also cultivated in England by Her Grace of Beaufort so long ago as 1699 (*Br. Mus. Sloane MSS.*, 525 and 3349; *Ait. Kew.*, v.) It would be interesting to ascertain in what way these plants reached England at that early period, and from what part of the American coast.

GEORGE LAWSON.

Dalhousie College, Halifax, N. S., March 20.

CHILLED POTATOES.

WHY THEY TASTE SWEET.

Almost every one has at some time made personal acquaintance with the sweet taste of potatoes which have been exposed to a very low temperature. This matter has recently been the subject of an extended investigation,* and the results are interesting, not only because they suggest a way in which the sweet taste may be removed, but also for the light which they throw upon the chemical and vital processes which go on in this and similar tubers during their period of rest.

Potatoes which have become sweet are commonly said to have been frozen. One of the first results of the investigation referred to, was that *freezing does not make potatoes sweet*. Hundreds of frozen potatoes were examined, but not a single one was found to have become sweet! In these trials, however, the potatoes were frozen *quickly*, while in a cellar they would be likely to be subject to a low temperature for a comparatively long time before freezing. The actual conversion of the juices of a potato into ice, is always rapid when it once begins; but it has been shown that the temperature must fall 5° or 6° below the freezing point of water before the solidification takes place. The difference between potatoes frozen artificially and those frozen accidentaly in a cellar, then, would be simply that the latter were chilled for some time before they actually froze.

This suggested the thought that it might be the chilling, and not the freezing, which made potatoes sweet. To test this, thirty tubers, as nearly alike as possible, were placed upon a table in a cellar, in February, and by occasional opening of the windows, the temperature was kept just above the point (26° to 27° F.) at which potatoes freeze. Every day for two weeks, two of the potatoes were tested; and from the seventh day on, the sweet taste became more and more manifest, although the potatoes never froze. In another trial, potatoes were frozen rapidly and preserved for a considerable time in this state. They did not become sweet. It is plain, then, that it is chilling, just falling short of freezing, and not the freezing itself, which causes the sweetness.

The next step was to ascertain the cause of this effect. The sweet taste suggests at once the presence of sugar, since this is by far the most common vegetable sweet. Chemical analysis confirmed this conjecture. Normal potatoes contain, roughly, 0.5 per cent. of sugar, while chilled potatoes contain much more,—one per cent. rendering them decidedly sweet, and two per cent. inedible. Whence, now, comes the excess of sugar in the chilled potatoes? Here some knowledge of vegetable chemistry is required.

The larger portion of the solid matter of the potato consists of starch, and starch is easily converted by various means into a form of sugar familiar to us in these days as "glucose." Commercially, glucose is made by heating starch with dilute acid; but it is a popular error that the acid enters into the composition of the glucose. It is not even necessary to its formation. Starch is changed into glucose by uniting chemically with the elements of water, and the change may be effected by simple heating with water under pressure, though the process is more rapid when acid is used. Starch may be changed into sugar in many other ways. The starch of our food, for example, is changed to sugar during digestion, so that every human being and every herbivorous animal is a walking glucose factory.

More interesting for our present purpose, however, is the action of malt upon starch. In the preparation of malt by sprouting barley, a substance called *diastase* is produced in the latter, and when the malt is subsequently brought into contact with fresh grain or other starchy material, this diastase attacks the starch and converts it into a form of sugar closely resembling glucose. In the subsequent fermentation, this sugar yields the alcohol of the beer or other liquor.

But malt is not the only material in which diastase is found. It has been pretty well made out that the cells of all or most plants contain a ferment which is so nearly like diastase that it may be called by that name, and which changes starch into sugar. This is the source of the sugar of chilled potatoes. The diastase in the cells has formed it from the starch which is present in such abundance. That this is so is shown by the fact that as a potato becomes sweet, its content of starch diminishes to an extent rather more than sufficient to produce the sugar which is found.

The utility of this change for the growth of the potato in the spring is obvious. It changes the insoluble starch into soluble sugar, which can be carried by the sap into the growing shoots, where it is needed for their nourishment. But of what use is it in the winter, and why should it manifest itself only when the tuber is cooled below a certain point? The answer to this question involves considerations of a different character.

We do not commonly associate the idea of life with such a thing as a potato and yet, if we stop to think, we know it is alive if it is sound. Now, every living thing breathes; this is as true of plants, as of animals, of a potato as of a man. Moreover, the chemical processes involved are in general the same. Both breathe in the oxygen of the air and use it to oxidize or burn some of the materials which they contain. This burning furnishes to the animal, heat and the force of its motion; to the plant, heat and the force of its (sometimes hidden) motion. Both exhale carbonic acid and water as the products of this internal combustion. Both too, perish sooner or later, if their supply of air is cut off, although plants may be deprived of air for a very much longer time than the higher animals, without being killed.

Now one object of the diastase in the cells of the potato, is to prepare fuel for this burning that is continually going on. The sugar into which it converts the starch, is burned up by the oxygen of the air which the potato breathes. It is true that the process is indirect, and by no means so simple as this bold statement would seem to make it. It is very different from the burning of sugar thrown into the fire, for example; it is a vital and not a merely chemical act. Nevertheless, the result is much the same. The sugar is destroyed, and a corresponding quantity of carbonic acid and water produced, in both cases.

This change of starch into sugar, and the burning up of the sugar, go on all the time in the living potato, though with different degrees of energy in different specimens and at different times. Ordinarily the sugar is burned up as fast as it is formed, as we know from the fact that it does not accumulate. When the potato is exposed to the low temperature for some time, it does accumulate, as we have seen, showing that the two processes are unequally affected by cold. As a matter of fact, the breathing of plants at the freezing point of water is reduced to a minimum; it is almost nothing. The action of diastase, on the other hand, though probably weaker, still goes on, sugar is formed faster than it is needed, and the potato becomes sweet. Actual freezing stops all these processes and kills the potato.

The sweetening of chilled potatoes, then, is not caused by any new action excited by the cold, but simply by the fact that the balance between two processes, formation and oxidation of sugar, is disturbed. This suggests a remedy, if one's

* Mueller, Landw. Jahrbuecher, XI, p 751.