THE USE OF THE MICROSCOPE IN THE DETECTION OF FOOD ADULTERATION.

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INTRODUCTION.

To the lay mind the statement that the microscope may be of use in the examination of food and drug products is a new idea and one which often calls forth many queries. It can be readily understood how gross adulteration may be detected by a simple magnifier, as, for instance, when foreign seeds, gravel, or powdered rock have been mixed with whole small spices. The adulterant may be of such character as easily to escape the notice of the ordinary buyer, though with even a small lens or reading glass the foreign substance may be seen to be very different from the true spice. One case recently brought to the attention of the Bureau of Chemistry was a sample of celery seed adulterated with nearly 40 per cent of powdered rock, the color and size of the rock particles being such as to be easily overlooked in a casual examination. A small magnifier, however, made the difference very apparent. Figure 1 of Plate XLVII, though magnified only 6 diameters, shows plainly the difference between the regular-shaped celery seeds and the angular rock particles.

The usefulness of the simple magnifier in examining food and drug materials, however, is of limited application, and for the examination of products which are made up of small particles, such as flour, ground spices, and powdered drugs, has little or no value. In such cases recourse must be had to the compound microscope with a magnifying power ranging from 50 to 400 diameters.

Although a large amount of work has been done by various investigators on the application of the microscope to analytical work, there are certain parts of the field as yet almost untouched and new problems are constantly being presented for solution. Analytical work was formerly conceived to consist only of test-tube and blast-lamp methods, but the constantly increasing complexity of the questions arising makes it necessary that the analyst should call to his aid physical and microscopical tests as well as those considered strictly chemical.
Among the products important from a commercial as well as an analytical point of view those consisting partially or wholly of starches are most easily examined and identified. The world's supply of starch comes for the most part from a limited number of plants—12 or 15 include nearly all that are of much commercial importance. To the naked eye these starches all appear as a fine white powder, but under a microscope grains or granules are seen which vary more or less in shape, size, rings, hilum (nucleus), and action toward polarized light. Some of the grains are almost spherical, others are angular or ovoid, and still others are very irregular in outline. In diameter they vary from one-tenth to one-thousandth of a millimeter. Our common starches, such as potato and rice starches, are good examples of variety in form and size, though neither of these quite reaches the limits sometimes found. These starches are shown on Plate XLIV, figures 1 and 2, which illustrate strikingly two typical variations in shape. In the case of potato starch the grains are large, with smooth outlines, while rice starch has small grains with angular outlines.

In no variety are all the starch grains of one size, but usually there are fairly well defined limits. An illustration of the way they sometimes vary in size in a given variety is demonstrated in the case of wheat starch (Pl. XLIV, fig. 3), where all gradations of grains from very small to quite large are represented. Most of the grains show, more or less clearly, fine lines of rings upon the surface. In some varieties these are arranged concentrically, while in others they are eccentric. A hilum whose form and position varies widely in certain species commonly occurs in starches. In some it is at the center, as in corn and wheat starches, in others near one end, as in potato and arrowroot. When viewed in polarized light starches show more or less strongly a cross with the bars passing through the hilum. Some of the most striking examples of the action of polarized light on starches are illustrated on Plates XLIV and XLV. Wheat starch (Pl. XLIV, fig. 4) has a central cross, while in maranta (arrowroot, fig. 5) it is eccentric and well defined. Bean starch (fig. 6), which illustrates

*Polarized light is light that has been modified in such a way that all of the waves vibrate in one plane. There are several means by which this can be accomplished, but the most convenient one for the microscope is by the use of the Nicol prism. Light which has been thus polarized is acted upon in a very characteristic way by various crystalline bodies and by the walls and contents of some plant cells having peculiar physical structures. This is strikingly shown in the case of the starches illustrated on Pl. XLIV, figs. 4, 5, and 6, and Pl. XLV, fig. 1.
Fig. 1.—Potato Starch.

Fig. 2.—Rice Starch.

Fig. 3.—Wheat Starch.

Fig. 4.—Wheat Starch Under Polarized Light.

Fig. 5.—Mananta Starch—Polarized Light.

Fig. 6.—Bean Starch—Polarized Light.

Some Common Starches (×200).
STARCH AND COFFEE ADULTERATIONS.
the leguminous type, has a spindle-shaped cross. In the oat a number of starch granules are joined together, forming a mass. When these masses of starch are examined under polarized light the individual grains in the mass have their own individual effect and interfere so with each other that there results little more than a hazy glow of light. (Pl. XLV, fig. 1.)

By becoming familiar with all these characteristics it is possible to identify with considerable accuracy nearly all of the commercial starches. Potato starch adulterated with cornstarch, wheat with corn flour, and buckwheat with wheat are examples of those most easily detected. Thus in Plate XLV, figure 2, is shown a picture of potato starch adulterated with a considerable amount of cornstarch. The grains of the latter are easily distinguished by their angular form.

SPICES.

Another interesting application of the microscopic method of food analysis is found in the examination of spices. Many of these naturally vary so widely as to ash, fiber, etc., and in taste that it is impossible to detect certain kinds of adulteration by chemical and physical means alone. A study of the structure of pure samples will usually fit the analyst to detect adulteration in the ground spices as well as to identify the adulterant used. In order to work most intelligently, however, it is imperative that the analyst should have a good foundation in histological botany, since in this class of products the plant cell in its various modifications becomes the means of identification. In an examination of this sort nearly all kinds of plant tissue are to be considered, because some spices are derived from roots or rhizomes (as ginger), some from barks (as cassia and cinnamon), some from flowers (as cloves), some from seeds (as mustard), some from fruits (as red pepper, black pepper, etc.), and some (such as sage and thyme) from leaves.

Fortunately most of the substances used for adulteration have a structure very different from the genuine spices. For example, although pepper adulterated with ground peas or beans may not always be detected by chemical means, especially when olive pits or pepper shells have been added to counteract the excess of starch present in peas, a microscopical examination will reveal such adulteration at once by showing the presence of the large starch grains characteristic of certain legumes. In pepper the starch is present in angular masses made up of small grains. A sample of this kind of adulteration is shown in Plate XLVI, figure 1, in which the angular masses of pepper are easily distinguished from the nearly ellipsoidal bean-starch grains.
It sometimes occurs that a manufacturer has added so large an amount of corn meal or foreign ground shells and fruit stones to a pepper as to make the adulteration apparent to the taste by the lack of pungency, which is often corrected by adding a small amount of cayenne pepper. A sophistication of this kind can be readily detected by the microscopic method of analysis, because the tissues added are so distinctly different from normal pepper tissue. In figure 2 of Plate XLVI is shown the microscopic appearance of a sample of pepper which was grossly adulterated with ground olive stones. The starchy material has been stained black in the picture, while the partly clear portions, more or less oblong in form, are the stone cells of the olive pits.

The capsicum fruits are readily identified by means of certain cells found on the inner portion of the pericarp (pod) and others on the seed coats. These cells have characteristic sinuous outlines which make them easy to detect even when present in very small numbers. (Pl. XLVI, fig. 3).

Sometimes cayenne is adulterated with colored corn flour and ground wood. Plate XLVI, figure 4, shows a sample of such an adulterant composed principally of powdered sawdust, the fibrous character of the wood differentiating it clearly from the pepper.

COFFEE AND CHOCOLATE PREPARATIONS.

In coffee and chocolate preparations roasted chicory, cereals, and peas in the case of the former, and starchy materials and cocoa shells in the case of the latter, are sometimes used for adulteration. Coffee, being the seed of a plant, has a structure which is very different from chicory, which is a root. The cell walls of coffee have a characteristic beaded appearance which is present in but few other seeds (Pl. XLV, fig. 3.). Even after roasting and grinding these beads can be easily distinguished, while chicory contains sap vessels by which it can be detected (Pl. XLV, fig. 4).

Chocolate and cocoa are made from the seeds of the cocoa plant, to which foreign starches are sometimes added. From the best grades of these products the shells are removed, but in the poorer grades the shells are left and even additional ones are sometimes added. Cocoa beans contain naturally a considerable amount of starch. The grains are small in size and are easily distinguished from the starchy adulterants, such as corn and wheat flours, or potato, corn, and arrowroot starches. An artificial chocolate coating has been examined which was composed of cocoa shells, cornstarch, beef tallow, and some mineral matter, probably used as a coloring substance.
Fig. 1.—Black Pepper, Adulterated with Bean Flour. The Angular Portions are Pepper Starch, the Rounded Bodies Bean Starch. (X200.)

Fig. 2.—Black Pepper, Adulterated with Ground Olive Stones. The Pepper Starch has been Colored Black with Iodin, Causing the Olive Cells to Appear in Contrast. (X150.)

Fig. 3.—Cayenne Pepper. Characteristic Sinuous Cells from Inner Portion of Pod. (X150.)

Fig. 4.—Adulterant for Cayenne Pepper Composed Largely of Powdered Sawdust. (X80.)

PEPPERS AND SOME ADULTERANTS.
SOME CURIOUS TYPES OF ADULTERATION.
JELLIES AND JAMS.

In the production of artificial jellies, jams, and some kinds of confections, various thickeners are used, among which might be mentioned gelatin, starch, agar-agar, gum tragacanth, and gum arabic. Some of these are difficult of identification, while others can readily be detected. Agar-agar is a product made from certain seaweeds and usually contains the siliceous shells of diatoms. These shells are characteristic and quite easily detected in the sediment from the bottom of a dish after the material has been digested with dilute nitric acid. Plate XLVII, figure 2, shows such a diatomaceous shell obtained from a sample of artificial "lemon slices" in which it was found that the jellying material used was agar-agar.

Starch can easily be detected by microchemical and microscopic tests. Gum tragacanth and some other gums of this class contain a certain amount of small starch grains. When allowed to swell in water a delicate laminated structure is developed by which these gums are disclosed even in such products as ice cream and marmalades.

CREAM.

A sample of thickener for cream composed of cornstarch and powdered gum tragacanth is shown in Plate XLVII, figure 3, and illustrates this feature quite satisfactorily. In this case the cornstarch is shown plainly as the angular particles, while the striated bodies near the center of the field are swollen fragments of the gum.

EDIBLE FATS.

The microscope is also of service in the examination of certain edible fats. Thus if pure lard is dissolved in ether and the latter is allowed to evaporate slowly under proper conditions, crystals of the lard will be formed. These if normal will appear under the microscope as narrow plates with chisel-shaped ends. Beef fat treated in a similar manner will normally crystallize out in sheaf-like tufts of crystals the ends of which are nearly or quite needle-like.

HONEY.

Another application of microscopic analysis is in the identification of the flowers from which honey is made. This is of practical value in the analysis of honeys purporting to be from certain flowers. Although bees will almost invariably gather honey from several kinds of flowers, sometimes one or another of these predominate to such an extent as to impart a distinctive color and taste, enough to allow the
honey to be called by that name. By microscopic examination it is readily ascertained whether a so-called apple-blossom honey or an orange-blossom honey is really largely derived from the source claimed. Plate XLVII, figure 4, shows several kinds of pollen found in an ordinary sample of honey.

Another application of this study of pollens is in locating in some cases the geographical origin of the product. This is made possible by the fact that many of the plants from which honey is obtained grow in comparatively limited geographical areas. Thus it is manifest that pollen from the orange tree would not be found in a honey made in any of the States except those of the southern or southwestern part of our country. It is sometimes possible to determine in this way whether a product is true to label as regards the part of the country in which produced.

Though only a few of the more obvious forms of adulteration have been discussed, for the field has as yet been only partly explored, they may serve to illustrate how the microscope comes to the aid of the chemist when he endeavors to detect fraud in foods and food products.