

could not be economically effected on a manufacturing scale by means of a solvent like ether, or even by the use of that much cheaper and still more powerful agent, the bisulphide of carbon ( $\text{CS}_2$ ); but it might be worth while to see how far a brief immersion of the leaf in an alkaline or soapy liquor would answer in actual practice. As an alkaline lye might be prepared from the ashes of the rejected parts of the leaves, the cost of such a treatment as that just suggested need not be considerable. Laboratory experiments have shown me that leaves cleansed from the surface-wax by means of a boiling alkaline solution, are far more easily acted upon by the materials used in their subsequent treatment. It may be here remarked that in the treatment of the dried plant with boiling alcohol, a solution of many of the proximate principles of the plant is obtained, and amongst these some of the wax or fat will be found; but as the solution cools, the greater part of this substance is deposited in granules, which are soluble in ether, and which fuse below the heat of boiling water.

#### C.—Sugar.

In determining the existence and proportion of sugar in the *Phormium* leaf, two plans were adopted. When an alcoholic extract of the leaves had been prepared, as described further on, under the heading "Bitter Principle," it yielded, after treatment with lead subacetate and separation of the resulting precipitate, a solution which contained certain lead compounds along with the bitter principle, and much sugar. This solution was freed from lead by means of sulphuretted hydrogen ( $\text{H}_2\text{S}$ ), and then, after filtration and concentration, gradually deposited a considerable amount of amorphous sugar. This sugar corresponded closely in properties to the sugar of acid fruits, known as *fructose* or *laevulose*. It was soluble in alcohol, and reduced the red oxide of copper from Fehling's sugar test very readily. A rough determination of its amount gave 4·3 per cent. as existing in the fresh leaves. This number is much higher than the estimate recorded by Dr. Hector in 1865 (1 to 1·5 per cent.); but I consider it rather under than beyond the truth. This apparent discrepancy may, however, be capable of ready explanation. The leaves of *Phormium* upon which my experiments were necessarily made had been grown in a greenhouse at Kew. The plant was a good deal shaded by the crowding of other foliage, and altogether was growing under quite artificial conditions. These conditions may have been, and are likely to have been, peculiarly favourable to the production of sugar.

When an aqueous extract of the plant was prepared, a still higher percentage of sugar was deduced from the examination of the matters thus removed from the tissues of the leaves. The analysis of the solution thus prepared led to the following numbers, as representing the proportion of sugar in the leaves of the *Phormium* :—

In the fresh leaves	...	...	...	...	Calculated as Cane Sugar.
In the dry leaves	...	...	...	...	5·45 per cent.
					19·20 "

It may be concluded that these numbers are rather too high, owing to the conversion of some of the gum and starch of the plant into sugar by means of the treatment to which the aqueous extract had been submitted. But though 5½ per cent. of sugar is probably an extravagant estimate, I am inclined to think that it is not more than 1 per cent. in excess of the truth; so far, at least, as the richness of English grown leaves is concerned.

#### D.—The Bitter Principle.

A notion appears to prevail that the bitter principle of the *Phormium tenax* is a coloured substance: this is quite incorrect. Doubtless when an aqueous or alcoholic extract of the leaf is made, the bitter principle, thus dissolved out, is accompanied by colouring matters, but these matters merely accompany the true bitter principle. If reference be made to the Report, p. xix., 1871, of the Flax Commissioners,\* it will be seen that the bitter principle is therein spoken of as coloured—"purity of colour can only be obtained by thoroughly washing out the bitter principle from the plant." Again, in the Appendix to the above-named Report, at page 84, Captain Hutton states, "The bitter principle might perhaps be used as a dye or stain for wood," &c. The mixed nature of the substances extracted from the plant by water, and the subsequent changes which some of the substances undergo in the presence of air and moisture, account for the mistake which I have pointed out. As I shall have again to refer to the colouring matters of *Phormium* in the next section, I will now merely describe the method by which the bitter principle was obtained in a state approaching purity.

The selected leaves were cut into small pieces and then carefully dried. About a pound of the dry matter was then exhausted with boiling alcohol. The hot alcoholic extract (or rather extracts) was then filtered, some wax (see § 1 B) being deposited on the filter during the passage of the liquid through it. The filtered liquid was then evaporated, first in a retort, then at 100° centigrade, and finally *in vacuo*. The residue corresponded to 19·6 per cent. of the dried leaves taken. It was of course free from starch and gum, but contained many other substances besides the bitter principle. In order to isolate this principle the following plan was adopted:—The last-described residue was boiled in abundance of water, and then the liquor was filtered. To the clear filtrate basic lead acetate was added so long as it occasioned a precipitate. [This precipitate, consisting chiefly of the lead-salts of organic acids, will be referred to further on in this section of the Report, under the heading F.] This precipitate was then filtered off, and the clear filtrate purified further as follows:—Excess of hydro-sulphuric acid was passed into it, it was filtered, warmed, and finally evaporated *in vacuo*. The syrupy residue of this evaporation consisted mainly of sugar, but contained also a large proportion of the total quantity of the bitter principle present, as well as some acid substances. To separate the bitter principle, the concentrated liquor was shaken up with ether, in which the acids as well as the sugar are almost entirely insoluble. The ethereal solution was then decanted off and evaporated: it left a residue which was slightly yellow in colour and resinous in appearance. On boiling this residue with much water and a little powdered animal charcoal, the greater part of the bitter principle was withdrawn from solution by the charcoal, which latter substance again yielded it up to strong boiling alcohol. Thus extracted, the bitter principle of *Phormium tenax* is colourless, and exhibits but very doubtful traces of crystallization. Its bitter taste is not disagreeable nor persistent. It does not