THESIS

STARCH AS FOUND IN VEGETABLE FOODS

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SENIOR AGRICULTURAL THESIS.

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BY

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Michigan Agricultural College, 1898.

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STARCH ($C_6H_{10}O_5$).

Plants produce by assimilation a larger amount of substance than they can employ at the time for cell growth. This substance is stored in the cells and is carried in solution through the plant from the protoplasm,where it is first visible,to the chlorophyll granules.

Starch grains have always,originally,a rounded form, usually spherical until growth presses them into the varied forms in which we find them.

Starch is never found in a perfectly pure state,always containing water of organization. The layers of stratification are alternately transparent and dark; those farthest from the nucleus being the most watery and that layer nearest,being the most dense. This last layer surrounds the small,very watery centre,called the nucleus. All layers are disposed about the nucleus as a common centre,-the size of the layers increasing toward the direction of most vigorous growth. Growth accomplished wholly be intussusception.

Starch is a product formed by the vital activity of plants. The amount of starch is increased by light and contains a lesser or greater amount of water according to the variety of the plant in which it is found. It consists of a soluble and an insoluble mass, granulose and cellulose,and these two masses can be separated by the action of saliva or pepsin. Starch is insoluble in cold water and swells to a

sticky paste with boiling water. Granules heated gently to 40° or 50° C.,will show lines of stratification much plainer. Caustic potash and chromic acid act on starch with the same result.

Starch is colored by iodine from a very pale blue to purple or black,according to the strength used. This is the principal test for starch.

Starch cellulose is only a small proportion(2%-6%) of starch and may be described as the skeleton of the starch granules.

Granulose may be extracted in several ways:

1. Maceration in saliva at 40°-47° C.
2. By organic acids,diastase or pepsin.
3. By slow action of very dilute H_2SO_4 or HCL.

The volume of a starch granule can be increased 125% heating or by the action of caustic potash.

Starch grains may be classified according to size,the limits,however,being .002 m.m. to those visible to the naked eye:

Small,(.002 - .015 m m) which includes starches of rice, oats,buck-wheat,and the smaller ones of wheat,rye and barley.

Medium,(.02 - .05 m m) as the compound granules of oats and rice,and the larger ones of wheat,rye and barley.

Large,(visible to the naked eye) as potato,canna etc.

Potato starch was discovered during the 17th century,

and since that we have in use starches from nearly all of the edible plants,most of which are illustrated in the Plates of this thesis. The starch of wheat was the only kind known to the Ancients,and was used extensively by the Egyptians and the Greeks.

In many plants we have not only single starch grains; but also double,triple and even quadruple grains. These compound grains usually contain as many nuclei as they have divisions,and are joined by several lines of stratification, while the remaining layers extend about only their individual nuclei. There are also simple or compound granules where the compound ones often contain eight or ten simple ones.

Starch appears in nearly all chlorophyll bearing plants. It was most lacking,however,in the sugar beet and was distinguishable in minute granules in the carrot,ruta baga etc.

Heated with dilute nitric acid the starch is converted into dextrin and finally into grape sugar. It is on account of this that starch is used to obtain glucose on a large scale.

Starch is used for many purposes: as a food, as glue, as a medicine and in the laundry.

Potato starch is obtained by grating the tubers and passing water over them until the water is no longer milky,which color is caused by the starch held in solution. The starch

will soon sink to the bottom and can be thus obtained. The process of obtaining wheat,rye and other starches,is much more difficult;though essentially the same.

Notes on Plate I.

A.- Wild potato from Mexico,(parent of our cultivated potato) average size:

a.- Cooked starch granule showing fissures. Greatly increased in size by cooking.

b.- Double granule with two nuclei.

c.- Long,slender,crooked granule.(rare)

d.- Triple granule.

e.- Nearly circular granule.

f.- Most common shaped grain of large size.

B.- Wild potato of Arizona; medium size,wild:

a.- Granule with nucleus at large end(most common).

b.- " " " " small " .

c.- Extra large,nearly oval granule.

d.- Angular granule.

e.- Star-shaped granule.

f.- Granule with small granule imbedded in one end.

g-h-i.- Types of grains.

m-n.- Cooked starch showing membrane at end and fissures on surface.

In this potato,nucleus found most generally at large end.

C.- Piece of bread showing mass of starch etc.,after process of cooking:

a.- Cooked wheat starch grain,flattened and much enlarged,though still retaining original shape.

b.- Grain showing slight lines of stratification, which in wheat starch are usually invisible.

c.- Granule showing no lines of stratification.

d-e-f.- Cooked grains,twisted and turned during process of cooking.

h-i-j-k.- Portions of wheat starch grains imbedded in gum arabic,to hold in place and then cut across to show shape etc.

D.- Cell from banana pulp,containing starch grains of different sizes and shapes:

a.- Long,tapering granule with nucleus at one end.

b.- Various shaped grains.

d.- Cooked grain showing great increase in size.

e.- Long,slender cooked granule.

Notes on Plate II.

E.- Cell containing starch grains from the yellow flinty portion of corn. Granules closely packed in the cell.

a-b.- Different forms of starch showing nucleus at the centre and radial lines running from it. Grains angular in shape.

F.- Cell with its starch,from white part of corn. Granules

less thick in cells,less angular,and each having a small split or fissure,often star-shaped,in the centre.

G.- Two cells of pop-corn unpopped.

H.- " " " " somewhat popped,and showing the enlargement of the cells and the action of heat upon them.

I.- Fully popped corn showing cells greatly extended,and the wavy lines (a) showing themelted starch imitating true plant cells.

K.- Masses of buck-wheat starch granules filling the cells.

L.- Granules of rye starch,showing no lines of stratification and varying in size and shape.

Notes on Plate III.

M.- Portion of a cross section of a kernel of oat. Cells of different size:

a.- Pallisade cells containing Aleurone.

b.- Starch found in the centre of section of kernel.

c.- Compound granule of oat starch showing portion broken off.

d.- Whole compound granule.

e.- Single grains broken from the compound grain.

f.- Cooked oat-meal showing compound grain enlarged by heat.

N.- Section from rice kernel:

a.- Aleurone cells.

b.- Cells of starch grains.

c.- Compound grains of rice starch and the separate kernels.

C.- Portion of a wheat kernel:

a.- Aleurone cells with thick walls.

b.- Starch cells with thin walls.

P.- Various sizes and shapes of the arrow root starch granules,showing plainly lines of stratification.

Q.- Granules from barley starch.

R.- Grain from Solanum Maylia of South America. Remarkably varied in size and shape.

S.- Granules form Allico Solernum of S.A.. Used as a potato in Peru. Lines of stratification seldom visible.

T.- Starch from pea:

a.- Heart-shaped granule.

b.- Double granule.

c.- Nearly triple granule.

U.- Tapioca starch,various sizes:

a.- Granule with end cut off.

b.- Cooked grains distorted and enlarged by heat.

V.- Bean starch:

a.- Bean,original size.

b.- Double granule of bean starch.

Y.- Very minute granules of starch from the Ruta Baga,starch found about one inch from the surface. Visible only by use of iodine.

PLATE NO. 1

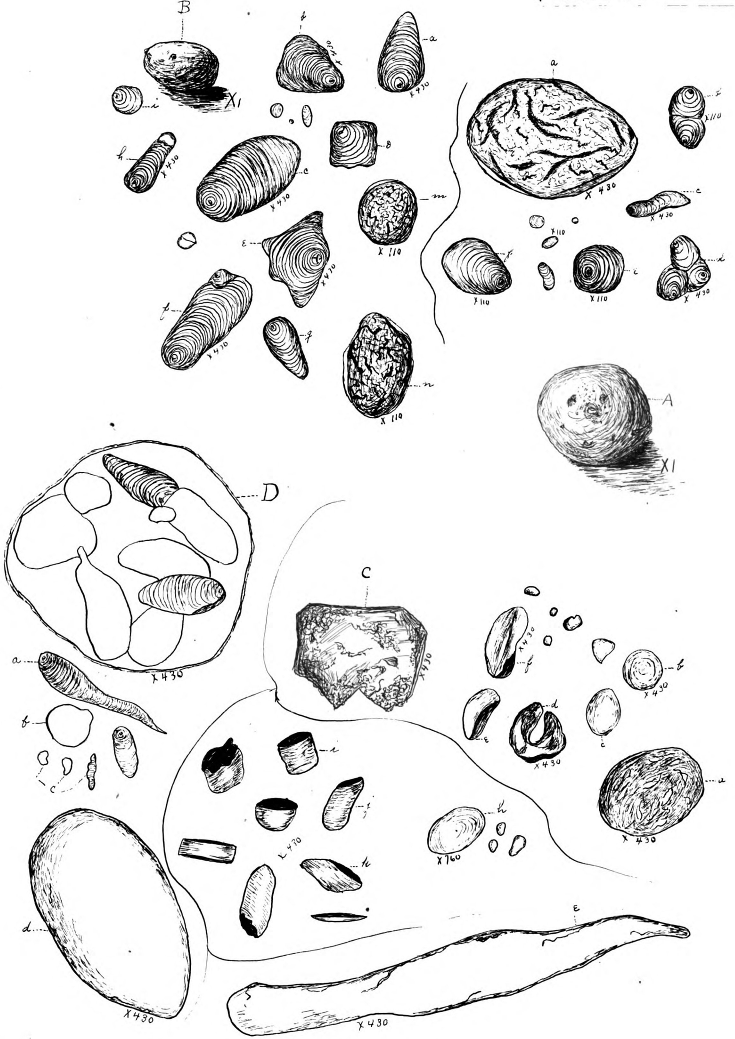

PLATE NO II

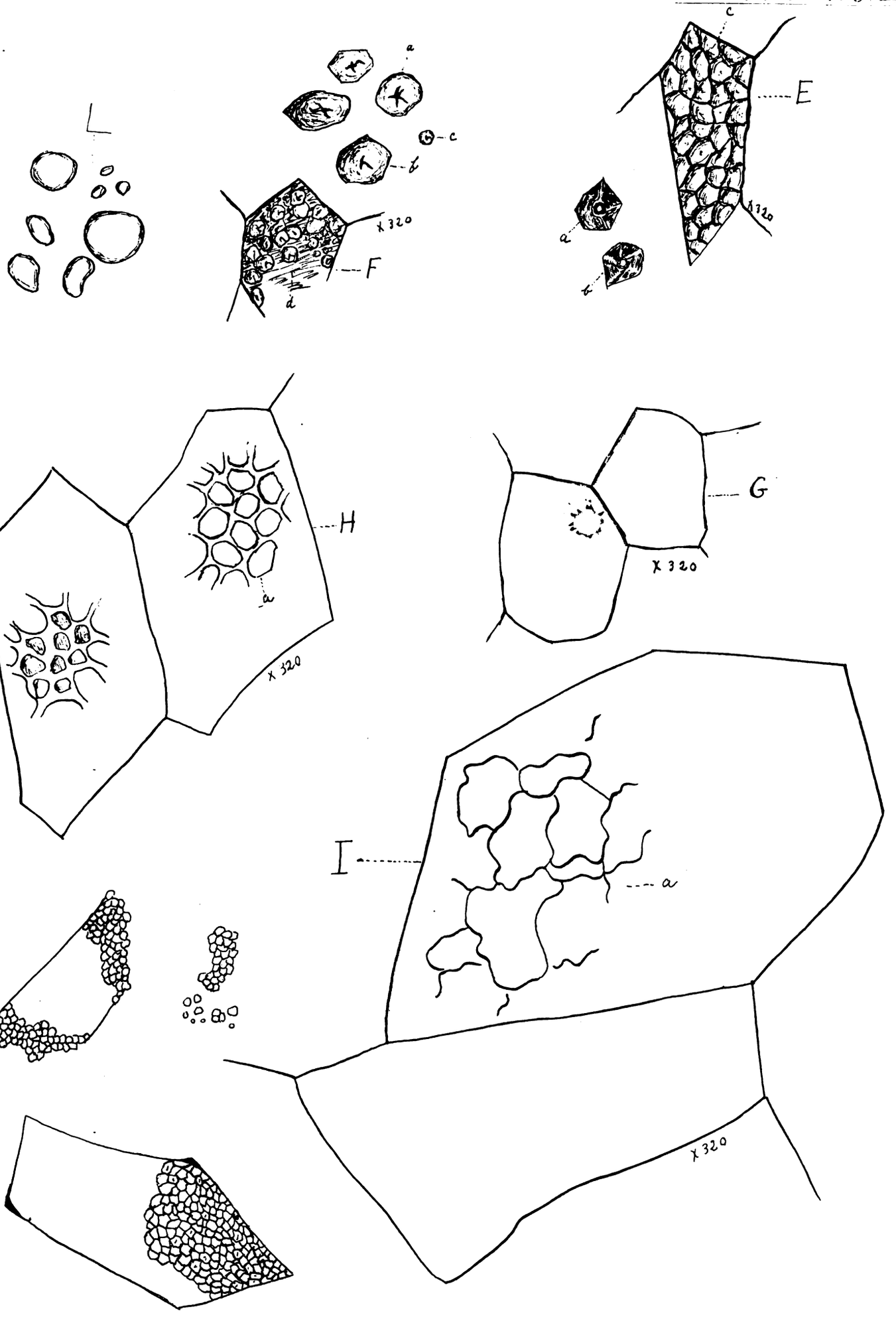

PLATE NO. III