deposit (36.40 per cent) there remains 1.42 per cent to be assigned to other acidic oxides.

Birge and Juday[8] state that Rickett's survey[2] indicates that about one half of the annual crop of higher plants of Green Lake—some 1,528 metric tons—is contributed by *Chara.* On correlating this observation with the values reported herein it would seem that the annual growth requirements of *Chara* for its major constitutent are 397 metric tons of calcium and 427 metric tons of carbon in terms of carbon dioxide. There are returned every year to this lake 993 metric tons of calcium carbonate.

Literature Cited

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[2] Rickett, H. W. A Quantitative study of the larger aquatic plants of Green Lake, Wisconsin. Trans. Wis. Acad. Sci., Arts, and Let. 21: 381. 1924.

[3] Kerner and Oliver, loc. cit., Vol. IV, p. 659.

[4] Association of Official Agricultural Chemists, Methods of Analysis. Washington, D .C. 1925, p. 39 et seq., 301.

[5] Treadwell–Hall. Analytical Chemistry. New York, Wiley & Sons. Vol. II, 1911, p. 50.

[6] Schuette, H. A. and Hoffman, Alice E. Notes on the chemical composition of the larger aquatic plants of Lake Mendota. I. Cladophera and Myriophyllum. Trans. Wis. Acad. Sci., Arts and Let. 20: 529. 1921.

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