stant fraction of the amount of energy which the sense organ has received previously.

VIII

Repeated stimulation of the kind just described, has frequently been called a process of adaptation to a stimulus. As such it has been used as a criterion for the presence of a "higher behavior" in many animals. Similarly, the fact that the reaction time continues to increase steadily has been taken to indicate a process of learning.

The experiments forming the basis of this communication, have, however, shown that these phenomena are dependent on changes which take place within the sense organs themselves. In addition, they have demonstrated that the process of "adaptation" to a photic stimulus in *Ciona* is subject to the course of a chemical reaction. The reverse of this reaction determines the ability of the organism to become "dark adapted." Furthermore, the changes which occur in the reaction time during both of these adaptional processes are consistent with the principle underlying the Weber-Fechner rule. This requires that in order to act as a stimulus, the light must form a quantity of a substance such that it will bear a definite ratio to the amount of that substance already present in the sense organ. The matter of "higher behavior" is nowhere evident in these experiments.

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A METHOD FOR PREPARING PECTIN

PECTIN bodies is a term applied to a group of substances occurring in practically all plants and fruits. They are complex carbohydrates, probably derived from one mother substance known as pectose, and are closely allied to the plant gums and mucilages. Pectin occurs most abundantly in the apple, quince, currant and gooseberry and appears in small quantities in strawberries, raspberries, etc. In suitable amounts of sugar and acid the pectins have the property of gelatinizing fruit juices or hot-water extracts of fruit pulp in which they are present or to which they may be added. The reason why some kinds of fruit juices do not jelly is due to an insufficient amount of pectin being present in them. For example the practise of mixing apple juice with raspberry or strawberry juice is for the purpose of increasing the pectin content and thereby make jelly from juices where it would be impossible to do so otherwise. The juices from the various kinds of fruits are known for their distinctive flavors. These qualities are impaired when a combination of juices are blended together. For this reason it has been the aim of manufacturers to make high-grade jellies from the low-containing pectin fruit juices by adding to them the purified pectin. The pectin, as now prepared, is very expensive and therefore its use in jelly-making is very limited.

Pectin is slightly soluble in water and therefore the pulp or pomace resulting from the pressing of ripe fruit contains practically all of the pectin. Hot water will slowly extract the pectin and for this reason fruits are cooked to a pulp with water before extracting the juice for jelly-making.

In the fruit-producing sections of the state of Washington, there is a considerable amount of cheap material such as cull apples, pomace from cider presses and cores and peelings from canning establishments which go to waste. This waste material might be utilized for the preparation of pectin which, in turn, could be used in making jelly from those fruit juices which lack pectin. The object of the experiment carried on in this laboratory was the finding of some simple and inexpensive process for the preparation of pectin from these waste products, without the use of alcohol, as is the case in Goldthwaite's[1] method.

The principle of the method is based upon the fact that pectin as extracted from the pulp or pomace is in a colloidal state and can be readily changed by electrolytes. Since pectin, after precipitation, must be dispersed again in order to be of any value as a gelatinizing agent, an electrolyte that will produce a reversible precipitation must be chosen. Also

[1] *J. Ind. and Eng. Chem.*, 2 (1910), 457.

the electrolyte chosen must be non-poisonous. Lead acetate or basic lead acetate will precipitate pectin, but the precipitation is an irreversible one, and the amount of lead absorbed or combined may be poisonous. For these reasons ammonium sulfate was chosen. Bigelow, Gore and Howard[2] in their review of the literature on pectin mention that in 1898 Bourquellot & Herissey used ammonium sulfate as a precipitant for pectin obtained from gentian root. Other than this no further use has been made of this precipitant for pectin.

METHOD

60 grams of dried apple pomace were boiled three successive times with 200 c.c. of water, filtering after each boiling. To each of the 100 c.c. of filtrate 25 grams of ammonium sulfate were added[3] and then heated to 70° C., whereupon the pectin was precipitated as a grayish white flocculent precipitate. The precipitate was separated from the mother liquor by filtering. (The mother liquor can be evaporated and the residue used again or the residue can be used as a fertilizer.) The precipitate was dissolved in hot water and again precipitated with ammonium sulfate. Again it was filtered and the precipitate was removed from filter paper and dried at 60–70° C. and when dry was washed several times with cold water to remove adhering ammonium sulfate. The precipitate was dried again and its gelatinizing power was tested by adding to a 1 per cent. solution of the pectin 0.5 per cent. solution of citric acid and 65 gm. of sugar. This solution was boiled for 10–20 minutes and upon cooling a nice stiff jelly was produced. The taste did not indicate the presence of ammonium sulfate and upon dissolving the jelly in hot water only a slight milkiness was produced when tested for sulfates.

In order to determine whether the yield of pectin by the above method was equal to the yield produced by the alcohol precipitation method, two samples of apple pomace from the same lot were treated exactly alike, except that ammonium sulfate was used in one case and alcohol in the other as the precipitating medium. The pectin was dissolved and reprecipitated in each case, then filtered and the precipitate was removed from filter paper and dried. The ammonium sulfate was removed from the one by washing with cold water, again dried and weighed. The amount of pectin recovered by each method is recorded in table below.

Precipitant	Pectin, Per Cent.
Ammonium sulfate	6.33
Alcohol	6.91

The amount of ammonium sulfate used can be reduced by concentrating the extract, either by evaporating on a steam bath, in a partial vacuum or by freezing.[4] The quality of the pectin is not impaired in either case.

SUMMARY

Pectin can be prepared by adding ammonium sulfate to the hot water extract of fruit, and heating to 70° C. The amount of pectin recovered is practically equivalent to that recovered by the alcohol precipitation method.

Concentrating the pectin extract below the boiling point did not impair the quality of the pectin.

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[2] Bul. 94 U. S. Dept. Agr. Bur. Chem.

[3] If wet pomace is used it will require a somewhat larger amount of ammonium sulfate. First add 25 grams per 100 c.c. and if precipitation does not occur, add successive portions of 5 grams until precipitation occurs. The pectin may also be precipitated by saturating the solution in the cold with ammonium sulfate.

[4] J. S. Caldwell, Bul. 147, Wash. Agr. Exp. Sta.

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